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Orthopedic implant and methods of implanting and removing same

Abstract

Illustrative embodiments of orthopedic implants and methods for surgically repairing hammertoe are disclosed. According to at least one illustrative embodiment, an orthopedic implant includes a proximal segment comprising a number of spring arms forming an anchored barb at a first end of the implant, a distal segment extending between the proximal segment and a second end of the implant, and a central segment disposed between the proximal and distal segment.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION (1) The present application is a continuation of U.S. patent application Ser. No. 16/891,732, filed on Jun. 3, 2020 which is a divisional of U.S. patent application Ser. No. 15/669,370, filed on Aug. 4, 2017, which is a

divisional of U.S. patent application Ser. No. 14/637,032 (now U.S. Pat. No. 9,757,168) filed Mar. 3, 2015, the disclosures of which are incorporated herein by reference.

TECHNICAL FIELD

(1) The present disclosure relates generally to orthopedic implants. More particularly, the present disclosure relates to orthopedic implants for surgically repairing joints and methods of implanting and removing same.

BACKGROUND OF THE INVENTION

(2) A hammertoe is condition in which the proximal interphalangeal joints of the second, third, fourth, or fifth toe has become deformed, thereby causing the toe to be permanently bent. Hammertoe occurs from a muscle and ligament imbalance around the joints between the toes, which causes the joints to bend and become stuck in a bent position. Hammertoe oftentimes causes painful rubbing and irritation on the top of the bent toe. If caring for any callouses or corns, changing ones footwear, and/or utilizing cushions, supports, or comfort devices in ones shoes do not alleviate the pain associate with hammertoe, surgical intervention may be required to alleviate the pain. A procedure may be utilized to anatomically correct the joint using a pin, screw, or other implant. After anatomical correction, fusion or bony consolidation of the joint area occurs.

SUMMARY OF THE INVENTION

(3) The present application discloses one or more of the features recited in the appended claims and/or the following features which alone or in any combination, may comprise patentable subject matter.

(4) According to a first aspect of the present disclosure, an orthopedic implant may include a proximal segment comprising at least three spring arms forming an anchored barb at a first end of the implant, wherein first threading extends around outer surfaces of at least a portion of each spring arm and the first threading includes minor and major diameters. The surgical implant may further include a distal segment extending between the proximal segment and a second end of the implant and including second threading extending along at least a portion of the distal segment.

(5) In some embodiments, at least two of the major diameters of the first threading may increase between the distal segment and the first end of the implant.

(6) In some embodiments, each of the major diameters of the first threading may increase between the distal segment and the first end of the implant.

(7) In some embodiments, the proximal segment may be configured to be implanted within a proximal phalanx of a patient and the distal segment may be configured to be threaded into a middle phalanx of the patient.

(8) In some embodiments, the surgical implant may include a marking disposed on the surgical implant between the proximal and distal segments, wherein the marking may be configured to identify an optimal depth for implantation of the distal segment of the implant into a middle phalanx of a patient.

(9) In some embodiments, the implant may be manufactured of polyetheretherketone (PEEK).

(10) In some embodiments, the second threading may include minor diameters and major diameters and at least two of the minor diameters may increase between the second end and the proximal segment.

(11) In some embodiments, each of the minor diameters of the second threading may increase between the second end and the proximal segment.

(12) In some embodiments, the proximal segment may include a drive feature formed in an end thereof that is configured to accept a tool for removal of the implant from a phalanx.

(13) According to a second aspect of the present disclosure, an orthopedic implant may include a proximal segment comprising at least two spring arms forming an anchored barb at a first end of the implant, wherein first threading may extend around outer surfaces of at least a portion of each spring arm and the first threading may include minor and major diameters. The surgical implant

