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### Minimally invasive surgical tools and systems

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#### Abstract

A surgical tool includes a body defining an opening sized and configured to receive a first bone portion therein, a displacement tip coupled to a first end of the body, the displacement tip sized and configured for insertion into a medullary canal of a second bone portion, and a deployable retention block configured to be transitioned from a first position to a second position. The deployable retention block is configured to maintain the first bone portion in a predetermined position when the deployable retention block is in the second position.

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## Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION (1) This application claims priority to U.S. Provisional Patent Application No. 63/155,497, filed Mar. 2, 2021, the entirety of which is incorporated by reference herein.

## BACKGROUND

(1) During surgery, such as bunion surgery, it may be necessary to fix a position of a first bone fragment and a second bone fragment. In some instances, an osteotomy is formed in a bone, such as the first metatarsal, to correct one or more defects. After forming the osteotomy, a first fragment of the bone and a second fragment of a bone are positioned to correct the defect and are fixed in place using one or more fixation elements. One or more bone fragments may also be formed as a result of an injury and/or medical procedure.

(2) Current surgical techniques rely on the placement of guide elements, such as k-wires, prior to insertion of the fixation elements. Placement of guide elements is performed by a surgeon and often requires the surgeon to insert and remove the guide element several times before a desired placement is achieved. The repeated insertion and removal of guide elements results in additional wounds in a patient and increases pain, recovery time, and complexity of surgery (including difficulty, increased surgical time, etc.)

## SUMMARY

(3) In various embodiments, a surgical tool is disclosed. The surgical tool includes a body defining an opening sized and configured to receive a first bone portion therein, a displacement tip coupled to a first end of the body, the displacement tip sized and configured for insertion into a medullary canal of a second bone portion, and a deployable retention block configured to be transitioned from a first position to a second position. The deployable retention block is configured to maintain the first bone portion in a predetermined position when the deployable retention block is in the second position.

(4) In various embodiments, a targeting guide is disclosed. The targeting guide includes a body extending from a first end to a second end substantially on a first longitudinal axis. The body defines a first guide hole extending from a first surface to a second surface. The targeting guide further includes a guide arm extending from a first end to a second end substantially on a second longitudinal axis. A first end of the guide arm is rotatably coupled to a first end of the body. A targeting arm is coupled to the second end of the guide arm. The targeting arm comprises a body defining a second guide hole. A guide element inserted through the second guide hole is configured to visualize an insertion trajectory of a guide element inserted through the first guide hole.

(5) In various embodiments, a surgical tool is disclosed. The surgical tool includes a handle body extending substantially on a first longitudinal axis, a displacement tip coupled to a first end of the handle body, the displacement tip extending substantially parallel to the first longitudinal axis, an arm extension extending substantially on a second longitudinal axis and having a first end coupled to the handle body, and a targeting arm coupled to a second end of the arm extension and defining at least one guide hole extending therethrough.

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## Description

### BRIEF DESCRIPTION OF THE FIGURES

(1) The features and advantages of the present invention will be more fully disclosed in, or rendered obvious by the following detailed description of the preferred embodiments, which are to be considered together with the accompanying drawings wherein like numbers refer to like parts and further wherein:

(2) FIG. 1 illustrates a minimally invasive surgery (MIS) displacement translator having an integrated block for retaining a portion of a patient, in accordance with some embodiments.

- (3) FIG. 2 illustrates a side view of the MIS displacement translator of FIG. 1, in accordance with some embodiments.
- (4) FIG. 3 illustrates a rear view of the MIS displacement translator of FIG. 1 in a collapsed position, in accordance with some embodiments.
- (5) FIG. 4 illustrates a rear view of the MIS displacement translator of FIG. 1 in a deployed position, in accordance with some embodiments.
- (6) FIG. 5 illustrates an isometric view of a first side of a k-wire guide including a translatable arm and a rotatable arm, in accordance with some embodiments.
- (7) FIG. 6 illustrates an isometric view of a second side of the k-wire guide of FIG. 4, in accordance with some embodiments.
- (8) FIG. 7 illustrates the k-wire guide of FIG. 5 positioned adjacent to a foot, in accordance with some embodiments.
- (9) FIG. 8 illustrates the k-wire guide of FIG. 7 having at least one k-wire inserted through a guide hole and into a portion of a foot, in accordance with some embodiments.
- (10) FIG. 9 illustrates an isometric view of a k-wire guide including a single-piece arm, in accordance with some embodiments.
- (11) FIG. 10 illustrates an isometric view of a k-wire guide including a single-piece arm and a plurality of guide holes formed through the body, in accordance with some embodiments.
- (12) FIG. 11 illustrates a MIS integrated displacement translator and targeting arm, in accordance with some embodiments.
- (13) FIG. 12 illustrates the MIS integrated displacement translator and targeting arm of FIG. 11 including a k-wire inserted through a targeting head of the targeting arm, in accordance with some embodiments.
- (14) FIG. 13 illustrates an MIS combination displacement translator and targeting arm, in accordance with some embodiments.
- (15) FIG. 14 illustrates a translation body of the MIS combination displacement translator and guide of FIG. 13 positioned adjacent to a foot having an osteotomy formed therein, in accordance with some embodiments.
- (16) FIG. 15 illustrates the MIS combination displacement translator and guide of FIG. 14 having a targeting arm coupled to the translation body, in accordance with some embodiments.
- (17) FIG. 16 illustrates the MIS combination displacement translator and guide of FIG. 15 having a k-wire guide coupled to the targeting arm, in accordance with some embodiments.
- (18) FIG. 17 illustrates a side view of the MIS combination displacement translator and guide of FIG. 16, in accordance with some embodiments.
- (19) FIG. 18 illustrates an MIS combination displacement translator and guide including an integrated displacement translator and targeting arm, in accordance with some embodiments.
- (20) FIG. 19 illustrates the MIS combination displacement translator and guide of FIG. 18 positioned adjacent to a foot, in accordance with some embodiments.
- (21) FIG. 20 illustrates a burr inserted through a cutting guide portion of the MIS combination displacement translator and guide of FIG. 19, in accordance with some embodiments.
- (22) FIG. 21 illustrates a MIS integrated displacement translator and targeting arm, in accordance with some embodiments.
- (23) FIG. 22 illustrates a side view of the MIS integrated displacement translator and targeting arm of FIG. 21, in accordance with some embodiments.
- (24) FIG. 23 illustrates a top-down view of the MIS integrated displacement translator and targeting arm of FIG. 21, in accordance with some embodiments.
- (25) FIG. 24 illustrates a MIS integrated displacement translator and targeting arm, in accordance with some embodiments.
- (26) FIG. 25 illustrates a side view of the MIS integrated displacement translator and targeting arm of FIG. 24, in accordance with some embodiments.