may further include a distal segment extending between the proximal segment and a second end of the implant and include second threading extending along at least a portion of the distal segment, wherein the second threading may include minor and major diameters and at least two of the minor diameters may increase between the second end and the proximal segment.
(14) In some embodiments, each of the minor diameters of the second threading of the distal segment may increase between the second end and the proximal segment.
(15) In some embodiments, each of the major diameters of the first threading of the proximal segment may increase between the distal segment and the first end of the implant.
(16) In some embodiments, the proximal segment may be configured to be implanted within a proximal phalanx of a patient and the distal segment may be configured to be threaded into a middle phalanx of the patient.
(17) In some embodiments, a marking may be disposed on the surgical implant between the proximal and distal segments, wherein the marking may be configured to identify an optimal depth for implantation of the distal segment of the implant into a middle phalanx of a patient.
(18) In some embodiments, the implant may be manufactured of polyetheretherketone (PEEK).
(19) In some embodiments, the proximal segment may include at least three spring arms forming the anchored barb at the first end of the implant.
(20) In some embodiments, the proximal segment may include a drive feature formed in an end thereof that is configured to accept a tool for removal of the implant from a phalanx.
(21) According to a third aspect of the present disclosure, a method of removing an orthopedic implant from a patient may include the step of severing an orthopedic implant in a central segment of the orthopedic implant that is disposed between a proximal segment configured for implantation within a proximal phalanx of the patient and a distal segment opposite the proximal segment and configured for implantation within a middle phalanx of the patient. The method may further include the steps of inserting a tool into the proximal or distal segment of the orthopedic implant and rotating the tool to remove the proximal or distal segment from the proximal or middle phalanx, respectively.
(22) In some embodiments, the method may include one or more of the steps of severing the implant, inserting the tool, which is made of a high-strength stainless steel, into the distal segment, which is made of a polymeric material, to thereby tap the tool into the distal segment, and removing the distal segment from the middle phalanx.
(23) In some embodiments, the method may include one or more of the steps of inserting the tool into an end of the proximal segment, mating a portion of the tool with a drive feature in the proximal segment of the implant, and rotating the tool to remove at least a portion of the surgical implant.
(24) In some embodiments, the drive feature may include a plurality of semi-cylindrical channels.
(25) According to a fourth aspect, a tool for implantation of an orthopedic implant having a proximal segment with at least three arms spaced from one another by recesses, the three arms configured for implantation with a proximal phalanx of a patient and a distal segment opposite the proximal segment and configured for implantation within a middle phalanx of the patient is disclosed. The implantation tool may include a body and at least three arms extending from an end of the body, wherein each of the arms is sized and shaped to fit within one of the recesses disposed between the three arms in the proximal segment of the implant.
(26) In some embodiments, the arms may have an outer diameter that is less than an outer diameter of the arms of the proximal segment of the implant.
(27) In some embodiments, the tool may be configured to retain the proximal segment of the implant on the end of the body.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) The concepts described in the present disclosure are illustrated by way of example and not by way of limitation in the accompanying figures. For simplicity and clarity of illustration, elements illustrated in the figures are not necessarily drawn to scale. For example, the dimensions of some elements may be exaggerated relative to other elements for clarity. Further, where considered appropriate, the same or similar reference labels have been repeated among the figures to indicate corresponding or analogous elements.

(2) FIG. **1** is an isometric view of a first embodiment of an orthopedic implant taken generally from a first end of the implant;

(3) FIG. **2** is an elevational view of a first side of the implant of FIG. **1**;

(4) FIG. **3** is an elevational view of a second side of the implant of FIG. **1**, wherein the second side is opposite the first side depicted in FIG. **2**;

(5) FIG. **4** is an elevational view of the first end of the implant of FIG. **1**;

(6) FIG. **5** is a cross-sectional view of the implant of FIG. **1** taken generally along the lines **5**-**5** of FIG. **4**;

(7) FIG. **6** is an isometric view of a second embodiment of an orthopedic implant taken generally from a first end of the implant;

(8) FIG. **7** is an elevational view of a first side of the implant of FIG. **6**;

(9) FIG. **8** is an elevational view of a second side of the implant of FIG. **6**, wherein the second side is opposite the first side depicted in FIG. **7**;

(10) FIG. **9** is an elevational view of the first end of the implant of FIG. **6**;

(11) FIG. **10** is an elevational view of a second end of the implant of FIG. **7**, wherein the second end is opposite the first end;

(12) FIG. **11** is a cross-sectional view of the implant of FIG. **6** taken generally along the lines **11**-**11** of FIG. **9**;

(13) FIG. **12** is a view depicting a tap advanced over a distal Kirschner wire (K-wire) into a middle phalanx of a patient during a first method of implantation of an orthopedic implant disclosed herein;

(14) FIG. **13** is a view depicting a proximal K-wire inserted into a center of a proximal phalanx of a patient and a drill advanced over the K-wire during the first method of implantation of an orthopedic implant;

(15) FIG. **14**A is a view depicting a second end of a distal segment of an orthopedic implant threaded into the middle phalanx of a patient during the first method of implantation of an orthopedic implant utilizing an implantation tool;

(16) FIG. **14**B is a perspective view of a drive end of the implantation tool shown in use in FIG. **14**A, wherein the implantation tool is utilized to thread the distal segment of the orthopedic implant into the middle phalanx;

(17) FIG. **15** is a view depicting insertion of a barbed anchor disposed at a first end of a proximal segment of an orthopedic implant into a pre-drilled hole in the proximal phalanx of the patient during the first method of implantation of an orthopedic implant;

(18) FIG. **16** is a view depicting a method of removing a distal segment of an orthopedic implant in which a threaded tool is utilized to tap an inner surface of the distal segment;

(19) FIG. **17** is a view depicting a method of removing an orthopedic implant in which a tool having a drive features is utilized in combination with a complementary drive feature within a proximal segment of an orthopedic implant to remove the implant; and

(20) FIGS. **18**A and **18**B are views depicting bending axes for orthopedic implants having two and three arms, respectively.