(27) FIG. 26 illustrates a top-down view of the MIS integrated displacement translator and targeting arm of FIG. 24, in accordance with some embodiments.

#### DETAILED DESCRIPTION

(28) 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,” “bottom,” “proximal,” “distal,” “superior,” “inferior,” “medial,” and “lateral” 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,” 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. Like elements have been given like numerical designations to facilitate an understanding of the present subject matter.

(29) As used herein, the term “substantially” denotes elements having a recited relationship (e.g., parallel, perpendicular, aligned, etc.) within acceptable manufacturing tolerances. For example, as used herein, the term “substantially parallel” is used to denote elements that are parallel or that vary from a parallel arrangement within an acceptable margin of error, such as  $\pm 5^\circ$ , although it will be recognized that greater and/or lesser deviations can exist based on manufacturing processes and/or other manufacturing requirements.

(30) In various embodiments, minimally invasive surgery (MIS) tools and methods are disclosed. The MIS tools may include one or more of a displacement translator (also referred to herein as an elevator) configured to translate a first bone fragment relative to a second bone fragment. The MIS displacement translators may include a body. The body may define a cavity sized and configured to receive a portion of a patient bone therein. A displacement tip extends from a portion of the body. The displacement tip is sized and configured to be received within the medullary canal of a first bone portion and to allow rotation and/or pivoting of the displacement translator to displace a second bone portion relative to the first bone portion. In some embodiments, the displacement translator includes a bone retention block configured to retain and/or interact with the second bone portion. The bone retention block may be transitioned from a collapsed position to a deployed position.

(31) In some embodiments, the MIS tools include a targeting guide. The targeting guide is configured to facilitate alignment, positioning, and/or insertion of one or more surgical guide elements, such as k-wires. The targeting guide may include a body having one or more positioning elements. The targeting guide is positioned adjacent to a foot and includes one or more guide holes sized and configured to receive a k-wire and/or a k-wire sleeve therethrough. The k-wires are positioned in a predetermined position with respect to the first and second bone portions by the targeting guide.

(32) In some embodiments, the MIS tools include a combination displacement translator and targeting guide. For example, a single tool may include elements of a displacement translator, such as a displacement body, displacement tip, etc. and elements of a targeting guide, such as a targeting arm, guide holes, etc. The combination displacement translator and targeting guide may include a modular construction including multiple connectable components and/or may include a monolithic construction.

(33) FIGS. 1-4 illustrate an MIS displacement translator **100** having an integrated block **120** for retaining a portion of a patient, in accordance with some embodiments. The displacement translator **100** includes a body **102** defining an opening **104** (or inner cavity). In the illustrated embodiment, the body **102** and the opening **104** each have a generally rounded rectangular shape, although it will be appreciated that the body **102** and/or the opening **104** may have any suitable shape, such as, for

example, a regular geometric shape (e.g., rectangular, ovoid, etc.) or an irregular shape. The cavity **104** is sized and configured to receive one or more anatomical features of a patient therein. For example, in some embodiments, the cavity **104** is sized and configured to receive a first portion of a patient's toe (including a first portion of a bone). The body **102** extends generally along a longitudinal axis **130** from a first end **114a** to a second end **114b**.

(34) In some embodiments, the body **102** includes an outer perimeter edge **106** defining an outer perimeter of the body **102** and an inner perimeter edge **108** defining the cavity **104**. The outer perimeter edge **106** and the inner perimeter edge **108** may define similar, identical, and/or different shapes. For example, in the illustrated embodiment, the outer perimeter edge **106** and the inner perimeter edge **108** generally define similar profiles such that the inner perimeter edge **108** is curved, straight, etc. adjacent to and/or parallel with portions of the outer perimeter edge **106** that are curved, straight, etc. In the illustrated embodiment, the generally rectangular body **102** defines a compressed or inset portion **110** defined by the both the outer perimeter edge **106** and the inner perimeter edge **108**. The compressed portion **110** extends partially into the cavity **104**. The compressed portion **110** may be configured to allow flexing of the body **102** at the compressed portion **110**.

(35) The body **102** includes a displacement tip **112** positioned at the first end **114a** of the body **102** (e.g., a distal end). The displacement tip **112** has a predetermined radius of curvature **115** (see FIG. 2). The displacement tip **112** is sized and configured for insertion into a medullary canal of a bone portion, such as, for example, a medullary canal of a metatarsal having an osteotomy formed therein. The radius of curvature **115** of the displacement tip **112** is configured to allow pivoting of the body **102** with respect to the first bone portion to cause displacement of one or more bone portions (e.g., the first bone portion, a second portion, etc.).

(36) In some embodiments, the displacement translator **100** includes an integrated block **120** sized and configured to retain an anatomical feature of a patient. The integrated block **120** is configured to maintain the anatomical feature in a predetermined position and/or alignment. For example, in some embodiments, the integrated block **120** is configured to maintain a rotated anatomical feature, such as a distal portion of a toe, in a rotated position. The integrated block **120** is configured to interface with a surface of the anatomical feature. In some embodiments, the integrated block **120** includes a surface configured to increase friction between the anatomical feature and the integrated block **120**. For example, the surface of the integrated block **120** may include a texture, retention elements (such as divots), a coating, and/or any other suitable element configured to increase friction and prevent movement of the anatomical feature.