DETAILED DESCRIPTION

(21) While the concepts of the present disclosure are susceptible to various modifications and

alternative forms, specific exemplary embodiments thereof have been shown by way of example in the figures and will herein be described in detail. It should be understood, however, that there is no intent to limit the concepts of the present disclosure to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the present disclosure.

(22) A first embodiment of an orthopedic implant **20** suitable for treatment and correction of hammertoe is depicted in FIGS. **1**-**5**. The implant **20** generally includes a pin-shaped body **22** extending along a longitudinal axis **24** and further includes a proximal segment **26** terminating in a first end **28** and a distal segment **30** terminating in a second end **32**. The proximal and distal segments **26**, **30** may be integral with one another and joined at a central, narrowed segment **34** of the implant **20**. The proximal segment **26** of the body **22** may generally comprise the central, narrowed segment **34** and three spring arms **36** that form a barbed anchor **38** and which extend away from the central, narrowed segment **34**. While the segment **34** is depicted as being narrowed, the segment **34** may alternatively not be narrowed or may have a constant outer diameter.

(23) As seen in FIGS. **1**, **2**, and **4**, each of the arms **36** is separated from adjacent arms **36** by a channel **40**. Helical threading **41** may be disposed about outer edges or surfaces **42** of each of the arms **36** and may continue between arms **36** (despite the existence of channels **40** therebetween). Each of the arms **36** is formed by opposing side edges **44** that, with side edges **44** of adjacent arms **36**, form the channels **40**. As seen in FIGS. **2** and **6**, each side edge **44** is formed of a straight segment **46** that is generally parallel to a longitudinal axis **24** of the implant **20** and a tapered segment **50** that tapers outwardly from the straight segment **46** at an angle A**1** of greater than 0 degrees to a tip forming a flattened edge **54**. In an illustrative embodiment, the angle A**1** may be between about 1 degree and about 15 degrees. In another illustrative embodiment, the angel A**1** may be between about 3 degrees and about 10 degrees. In a further illustrative embodiment, the angel A**1** may be about 7 degrees. As seen in FIG. **4**, each arm **36** further includes a generally cylindrical inner edge **56** (FIG. **4**) that tapers outwardly from an inner, generally cylindrical surface **57** of the proximal segment **26**. The tapered segment **50** and the inner edge **56** are tapered to thin out the arms **36** to provide a desired stiffness and even stress distribution for each of the arms **36**.

(24) The use of three arms **36** provides more resistance to bending of the arms **36** along various axes that are perpendicular to the longitudinal axis **24**. Less bending equates to higher contact forces and improved fixation. Three arms **36** also stabilize the bone in which implantation occurs more than two arms, since two arms leave a weak bending axis.

(25) Currently, a number of hammertoe implant designs incorporate two spring arms for retention in the proximal phalanx, the middle phalanx, or both. Designs with two arms are intrinsically easier to manufacture through machining and may be easier to insert into the bone, as well. It has been discovered in the present invention that designs with multiple arms, for example, those with an odd number of arms, impart a strong advantage to implant fixation in the bone. Implant fixation into the bone is a common failure mode because bone in older hammertoe patients is oftentimes osteopenic and poorly supports an interface with the implant. The key to implant stability is the ability of the implant to uniformly impart stresses to the underlying bone. The loading vector for a hammertoe implant is predominantly in the dorsal-plantar direction as the foot moves through the gait cycle, however, complex tri-axial stresses also occur in all planes as the foot pushes laterally or moves over uneven surfaces. The objective of the implant designer should be to create a design that retains strength and fixation even in a tri-axial stress state.

(26) A two-arm implant design, as seen in FIG. **18**A, has a weak bending axis **55***a* on a plane of symmetry between the two arms. This weak axis **55***a* imparts a deficiency to the design in resisting tri-axial stresses, particularly when the dorsal-plantar loading vector is aligned perpendicularly to a vector of the arm spring force **59***a*. In this case, the spring arms contribute little to the stability of the implant in the bone.

(27) As seen in FIG. **18**B, a three-arm implant design still has weak bending axis **55***b*, but the weak

bending axis **55***b* is not as weak as the weak bending axis **55***a* of the two-arm design since there are now arms at more angular positions along a diameter of the implant. Even if a weak axis **55***b* of the implant is aligned with the dorsal-plantar loading vector, there are portions of the adjacent spring arms that directly contribute to resistance on the loading vector. This advantage is shared by all arm designs having three or more arms, although odd-numbered arm designs convey a particular evenness between the strong and weak axes. Additionally, with odd-numbered arm designs, the dorsal-plantar loading vector is not aligned perpendicularly to the vector of the arms spring force **59***b*. An additional advantage of a three-arm design is that it self-centers in a center of a hole in the bone in which it is implanted.

(28) Referring to FIG. **6**, the inner surface **57** of the proximal segment **26** has an inner diameter **58** that does not vary along a first section **62** that includes both the central, narrowed segment **34** and a portion of the arms **36**. The inner surface **58** further includes a second section **64** that includes the generally cylindrical surface **57** of the arms **36** and which has a diameter **65** that increases along the longitudinal axis **24** from the central segment **34** toward the first end **28**. The arms **36**, as seen in FIG. **6**, include outer edges **42** that, due to the helical threading **41**, have minor diameters **66***a*-**66***e* and major diameters **68***a*-**68***e*. The minor diameters **66***a*-**66***e* of the helical threading **41** may be constant in that the diameters thereof do not vary along a length of the threading **41**. The major diameters **68***a*-**68***e* of the helical threading **41** may increase from a first major diameter **68***a* closest the central segment **34** toward the first end **28** of the proximal segment **30**. More particularly, a major diameter **68***a* of the threading **41** may be smaller than each of the other major diameters **68***b*-**68***e* and the major diameters **68***b*-**68***e* may each increase between the central segment **34** and the first end **28**. An increasing major diameter **68***a*-**68***e* maximizes bony contact during insertion of the second end **28** of the implant **20** into a proximal phalanx, as discussed in more detail below. In other illustrative embodiments, two or more consecutive or non-consecutive major diameters **68***a*-**68***e* may be increasing between the major diameter **68***a* and the major diameter **68***e* and/or two or more consecutive or non-consecutive major diameters **68***a*-**68***e* may be the same.

(29) Referring again to FIG. **6**, the distal segment **30** includes an inner cylindrical surface **80** having an inner diameter **82**. The inner diameter **82** may be the same or different than the inner diameter **58** of the proximal segment **26**. Helical threading **84** may be disposed on an outer surface **86** of all or a portion of the distal segment **30**. As seen in FIG. **6**, the helical threading **84** includes minor diameters **88***a*-**88***e* and major diameters **92***a*-**92***e*, wherein the minor diameters **88***a*-**88***e* may increase along the longitudinal axis **24** of the implant **20** between the second end **32** and the first end **28**. More particularly, a minor diameter **88***a* of the threading **84** may be smaller than each of the other minor diameters **88***b*-**88***e* and the minor diameters **88***a*-**88***e* may increase between minor diameter **88***a* and minor diameter **88***e*. Increasing minor diameters **88***a*-**88***e* provide tactile feedback when implanting the distal segment **30** of the implant **20** into a middle phalanx, as discussed in greater detail below. In alternative illustrative embodiments, two or more consecutive or non-consecutive minor diameters **88***a*-**88***e* may increase between minor diameter **88***a* and minor diameter **88***e* and/or two or more consecutive or non-consecutive minor diameters **88***a*-**88***e* may be same. Major diameters **92***a*-**92***e* of the helical threading **84** may increase in diameter from the major diameter **92***a* to the major diameter **92***e* or the major diameters **92***a*-**92***e* may be the same. Still alternatively, two or more consecutive or non-consecutive major diameters **92***a*-**92***e* may be increasing between the major diameters **92***a* and the major diameter **92***e* and/or two or more consecutive or non-consecutive major diameters **92***a*-**92***e* may be the same.

(30) While a particular number of threads are depicted for the threading **41** and **84**, any number of threads may be present depending on a particular application for the implant **20**.

(31) A second embodiment of an orthopedic implant **220** suitable for treatment and correction of hammertoe is depicted in FIGS. **6**-**11**. The implant **220** generally includes a pin-shaped body **222** extending along a longitudinal axis **224** and further includes a proximal segment **226** terminating in a first end **228** and a distal segment **230** terminating in a second end **232**. The proximal and distal

segments **226**, **230** may be integral with one another and joined at a central, cylindrical flattened segment **234** of the implant **220**. The proximal segment **226** of the body **222** may generally comprise the central flattened segment **234** and three arms **236** that form a barbed anchor **238** and which extend away from the central, flattened segment **234**.