(37) In some embodiments, the integrated block **120** can be transitioned from a first, collapsed, position (as illustrated in FIGS. 2 & 3) to a second, deployed, position (as illustrated in FIG. 4). In the collapsed position, the integrated block **120** is co-planar with a surface **122** of the body **102**. The integrated block **120** may be positioned partially and/or entirely within the cavity **104** defined by the body **102** in a collapsed position. The integrated block **120** may be transitioned from the collapsed position to a deployed position in which at least a portion of the integrated block **120** is positioned outside of (e.g., is not coplanar with) the body **102**.

(38) In some embodiments, the integrated block **120** includes a rod **124** and a plurality of retention elements **126a**, **126b** configured to pivot about the rod **124**. In the illustrated embodiment, the retention elements **126a**, **126b** are generally rectangular shaped, although it will be appreciated that the retention elements **126a**, **126b** can include any suitable shape (and may each have a different shape) configured to retain an anatomical feature of a patient. The retention elements **126a**, **126b** are pivotably coupled to the rod **124** to allow the retention elements **126a**, **126b** to rotate between a position in-plane with the body **102** (illustrated in FIG. 3) and a position out-of-plane with respect to the body **102** (illustrated in FIG. 4).

(39) In some embodiments, the integrated block **120** includes one or more mechanisms to allow partial deployment, incremental deployment, and/or to resist collapsing once deployed. The

mechanism may include any suitable mechanism such as, for example, a ratcheting mechanism, mechanical stops, and/or any other suitable mechanism. The mechanism may be part of and/or formed integrally with the rod **124**, one or more retention elements **126a**, **126b**, the body **102**, and/or any other suitable element.

(40) In the illustrated embodiment, the integrated block **120** is a V-block having a first retention element **126a** and a second retention element **126b** configured to form a V, or wedge, shape when in a deployed position (see FIG. 4). The V-block is configured to retain an anatomical feature, such as a portion of a patient's toe, in a predetermined position. For example, in some embodiments, a distal portion of a toe may be displaced after forming an osteotomy (using, for example, the displacement tip **112** as discussed above). After displacement, the distal portion of the toe is manually rotated and the integrated block **120** is deployed against the distal portion of the toe. The V-shape formed by the first and second retention elements **126a**, **126b** maintains the distal portion of the toe in the rotated position. After completing a surgical procedure, the anatomical feature may be removed and the integrated block **120** may be transitioned from the deployed position to the collapsed position. In some embodiments, the surface **128a**, **128b** of each of the retention elements **126a**, **126b** may include a coating to increase friction and/or otherwise retain the anatomical feature in a fixed position with respect to the retention elements **126a**, **126b**.

(41) FIGS. 5-8 illustrate a targeting guide **200** including a rotatable arm **230** and a translatable arm **250**, in accordance with some embodiments. The targeting guide **200** includes a body **202** extending from a first end **204a** to a second end **204b** generally along a longitudinal axis **206**. The body **202** includes an upper surface **208a**, a lower surface **208b**, a first side surface **210a**, and a second side surface **210b**. In some embodiments, the body **202** includes one or more openings **212** (or cavities) extending from any one surface to any other surface. For example, in the illustrated embodiment, an opening **212** extends from a first side surface **210a** to a second side surface **210b**. The openings **212** may be configured to provide visual alignment indicators, reduce weight of the targeting guide **200**, allow a user to grip the targeting guide **200**, and/or provide any other suitable function. In some embodiments, the body **202** includes an offset or angled portion **203** adjacent to the first end **204a**. The angled portion **203** extends from the body **202** at an angle with respect to the longitudinal axis **206**.

(42) The body **202** defines at least one guide hole **214** extending from a first surface to a second surface of the body **202**. For example, in the illustrated embodiment, the body **202** includes a first guide hole **214** extending from a first end **204a** through the angled portion **203** of the body **202** and exiting from the first side surface **208a**. The first guide hole **214** extends on an axis at an angle to the longitudinal axis **206**. For example, in the illustrated embodiment, the guide hole **214** extends through the angled portion such that the angled portion **203** and the guide hole **214** are longitudinally aligned, although it will be appreciated that the guide hole **214** can extend through the angled portion **203** at any suitable angle with respect to the longitudinal axis **206**. The guide hole **214** is sized and configured to receive a guide element, such as a k-wire **50b**, therethrough. The guide hole **214** positions the received guide element at a predetermined angle with respect to the longitudinal axis **206** of the body **202** and at a predetermined location with respect to one or more additional guide elements, as discussed below.

(43) In some embodiments, a rotation housing **216** is coupled to and/or formed integrally with a second end **204b** of the body **202**. The rotation housing **216** defines a hinge opening **218** sized and configured to receive a first end **234a** of a rotatable arm **230** therein. The rotation housing **216** further defines a pin channel **220** sized and configured to receive a pin **224** therein. In some embodiments, the pin **224** defines a guide hole **226** sized and configured to receive a fixation element, such as an olive wire **225**, therethrough.

(44) In some embodiments, a rotatable arm **230** is coupled to the rotation housing **216**. The rotatable arm **230** includes a body **232** extending between a first end **234a** and a second end **234b**. The first end **234a** of the rotatable arm **230** defines a portion of the pin channel therethrough **220**.

The pin **224** is inserted through the pin channel **220** to rotatably couple the rotatable arm **230** to the body **202**.