(32) As seen in FIGS. **5**, **6**, **7**, and **9**, each of the arms **236** is separated from adjacent arms **236** by a channel **240**. Helical threading **241** may be disposed about outer edges or surfaces **242** of each of the arms **236** and may continue between arms **236** (despite the existence of channels **240** therebetween). Each of the arms **236** is formed by opposing side edges **244** that, with side edges **244** of adjacent arms **236**, form the channels **240**. As seen in FIGS. **7** and **12**, each side edge **244** tapers outwardly at an angle A**2** of greater than 0 degrees to a tip forming a flattened edge **254**. In an illustrative embodiment, the angle A**2** may be between about 1 degree and about 15 degrees. In another illustrative embodiment, the angel A**2** may be between about 3 degrees and about 10 degrees. In a further illustrative embodiment, the angel A**2** may be about 7 degrees. As seen in FIGS. **6** and **10**, each arm **236** further includes an inner, generally cylindrical edge **256** that tapers outwardly from an inner, generally cylindrical surface **258** of the proximal segment **226**.

(33) Referring to FIG. **11**, the inner surface **258** of the proximal segment **226** has an inner diameter **259** that may not vary along a first section **262** and that may include both the central segment **234** and a portion of the arms **236**. The inner diameter **258** may further include a second section **264** that includes at least a portion of the arms **236** and which has a diameter **265** that increases along the longitudinal axis **224** from the central segment **234** toward the first end **228**. The arms **236**, as seen in FIG. **11** include helical threading **241** that has minor diameters **266***a*-**266***e* and major diameters **268***a*-**268***e*. The minor diameters **266***a*-**266***e* of the helical threading **41** may be constant in that the diameters thereof do not vary along a length of the threading **241** or the minor diameters **266***a*-**266***e* may have different or varying diameters. The major diameters **268***a*-**268***e* of the helical threading **41** may be constant in that the diameters thereof do not vary along a length of the threading **241** or the major diameters **268***a*-**268***e* may have different or varying diameters. In illustrative embodiments and similar to the embodiment of FIGS. **1**-**5**, the major diameters **268***a*-**286***e* may increase from a first major diameter **268***a* closest the central segment **234** toward the first end **228** of the proximal segment **230**. In other illustrative embodiments, two or more consecutive or non-consecutive major diameters **268***a*-**268***e* may be increasing between the major diameter **268***a* and the major diameter **268***e* and/or two or more consecutive or non-consecutive major diameters **268***a*-**268***e* may be the same.

(34) Referring again to FIG. **11**, the distal segment **230** includes an inner cylindrical surface **280** having an inner diameter **282**. The inner diameter **282** may be constant or may vary along the longitudinal axis **224**. The inner diameter **282** may be the same as or less than the inner diameter **259** of the proximal segment **226**. Helical threading **284** may be disposed on an outer surface **286** of all or a portion of the distal segment **230**. As seen in FIG. **11**, a minor diameter **288***a*-**288***e* of the helical threading **284** may be the same for each thread or may increase along the longitudinal axis **224** of the implant **220** from the second end **232** toward the first end **228**, as discussed above with respect to the embodiment of FIGS. **1**-**5**. In other illustrative embodiments, two or more consecutive or non-consecutive minor diameters **288***a*-**288***e* may be increasing between the minor diameter **288***a* and the minor diameters **288***e* and/or two or more consecutive or non-consecutive minor diameters **288***a*-**288***e* may be the same.

(35) Major diameters **292***a*-**292***e* of the helical threading **284** may increase in diameter from the major diameter **292***a* to the major diameter **292***e* or the major diameters **292***a*-**292***e* may be the same. Still alternatively, two or more consecutive or non-consecutive major diameters **292***a*-**292***e* may be increasing between the major diameters **292***a* and the major diameter **292***e* and/or two or more consecutive or non-consecutive major diameters **292***a*-**292***e* may be the same.

(36) While a particular number of threads are depicted for the threading **241** and **284**, any number of threads may be present depending on a particular application for the implants **20**, **220**.

(37) Implantation of the implants **20**, **220** will now be discussed in detail. Prior to implantation, the proximal interphalanxal (PIP) joint of the patient is opened using, for example, a dorsal approach. A head of a proximal phalanx **104** of the patient is prepared by reaming until bleeding bone is reached, for example, using a proximal phalanx reamer and a base of a middle phalanx **100** of the patient is also reamed until bleeding bone is reached, for example, using a middle phalanx reamer. Once the middle phalanx **400** is reamed, a distal K-wire may be inserted into a center of the middle phalanx **400**. As seen in FIG. **12**, tap **410** of the appropriate size **410** is selected for the desired implant size and, using firm axial pressure, the tap **410** is advanced over the distal K-wire into the middle phalanx **100** until a laser line **412** on the tap **410** is level with an outer surface **414** of the middle phalanx **400**. A proximal K-wire **416** may be inserted into a center of the proximal phalanx **404**, as seen in FIG. **13**. In an illustrative embodiment, the K-wire **416** may be introduced at a 10 degree angle plantar to a medial axis of the proximal phalanx **404**. An appropriate drill size may be selected and advanced over the K-wire **416** into the proximal phalanx **404** until a laser line **420** on the drill **418** is level with an outer surface **422** of the proximal phalanx **404**, as seen in FIG. **13**, and the proximal K-wire **416** may be removed after drilling.

(38) The second end **32**, **232** of the distal segment **30**, **230** of either implant **20**, **220** is threaded into the middle phalanx **400** of the patient, as seen in FIG. **14**A, using an implantation tool **500**, until an increase in torque indicates firm seating of the implant **20**, **220**. Additionally, an outer edge of the middle phalanx **400** may be aligned with a laser line **402** positioned between the proximal and distal segments **26** or **226**, **30** or **230** and should be facing dorsally. The laser line **402** is formed of one or more of a black burn, engraving, one or more dyes, or any other suitable substance capable of creating a line, marker, or other indicator. The laser line **402** provides guidance to a surgeon or other healthcare professional such that the distal segment **30**, **230** of the implant **20**, **220** is threaded into the middle phalanx **400** to an optimal or ideal depth. The laser lines on the tap **410** and the drill **418** additionally prepare the bone for insertion of the implant **20**, **220** to an appropriate depth.

(39) The implantation tool **500**, as best seen in FIG. **14**B, may include a generally cylindrical body **502**, although, the body **502** need not be cylindrical. Three arms **504** extend outwardly from a first end **506** of the body **502**. Each of the arms **504** includes a wider based **508** that tapers into a narrowed tip **510**. The arms **504** are sized and shaped to be complementary to and fit within the channels **40**, **240** formed by the arms **36**, **236** of the implant **20**, **220**, as seen in FIG. **14**A. In illustrative embodiments, the implantation tool **500** may retain the implant **20**, **220** on the first end **506** by, for example, an interference fit. In other illustrative embodiments, the implantation tool **500** may fit within the implant **20**, **220**, but may not retain the implant **20**, **220** on the first end **506**.

(40) As may be seen in FIG. **14**A, an outer diameter of the arms **504** of the implantation tool **500** is fully within an outer or major diameter of the threads **68***a*-**68***e*, **268***a*-**268***e*. Each of the arms **504** may also include a laser mark **512** that denote which way the implant arms **36**, **236** are oriented. As one skilled in the art will understand, if an implant includes more than three arms/three recesses, the implantation tool **500** may include a similar number of arms.

(41) After the distal segment **30**, **230** is implanted within the middle phalanx **400** and the distal K-wire **416** is removed, the proximal segment **26**, **226** of the implant **20**, **220** is aligned with a proximal phalanx **404** of the patient. More specifically, the barbed anchor **38**, **238** at the first end **28**, **228** of the proximal segment **26**, **226** is aligned with and inserted into the pre-drilled hole in the proximal phalanx **404**, as seen in FIG. **15**. The proximal segment **26**, **226** is thereafter pressed into the proximal phalanx **404**. Once both the proximal and distal segments **26** or **226**, **30** or **230** are implanted within the proximal and middle phalanges **404**, **400**, respectively, a typical surgical procedure is used to close the patient.

(42) Oftentimes, implants, such as implant **20**, **220** or any of the implants disclosed herein, must be removed and replaced (during, for example, a revision surgical procedure). It can be very difficult to remove the distal and/or proximal segments **30** or **230**, **26** or **226** from the middle and proximal phalanges **400**, **404**, respectively. The implant **20**, **220** may be provided with features that allow for

easier removal of the implant **20**, **220** from the middle and proximal phalanges **400**, **404**. More particularly, in illustrative embodiments, the implant **20**, **220** may be manufactured of a polymeric material, for example, ultra-high molecular weight polyethylene (UHMWPE), polyetheretherketone (PEEK), or any other suitable polymeric material. The central segment **34**, **234** of the implant **20**, **220** may be cut to sever the proximal and distal segments **26** or **226**, **30** or **230** from one another. In illustrative embodiments, the central segment **34**, **234** may be cut at a point **130** adjacent the distal segment **30**, **230**.