(45) The rotatable arm **230** can be rotated about an axis **238** defined by the pin **224** and the pin channel **220**. In the illustrated embodiment, the axis **238** defined by the pin **224** and the pin channel **220** is perpendicular to the longitudinal axis **206**, although it will be appreciated that the axis **238** may be disposed at any angle with respect to the longitudinal axis **206**. The rotatable arm **230** may be rotatable within a predetermined range. For example, in the illustrated embodiment, the rotatable arm **230** is rotatable within a 180° range extending from 90° above the longitudinal axis **206** (e.g., +90°) to 90° below the longitudinal axis **206** (e.g., -90°). Although specific embodiments are discussed herein, it will be appreciated that the rotatable arm **230** may have any suitable range of motion, such as, for example, ±90°, ±60°, ±45°, ±30°, and/or any other suitable range.

(46) The second end **234b** of the rotatable arm **230** defines an arm channel **240** sized and configured to receive a translatable arm **250** therein. The arm channel **240** is spaced a predetermined distance from the pin channel **220** as determined by the length of the body **232**. The arm channel **240** extends through the rotatable arm **230** on a longitudinal axis **242**. In the illustrated embodiment, the axis **242** is parallel to the axis **238** and perpendicular to the axis **206**, although it will be appreciated that the axis **242** can be disposed at any angle with respect to the axis **206** and/or the axis **238**.

(47) In some embodiments, the translatable arm **250** is sized and configured to be received at least partially within the arm channel **240**. The translatable arm **250** includes a body **252** extending from a first end **254a** to a second end **254b** on the axis **242**. In the illustrated embodiment, the body **252** includes a generally rectangular shape defined by an upper surface **256a**, a lower surface **256b**, and a perimeter wall **258**, although it will be appreciated that the translatable arm **250** can include any suitable shape, such as rectangular, cylindrical, etc.

(48) The translatable arm **250** is moveable on the axis **242**. The translatable arm **250** is maintained parallel with the rotatable housing **216** by the arm channel **240**. Translation of the translatable arm **250** within the arm channel **240** alters a distance between a guide portion **260** positioned at a first end **254a** of the translatable arm **250** and a fixed lateral position, such as, for example, the rotatable arm **230** (e.g., an axis defined by the rotatable arm **230**). In use, a first guide element, such as a first k-wire **50a** or guide sleeve (not shown) is inserted through the guide portion **260** to visualize an insertion trajectory of a second guide element, such as a second k-wire **50b** or guide sleeve **52** inserted through the guide hole **214** defined through the body **202** (see FIG. 8). Before, during, and/or after insertion of the first guide element **50a**, the translatable arm **250** may be translated within the arm channel **240** to position the first guide element **50a** to match and/or otherwise provide visualization of the trajectory of the second guide element **50b**.

(49) In some embodiments, the guide portion **260** includes a rotation body **262** and a rotatable guide element **264**. The rotation body **262** defines a rotation channel **266** sized and configured to receive a rotatable guide pin **268** therein. In the illustrated embodiment, the rotation body **262** defines a cylindrical shape, although it will be appreciated the rotation body **262** can define any suitable shape, such as, for example, a rectangular shape, a cylindrical shape, an irregular shape, etc. In some embodiments, the rotation body **262** is sized and configured to prevent the translatable arm **250** from translating fully through the arm channel **240** in a first direction. For example, in the illustrated embodiment, the rotation body **262** has both a height and a radius that prevent the rotation body **262** from moving through the arm channel **240**, although it will be appreciated that a single dimension (e.g., only height or only radius) is sufficient to prevent movement of the guide portion **260** through the arm channel **240**.

(50) In some embodiments, the rotatable guide element **264** is coupled to the rotation body **262**. The rotatable guide element **264** includes a rotatable pin **268** and a fixed cap **270**. The rotatable pin **268** is received within the rotation channel **266** defined by the rotation body **262**. The rotatable pin **268** defines at least one guide hole **272** extending through the body of the rotatable pin **268**. In the



illustrated embodiment, the at least one guide hole 272 is centered with respect to a diameter of the pin 268, although it will be appreciated one or more guide holes 272 may be offset within the pin 268.

(51) In some embodiments, the fixed cap 270 is fixedly coupled to the rotation body 262. The fixed cap 270 defines a guide channel 274 sized and configured to receive a first guide element 50a therein and to limit rotation of the first guide element 50a. For example, in the illustrated embodiment, the guide channel 274 includes a closed channel having a channel wall 276 blocking a portion of the guide channel 274 and preventing complete rotation of the guide element 50a inserted through the guide hole 272 of the rotatable pin 268. The guide channel 274 allows rotation of the guide element 50a within a predetermine range, such as, for example, 0-270°, 0-180°, 0-90°, etc. As discussed in greater detail below, in some embodiments, the guide portion 260 includes a fixed guide portion.

(52) FIG. 7 illustrates the targeting guide 200 of FIGS. 5-6 positioned adjacent to a foot 2, in accordance with some embodiments. In use, the targeting guide 200 is positioned adjacent to at least one bone 4 of a foot 2, such as, for example, a first metatarsal. The bone 4 may have an osteotomy formed therein prior to and/or after positioning the targeting guide 200 adjacent to the bone 4. The axis 206 of the body 202 is aligned with an axis of the bone 4. A pin driver (not shown) may be used to drive a tip of the olive wire 225 (or other fixation element) into a portion of the bone 4, such as a first portion 4a. In the illustrated embodiment, the first portion 4a includes a head of the first metatarsal.

(53) A first guide element 50a is inserted through the guide hole 272 defined in the rotatable pin 268. The first guide element 50a and the rotatable pin 268 may be rotated to align a long axis of the guide element 50a parallel to an axis of a guide hole 214 formed through the body 202. After aligning the axes, the translatable arm 250 is translated within the arm channel 240 to position the first guide element 50a in a position configured to provide visualization for insertion of a second guide element 50b into the bone 4, as shown in FIG. 8. The guide element 50a may be aligned with respect to a predetermined plane, such as, for example, the anterior-posterior (A-P) plane.