(43) In illustrative embodiments, once the implant, for example, the implant **20**, is severed, a tool **440** that is made of a high-strength material, for example, stainless steel, having threading **442** may be threaded into the distal segment **30**. In illustrative embodiments, the threading **442** on the tool **440** taps out the inner cylindrical surface **80** of the distal segment **30** such that opposing threads are created therein. Once the tool **440** is threaded a sufficient distance into the distal segment **30**, the tool **440** may be threaded or pulled in a direction **444** opposite the direction of threading to remove the distal segment **30** from the middle phalanx **400**. In a similar manner, the tool **440** may be threaded into the proximal segment **26**, for example, such that the threading **442** on the tool **440** taps out an inner surface **446** of the central segment **34** and/or the proximal segment **26**, thereby creating opposing threads therein. Once the tool **440** is threaded a sufficient distance into the proximal segment **26**, the tool **440** may be threaded or pulled in a direction opposite the direction of threading to remove the proximal segment **26** from the proximal phalanx **404**.

(44) In other illustrative embodiments, the implant, for example, the implant **220**, may include a proximal segment **226** having an internal drive feature **450** (see FIG. **9**) that mates with a tool **452** such that, upon rotation of the tool **452**, the distal segment **230** may be threaded out of the bore in which it was implanted. In the illustrative embodiment, the drive feature **450** may be comprised of a hexalobe bore formed by the cylindrical inner edge **256** that form semi-cylindrical channels and portions of the central segment **34** that form semi-cylindrical channels. Alternatively or additionally, the drive feature **450** may include any suitable feature(s) or geometr(ies) configured to accept a tool and allows for rotation of the implant **220** using the tool **452**. While six semi-cylindrical channels are depicted in FIG. **9**, any suitable number of semi-cylindrical channels may be utilized.

(45) Any of the implants disclosed herein may be manufactured in different sizes, for example, for differently-sized phalanges of the same foot or phalanges of persons with differently-sized feet, toes, and/or phalanges. In an illustrative embodiment, three or more differently-sized implants may be provided, for example, small, medium, and large implants or small, medium, large, and extra-large implants. In an illustrative embodiment with small, medium, and large implants, an overall length of the small implant may be 13 millimeters, a proximal length L**1** may be 7 millimeters, and a distal length L**2** may be 6 millimeters. Similarly, an overall length of the medium implant may be 14 millimeters, the proximal length L**1** may be 7 millimeters, and the distal length L**2** may be 7 millimeters. Still further, an overall length of the large implant may be 15 millimeters, the proximal length L**1** may be 7 millimeters, and the distal length may be 8 millimeters. In other embodiments, the overall length of one or more implants may be between about 5 millimeters and about 20 millimeters.

(46) Any of the implants disclosed herein may be manufactured of one or more of metal, ultra-high molecular weight polyethylene (UHMWPE), ceramic, polyetheretherketone (PEEK), or any other suitable material or materials.

(47) While the implants disclosed in detail herein are discussed as being suitable for treatment and correction of hammertoe, the implants disclosed herein may be utilized for treatment and/or correction of other conditions, for example, other conditions in the foot or hand and/or conditions related to other joints.

(48) Any one or more features of any of the implant disclosed herein may be incorporated (alone or in combination) into any of the other implants disclosed herein.

(49) While certain illustrative embodiments have been described in detail in the figures and the foregoing description, such an illustration and description is to be considered as exemplary and not restrictive in character, it being understood that only illustrative embodiments have been shown and described and that all changes and modifications that come within the spirit of the disclosure are desired to be protected. There are a plurality of advantages of the present disclosure arising from the various features of the apparatus, systems, and methods described herein. It will be noted that alternative embodiments of the apparatus, systems, and methods of the present disclosure may not include all of the features described yet still benefit from at least some of the advantages of such features. Those of ordinary skill in the art may readily devise their own implementations of the apparatus, systems, and methods that incorporate one or more of the features of the present disclosure.