(54) In some embodiments, after positioning the first guide element 50a, a guide sleeve 52 is inserted through the guide hole 214 and a second guide element 50b is inserted into the first bone 4 through the guide sleeve 52. The guide sleeve 52 may include a first end 54a positioned in contact with and/or immediately adjacent to a second bone portion 4b of the first bone 4. The guide sleeve 52 defines a longitudinal channel extending from the first end 54a to a second end 54b. The longitudinal channel is sized and configured to receive the second guide element 50b therethrough. The second guide element 50b is guided into contact with the second bone portion 4b by the guide sleeve 52 and advanced through the second bone portion 4b into the first bone portion 4a to fix the location of the first bone portion 4a relative to the second bone portion 4b. After inserting the second guide element 50b, the guide sleeve 52 and the targeting guide 200 are removed from the foot 2, leaving the second guide element 50b in place for further guidance of drilling, fixation, and/or other procedures.

(55) FIG. 9 illustrates one embodiment of a targeting guide 200a having a rotatable guide arm 280, in accordance with some embodiments. The targeting guide 200a is similar to the targeting guide 200 discussed above, and similar description is not repeated herein. The targeting guide 200a includes a rotatable guide arm 280 in place of the rotatable arm 230 and translatable arm 250 of the targeting guide 200. The rotatable guide arm 280 is rotatable coupled to the body 202 by a pin 224 at a first end 288a as discussed above with respect to the targeting guide 200. The rotatable guide arm 280 includes a first portion 282 extending substantially along a first longitudinal axis 286a and a second portion 284 extending substantially along a second longitudinal axis 286b from a second end 288b of the first portion 282. In some embodiments, the second portion 284 is disposed in a common plane but perpendicular to the first portion 282, as illustrated in FIG. 9, although it will be appreciated that the first portion 282 and the second portion 284 may be disposed at any suitable

angle, in plane and/or out of plane.

(56) The second portion **284** of the rotatable guide arm **280** defines a guide hole **290** extending therethrough. The guide hole **290** is sized and configured to receive a guide element, such as a guide wire **50a**, therethrough. The guide hole **290** includes a hole axis extending parallel to an axis defined by the guide hole **214** formed in the body **202**. The guide hole **290** may be configured to position a guide element, such as guide wire **50a**, in-plane or out-of-plane with respect to a guide element, such as guide wire **50b**, inserted through the guide hole **214** formed in the body **202**. The guide element, e.g., guide wire **50a**, inserted through the guide hole **290** may be removably inserted into the guide hole **290** and/or may be fixedly coupled to the second portion **284**, such as, for example, by an adhesive, welding, and/or any other suitable fixation. Although embodiments are discussed herein including a guide wire **50a**, it will be appreciated that any suitable guide element, such as a guide sleeve, guide wire, k-wire, etc., may be used.

(57) In some embodiments, the targeting guide **200**, **200a** can include multiple guide holes **214** formed through the body **202**. For example, FIG. **10** illustrates one embodiment of a targeting guide **200b** including a first guide hole **214a** and a second guide hole **214b** formed through the body **202a**. The targeting guide **200b** is similar to the targeting guide **200a** discussed above, and similar description is not repeated herein. The first guide hole **214a** and the second guide hole **214b** extend through the body **202a** on parallel hole axes that are aligned in-plane with respect to a plane defined by the longitudinal axis **206** of the body **202a** and the axes of the guide holes **214a**, **214b**, although it will be appreciated that one or both of the guide holes **214a**, **214b** can be positioned out-of-plane and/or the guide holes **214a**, **214b** may be non-parallel.

(58) In some embodiments, one or more elements of the displacement elevator **100** and one or more elements of a targeting guide **200**, **200a**, **200b** may be combined into a single combination displacement and targeting device. For example, in some embodiments, a combination displacement and targeting device including a displacement tip configured to displace a bone fragment and a targeting guide configured to guide insertion of at least one guide or fixation element may be used to prevent switching of surgical devices during surgery.

(59) FIG. **11** illustrates a combination displacement and targeting surgical tool **300**, in accordance with some embodiments. The combination displacement and targeting surgical tool **300** includes a handle body **302** extending substantially along a longitudinal axis **306** from a first end **304a** to a second end **304b**. In the illustrated embodiment, the handle body **302** has a generally rectangular shape, although it will be appreciated that the handle body **302** can have any suitable shape, such as, for example, a rectangular, cylindrical, irregular, etc. A displacement extension **310** extends from a second end **304b** of the body **302**. The displacement extension **310** includes a longitudinal body **314** extending substantially along the longitudinal axis **306** and a displacement tip **312**. The displacement tip **312** is similar to the displacement tip **112** discussed above, and similar description is not repeated herein.

(60) In some embodiments, the displacement and targeting surgical tool **300** includes an arm extension **320** extending from the body **302**. In the illustrated embodiment, the arm extension **320** extends perpendicular to the longitudinal axis **306**, although it will be appreciated that the arm extension **320** can extend at any suitable angle with respect to the body **302** and/or the longitudinal axis **306**. The arm extension **320** is coupled to targeting arm **330** at a first end **322**. The targeting arm **330** may be pivotably coupled to the arm extension **320** by a pivoting connection **338** and/or may be fixedly coupled to the targeting arm **330**.

(61) In some embodiments, the targeting arm **330** includes a first portion **332** extending substantially on a first arm axis **336a** and a second portion **334** extending substantially on a second arm axis **336b**. The first arm axis **336a** is disposed at a predetermined angle with respect to the second arm axis **336b**. For example, in the illustrated embodiment, the first arm axis **336a** is positioned perpendicular (e.g., 90°) to the second arm axis **336b**, although it will be appreciated that a greater and/or lesser angle is possible.

(62) In some embodiments, the targeting arm **330** may be adjustable along one or more of the first arm axis **336a** and the second arm axis **336b**. For example, in some embodiments, the targeting arm **330** may be lengthened and/or shortened along the first arm axis **336b** to adjust the distance between the handle body **302** and the targeting arm **330**. In other embodiments, the arm extension **320** may be adjustable to adjust the distance between the handle body **302** and the targeting arm **330**. Although specific embodiments are discussed herein, it will be appreciated that the first portion **332** and/or the second portion **334** of the targeting arm and/or the targeting extension **320** may be shortened and/or lengthened to adjust a position of the pivotable targeting head **342** with respect to the body **302**.

(63) In some embodiments, a pivoting targeting head **342** is coupled to a second end **340b** of the targeting arm **330**. The pivoting targeting head **342** includes a targeting body **344** defining at least one guide hole **346** extending from a first side **348a** to a second side **348b**. The guide hole **346** is sized and configured to receive a guide element, such as a k-wire or guide sleeve, therethrough, as illustrated in FIG. 12. In some embodiments, the body **344** includes a first hinge element **344a** and a second hinge element **344b** defining an arm receiving slot **347** therebetween. The arm receiving slot **347** is sized and configured to receive a second end **340b** of the targeting arm **330** therein. At least one of the hinge elements **344a**, **344b** and the second end **340b** of the targeting arm **330** define a pin slot **349** sized and configured to receive a pivot pin **350** therein. The pivot pin **350** pivotably couples the targeting head **342** to the targeting arm **330**.

(64) In some embodiments, the combination displacement and targeting surgical tool **300** includes a modular design allowing one or more of the components to be connected and/or disconnected from one or more other components. For example, in some embodiments, the displacement extension **310** is slideably received within a channel defined in the front of the handle body **302** such that the displacement extension **310** may be used separately from the handle body **302**. As another example, the targeting arm **330** may be configured to be connected/disconnected to the arm extension **320**. Although specific embodiments are discussed herein, it will be appreciated that any suitable portion of the combination displacement and targeting surgical tool **300** can include a modular configuration.

(65) In use, a surgeon creates an incision in the skin adjacent to a first bone, such as the first metatarsal illustrated in FIG. 9. An osteotomy is generated in the first bone, for example, using a burr. The displacement tip **312** of the displacement extension **310** is inserted into the medullary canal of a first portion of the bone, such as, for example, a proximal fragment of a first metatarsal. The displacement extensions **310** and/or the handle body **302** are rotated (or pivoted) about the displacement tip **312** to displace a second portion (e.g., a distal fragment of the first metatarsal laterally).

(66) A guide element, such as a k-wire **50** as illustrated in FIG. 12, is inserted through the rotatable targeting head **342**. The targeting head **342** and/or the targeting arm **330** are adjusted to position the guide element, e.g., k-wire **50**, at a position matching an intended trajectory of a guide element inserted into the first bone. The surgical site may be reviewed visually (e.g., fluoroscopically) to confirm position of the k-wire **50** and/or to mark an insertion path. A k-wire or other fixation device is inserted into a surgical wire driver and inserted along a trajectory parallel to the trajectory of the guide element **50**. After inserting the k-wire through the first bone portion and the second bone portion, the combination displacement and targeting surgical tool **300** can be removed from the surgical site and additional surgical procedures (e.g., insertion of additional guide elements, fixation, etc.) can be performed.

(67) FIG. 13 illustrates a combination displacement and targeting surgical tool **400**, in accordance with some embodiments. The combination displacement and targeting surgical tool **400** includes a handle body **402** extending from a first end **404a** to a second end **404b**. The handle body **402** includes a thickness extending between a first surface **406a** and a second surface **406b**. In some embodiments, an arm channel extension **408** is coupled to and/or formed integrally with the second

surface **406a** of the body **402**. The arm channel extension **408** defines a channel **410** sized and configured to receive a targeting arm **430** therein, as discussed in greater detail below. In the illustrated embodiment, the arm channel extension **408** (and the arm channel **410**) are centered with respect to the handle body **402**, although it will be appreciated that the arm channel extension **408** may be offset with respect to the handle body **402**.

(68) In some embodiments a displacement tip **412** extends substantially longitudinally from a first side **404a** of the body **402**. The displacement tip **412** is similar to the displacement tip **112** discussed above in conjunction with displacement translator **100**, and similar description is not repeated herein. The displacement tip **412** may include a curved and/or straight profile. For example, in the illustrated embodiment, the displacement tip **412** defines an arc extending from a first end **412a** to a second end **412b** of the displacement tip **412**.

(69) In some embodiments, the arm channel **410** is sized and configured to receive a portion of a targeting arm **430** therein. The arm channel **410** may define a closed channel (e.g., having an opening at only a first end) or an open channel (e.g., having an opening at either end of the channel **410**). The arm channel **410** may extend the entire length of the body **402** (as illustrated) or may extend over only a portion of the body **402**. The arm channel **410** defines at least one opening **414** sized and configured to receive a first end of the targeting arm **430** therein.

(70) In some embodiments, the targeting arm **430** includes a first longitudinal portion **432a** extending substantially on a first longitudinal axis **434a** and a second longitudinal portion **432b** extending substantially on a second longitudinal axis **434b** disposed at an angle with respect to the first longitudinal axis **434a**. A curved portion **436** couples the first longitudinal portion **432a** to the second longitudinal portion **432b**. The curved portion **436** is configured to position the second longitudinal portion **434b** at an angle with respect to the first longitudinal portion **434a** to provide visualization with respect to a bone and/or to position a targeting body **450**, as discussed in greater detail below. The first longitudinal portion **432a** is sized and configured to be received within the arm channel **410**. The targeting arm **430** may include one or more bumps, surface slots, markings, and/or other suitable depth marking configured to allow the targeting arm **430** to be inserted into the arm channel **410** at a predetermined depth.