Claims

1. An orthopedic implantation kit, comprising: an orthopedic implantation tool including: a body defining a longitudinal axis; three circumferentially spaced apart tool arms extending from the body, each of the tool arms including: a first surface extending from the body and within a first plane parallel to the longitudinal axis; and a second surface distal to and extending distally from the first surface, the second surface being within a second plane transverse to the longitudinal axis, wherein each of the first and the second surfaces extends across a full width of the arm defined within a plane extending radially from the longitudinal axis; and an orthopedic implant defining respective recesses configured to receive the three circumferentially spaced tool arms of the orthopedic implantation tool, wherein the tool arms are configured for moving and thereby causing implantation of the orthopedic implant when the tool arms are received by the recesses of the orthopedic implant.
2. The orthopedic implantation kit of claim 1, wherein the orthopedic implant includes a laser line configured to indicate alignment of the orthopedic implant with a surface of the bone.
3. The orthopedic implantation kit of claim 1, wherein each of the tool arms is inserted between respective sets of two circumferentially spaced apart implant arms of the orthopedic implant when recesses of the orthopedic implant receive the tool arms.
4. The orthopedic implantation kit of claim 3, wherein each of the tool arms includes a base and a tip that is attached to and thinner than the base, wherein the respective sets of two circumferentially spaced apart implant arms of the orthopedic implant each define a semi-cylindrical channel, and wherein the tip of each implant arm is complementary to each semi-cylindrical channel and the base is complementary to a surface wider than each semi-cylindrical channel.
5. The orthopedic implantation kit of claim 1, wherein the orthopedic implant extends between a first end and a second end opposite the first end, wherein the recesses of the orthopedic implant are positioned at the first end, and wherein the second end is threaded.
6. The orthopedic implantation kit of claim 1, wherein each of the implant arms includes a third surface within a third plane, the third plane being transverse to the second plane and the third surface being distal to the second surface, the third surface further extending from the second surface along a full width of the second surface.
7. The orthopedic implantation kit of claim 1, wherein the tool arms of the orthopedic implantation tool are configured to rotate the orthopedic implant when the recesses of the orthopedic implant receive the tool arms of the orthopedic implantation tool.
8. An orthopedic implantation kit, comprising: an orthopedic implantation tool including: a body; three tool arms extending from the body, wherein each of the tool arms defines a central plane that extends radially from the center of the implantation tool, wherein a distal end of each of the tool arms is spaced apart from the distal ends of each of the other tool arms, and wherein each of the tool arms includes a side having a plurality of surfaces defining a set of planes, each of the planes

of the set of planes of the side being parallel to or forming a different angle with respect to the central plane of the respective tool arm than the other planes of the set of planes; and an orthopedic implant defining respective recesses configured to receive the three tool arms of the orthopedic implantation tool, wherein the tool arms are configured for moving and thereby causing implantation of the orthopedic implant when the tool arms are received by the recesses of the orthopedic implant.

9. The orthopedic implantation kit of claim 8, wherein the tool arms of the orthopedic implantation tool are configured to rotate the orthopedic implant when the recesses of the orthopedic implant receive the tool arms of the orthopedic implantation tool.

10. The orthopedic implantation kit of claim 8, wherein each of the tool arms of the implantation tool is sized and shaped to be a complementary fit within a channel formed between adjacent implant arms on a first end of the implant.

11. The orthopedic implantation kit of claim 10, wherein each of the tool arms of the implantation tool has a base at a proximal end of the tool that tapers in a distal direction to a tip narrower than the base.

12. The orthopedic implantation kit of claim 8, wherein each of the tool arms includes a first surface extending from the tool body along a plane parallel to a longitudinal axis defined by the tool body, each of the tool arms further including a second surface distal to the first surface and extending along a plane parallel to the longitudinal axis, the first and the second surface spanning a full width of each of the respective tool arms.

13. The orthopedic implantation kit of claim 8, wherein each of the tool arms defines a respective tip spanning a full width of the respective tool arm.

14. An orthopedic implantation kit, comprising: an orthopedic implant extending from a first end to a second end and including: a central segment; and three circumferentially spaced bendable implant arms at the first end extending from the central segment and defining a channel between adjacent ones of the implant arms; and an orthopedic implantation tool including: tool arms sized and shaped to complementarily fit into the first end of the implant, wherein a surface of each of the tool arms contacts first and second surfaces of corresponding ones of the implant arms and each of the tool arms contacts at least two of the implant arms, and wherein the first and second surfaces of each of the implant arms define planes extending in transverse directions to each other.

15. The orthopedic implantation kit of claim 14, wherein the first surface of each of the tool arms defines a plane parallel to a longitudinal axis of the tool arm and the second surface of each of the tool arms defines a plane transverse to the respective first surface.

16. The orthopedic implantation kit of claim 14, wherein the orthopedic implant is configured to be implanted into a middle phalanx.

17. The orthopedic implantation kit of claim 14, wherein the first end of the orthopedic implant is configured to be implanted into a proximal phalanx and the second end of the orthopedic implant is configured to be threaded into a middle phalanx.

18. The orthopedic implantation kit of claim 14, wherein the second end of the implant includes an outer surface having a helical threading.

19. The orthopedic implantation kit of claim 14, wherein the orthopedic implant includes a marking configured to indicate alignment of the orthopedic implant with a surface of a bone.

20. The orthopedic implantation kit of claim 14, wherein each of the implant arms includes a barb at the first end of the implant for anchoring the implant.