(71) In some embodiments, the targeting arm **430** defines one or more slots **438a-438d** sized and configured to receive a portion of a targeting body **450** therein. The one or more slots **438a-438d** may be defined through any portion of the targeting arm **430**. For example, in the illustrated embodiment, each of the slots **438a-438d** are formed through the second longitudinal portion **432b**, although it will be appreciated that some or all of the slots **438a-438d** may be formed through the first longitudinal portion **432a**. In some embodiments, the slots **438a-438d** are replaced with another suitable attachment mechanism, such as, for example, snaps, a mechanical joining mechanism, etc. In other embodiments, the slots **438a-438d** are omitted and the targeting body **450** is formed integrally with and/or permanently coupled to the targeting arm **430**.

(72) In some embodiments, the targeting arm **430** includes one or more radiopaque elements configured to visualize alignment in one or more planes. For example, in some embodiments, the targeting arm **430** is made at least partially of a radiopaque material. As another example, in some embodiments, the targeting arm **430** includes one or more radiopaque strips coupled to and/or embedded in the targeting arm **430**. The radiopaque elements may be configured to provide visualization of the alignment between the targeting arm **430** and a bone using fluoroscopy (or other suitable imaging technique).

(73) In some embodiments, a targeting body **450** is releasably coupled to the targeting arm **430**. For example, in the illustrated embodiment, the targeting body **450** includes a first coupling leg **452a** and a second coupling leg **452b** each including a free end **454a**, **454b** sized and configured to be received at least partially within one of the slots **438a-438d** formed in the targeting arm **430**. It will be appreciated that the targeting body **450** may include different coupling mechanisms and/or may omit one or more coupling legs **452a**, **452b** in embodiments having a different coupling

mechanism, such as snaps, formed on the targeting arm **430**.

(74) In some embodiments, the targeting body **450** includes a targeting body **456** defining one or more guide holes **458** therethrough. The guide holes **458** are sized and configured to receive a guide element, such as a k-wire, therethrough. The guide element is positioned by the guide hole **458** to visualize a trajectory of a guide element inserted into a bone, such as a first metatarsal, as discussed above with respect to targeting guide **200**. In some embodiments, the targeting body **456** includes a slot **460** configured to provide a viewing window for alignment.

(75) In some embodiments, the targeting body **456** includes one or more radiopaque elements configured to provide visualization of a trajectory of a guide element inserted into a bone, such as a first metatarsal. For example, in some embodiments, the targeting body **456** (or a portion thereof) is formed of a radiopaque material. As another example, in some embodiments, the targeting body **456** (or a portion thereof) is formed of a radiolucent material having one or more radiopaque stripes (or other elements) embedded therein. Although specific embodiments are discussed herein, it will be appreciated that the targeting body **456** can provide targeting in any suitable spectrum and/or using any suitable mechanism.

(76) In use, the combination displacement and targeting surgical tool **400** is configured to provide displacement of a bone fragment and targeting for insertion of one or more guide elements without requiring multiple surgical tools. As illustrated in FIG. **14**, after forming an osteotomy in a first bone **4**, such as a first metatarsal, the handle body **402** of the combination displacement and targeting surgical tool **400** is positioned adjacent to a second bone fragment **4b**. The displacement tip **412** is inserted into a medullary canal of the second bone fragment **4b** and the handle body **402** is pivoted to displace the second bone fragment **4b** relative to the first bone fragment **4a**.

(77) As shown in FIG. **15**, after displacing the second bone fragment **4b**, a targeting arm **430** is coupled to the handle body **402**, for example, by slideably inserting a portion of the targeting arm **430** into an arm channel **410** defined by the handle body **402** (see FIG. **13**). The targeting arm **430** includes a first longitudinal portion **432a** extending substantially on a first longitudinal axis **434a** shared with the handle body **402** and a second longitudinal portion **432b** extending substantially on a second longitudinal axis **434b** disposed at an angle with respect to the first longitudinal axis **434a** (see FIG. **13**).

(78) As shown in FIGS. **16-17**, a targeting body **450** is coupled to the targeting arm **430** using a suitable coupling mechanism. For example, in the illustrated embodiment, a first coupling leg **452a** and a second coupling leg **452b** are slideably inserted into slots **438a**, **438d** defined by the targeting arm **430**, although it will be appreciated that other suitable coupling mechanisms may be used. The targeting body **450** may be used to visualize an insertion trajectory of one or more guide elements. For example, the targeting body **450** may include one or more guide holes for receiving a guide element therethrough and/or may include one or more radiopaque guide elements formed integrally therewith.

(79) FIG. **18** illustrates a targeting guide **400a** including a fixed handle body **402a**, in accordance with some embodiments. The targeting guide **400a** is similar to the targeting guide **400** discussed above, and similar description is not repeated herein. The targeting guide **400a** includes a fixed handle body **402a** having a generally rounded rectangular shape and defining an inner cavity **404**. The targeting guide **400a** is fixedly coupled to a targeting arm **430a** extending substantially along a longitudinal axis **434**. The targeting arm **430a** defines a cutting guide slot **460**. The cutting guide slot **460** is sized and configured to receive a surgical tool, such as a burr **60** therein (see FIG. **20**). The targeting arm includes a plurality of slots **438a-438e** sized and configured to receive a targeting body **450** therein.

(80) In use, and as shown in FIG. **19**, the targeting guide **400a** is positioned adjacent to a first bone **4**. The targeting **400a** may be imaged, for example using fluoroscopy, to confirm alignment of the targeting guide **400a** with the first bone **4**. After confirming alignment, and as shown in FIG. **20**, a burr **60** may be inserted through a cutting guide slot **460** to form an osteotomy in the first bone **4**.

After forming the osteotomy, the targeting guide **400a** may be used to target and/or align one or more guide element for insertion into the first bone **4**, as discussed in above.

(81) FIGS. **21-23** illustrate a combination displacement and targeting surgical tool **500**, in accordance with some embodiments. The combination displacement and targeting surgical tool **500** is similar to the displacement and surgical tools **100-400** described above, and similar description is not repeated herein. The combination displacement and targeting surgical tool **500** includes a handle body **502** extending from a first end **503a** to a second end **503b**. The handle body **502** includes a slot or longitudinal opening **506** defined by a first rail **507a** and a second rail **507b** spaced apart from the first rail **506a**. The slot **506** extends through the body **502** from a first side **505a** to a second side **505b**.

(82) In some embodiments, a head portion **510** is coupled to the body **502** by an offset or thickened portion **508**. The head portion **510** includes a guide hole **518** defined at least partially by a guide head **516**. The guide hole **518** extends from a first end **511a** of the head portion **510** to a second end **511b** of the head portion **510** substantially on a longitudinal axis that is substantially perpendicular to the longitudinal axis of the handle body **502**. The guide hole **518** is sized and configured to receive a guide element, such as a k-wire, therethrough.

(83) In some embodiments, a displacement tip **512** extends from the head portion **510**. The displacement tip **512** may extend at any suitable angle with respect to the head portion **510**. For example, in the illustrated embodiment, the displacement tip **512** extends substantially along a longitudinal axis that is substantially parallel to the longitudinal axis of the head portion **510**. The displacement tip **512** is similar to the displacement tip **112** discussed above in conjunction with displacement translator **100**, and similar description is not repeated herein. The displacement tip **512** may include a curved and/or straight profile. For example, in the illustrated embodiment, the displacement tip **512** defines a generally straight profile, although it will be appreciated that any suitable curved profile may also be used.

(84) A slideable guide portion **504** is slideably coupled to the body **502** via the first and second rails **507a**, **507b**. For example, in some embodiments, the slideable guide portion **504** includes a slide body **507** defining at least one channel sized and configured to receive the first rail **507a** and/or the second rail **507b** of the handle body **502** therein. In some embodiments, the slideable guide portion **504** may include a slide element sized and configured to be received within the slot **506** defined by the handle body **502**. Although specific embodiments are discussed herein, it will be appreciated that any suitable mechanism may be used to slideably couple the slideable guide portion **504** to the handle body **502**.

(85) In some embodiments, the slideable guide portion **504** includes a pivoting guide element **520** coupled to the slide body **507** in a pivoting arrangement. The pivoting guide element **520** includes a handle portion **521** and a pivoting body **522** each defining a guide hole **526** sized and configured to receive a guide element **524** therethrough. The pivoting guide element **520** may be pivoted with respect to the handle body **502** to change the angle defined between the guide element **524** and the handle body **502**.

(86) In some embodiments, the slideable guide portion **504** defines a first hole **528** sized and configured to receive a fixation element **532** (see FIG. **23**) therein. The fixation element **532** is configured to lock or maintain the pivoting body **522** at a selected angle with respect to the handle body **502**. In the illustrated embodiment, the first hole **528** includes an internal thread configured to couple to an external thread defined by the fixation element **532**. The fixation element **532** may extend into a hole defined in the pivoting body **522** to lock the pivoting body **522** at the preselected angle. In other embodiments, the fixation element **532** may provide a friction or other locking mechanism with respect to the pivoting body **522**.

(87) In some embodiments, the slideable guide portion **504** defines a second hole **530** sized and configured to receive a fixation element **534** (see FIG. **23**) therein. The fixation element **534** is configured to lock or maintain a longitudinal position of the slideable guide portion **504** with

respect to the handle body **502**. In the illustrated embodiment, the second hole **530** includes an internal thread configured to couple to an external thread defined by the fixation element **534**. The fixation element **534** may provide friction or other locking mechanism with respect to the handle body **502** to maintain the slideable guide portion **504** at a selected longitudinal position with respect to the handle body **502**.

(88) FIGS. **24-26** illustrate a combination displacement and targeting surgical tool **500a**, in accordance with some embodiments. The combination displacement and targeting surgical tool **500a** is similar to the combination displacement and surgical tool **500** described above, and similar description is not repeated herein. The combination displacement and targeting surgical tool **500a** includes a displacement tip **512a** that extends substantially parallel to the longitudinal axis of the head **510a**. The displacement tip **512a** extends from the head portion **510a** at a location that is substantially parallel with the handle body **502**. The displacement tip **512a** is similar to the displacement tip **112** discussed above in conjunction with displacement translator **100**, and similar description is not repeated herein. The displacement tip **512a** may include a curved and/or straight profile. For example, in the illustrated embodiment, the displacement tip **512a** defines a generally curved profile, although it will be appreciated that any suitable profile may also be used.

(89) 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 surgical tool, comprising: a handle body extending substantially on a first longitudinal axis; a displacement tip coupled to a first end of the handle body, the displacement tip extending substantially parallel to the first longitudinal axis; and an arm extension extending substantially on a second longitudinal axis, wherein a first end of the arm extension is coupled to the handle body; and a targeting arm pivotably coupled to a second end of the arm extension by a pivoting connection, the targeting arm defining at least one guide hole extending therethrough, wherein the targeting arm is configured to be lengthened or shortened to adjust a distance between the handle body and the targeting arm.
  2. The surgical tool of claim 1, wherein the targeting arm comprises a pivoting targeting head including a targeting body defining the at least one guide hole.
  3. The surgical tool of claim 2, wherein the pivoting targeting head is coupled to the targeting arm with a hinge.
  4. The surgical tool of claim 1, wherein the displacement tip is slideably received within a channel defined in the handle body.
  5. The surgical tool of claim 1, wherein the arm extension defines a channel sized and configured to receive a portion of the targeting arm therein.
  6. The surgical tool of claim 5, wherein the channel comprises a closed channel.
  7. The surgical tool of claim 1, wherein the targeting arm comprises: a first longitudinal portion extending substantially on a third longitudinal axis; a second longitudinal portion extending substantially on a fourth longitudinal axis; and a curved portion coupling the first longitudinal portion to the second longitudinal portion.
  8. The surgical tool of claim 1, wherein the arm extension is adjustable to adjust a distance between the handle body and the targeting arm.
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