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Anterior lumbar interbody fusion device with bidirectional screws

Abstract

Various implementations include an implant. The implant includes a body defining a central opening. The body has a first surface and a second surface spaced apart and opposite from the first surface. The second surface at least partially defines the central opening. The first surface defines a plurality of openings including a first opening and a second opening. Each of the openings extends along an axis from the first surface to the second surface. The first opening and the second opening at least partially overlap at the first surface, and the axis of the first opening is transverse to the axis of the second opening.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application is a continuation of U.S. Ser. No. 17/179,056 filed Feb. 18, 2021, which in turn claims the benefit of U.S. Provisional Patent Application No. 62/978,060, filed Feb. 18, 2020, the contents of which are incorporated herein by reference in their entirety.

BACKGROUND

(1) An interbody device is a prosthesis used during spinal surgery. An interbody device is inserted into the space between spinal disks to provide stability. For example, an interbody device can be introduced between vertebrae of a patient's spine (i.e., in the disk space between adjacent vertebrae) for fixation with bone to immobilize the joint as part of a surgical treatment. Interbody devices are fastened with anchors and often have a plurality of single openings for insertion of each anchor. The single openings provide a predetermined location in the spinal column for each anchor to be inserted during an operation. However, due to differences in patients' spines and existing medical hardware, the specific anchor locations of current interbody devices may be unsuitable in some cases.

(2) Thus, a need exists for an implantable interbody device that provides for versatility of anchor insertion locations.

SUMMARY

(3) Various implementations include an implant. The implant includes a body defining a central opening, the body has a first surface and a second surface spaced apart and opposite from the first surface. The second surface at least partially defines the central opening. The first surface defines a

plurality of openings including a first opening and a second opening. Each of the openings extends along an axis from the first surface to the second surface. The first opening and the second opening at least partially overlap at the first surface, and the axis of the first opening is transverse to the axis of the second opening.

(4) In some implementations, the plurality of openings further includes a third opening, a fourth opening, a fifth opening and a sixth opening. The third opening and the fourth opening at least partially overlap at the first surface, and the axis of the third opening is transverse to the axis of the fourth opening. The fifth opening and the sixth opening at least partially overlap at the first surface, and the axis of the fifth opening is transverse to the axis of the sixth opening.

(5) In some implementations, the first surface of the body further includes an alignment axis. An intersection point of the axis of the first opening with the first surface and an intersection point of the axis of the second opening with the first surface are equally spaced on opposite sides of the alignment axis from each other. An intersection point of the axis of the third opening with the first surface and an intersection point of the axis of the fourth opening with the first surface are equally spaced on opposite sides of the alignment axis from each other. An intersection point of the axis of the fifth opening with the first surface and an intersection point of the axis of the sixth opening with the first surface are equally spaced on opposite sides of the alignment axis from each other.

(6) In some implementations, the first opening and the second opening are configured such that a first anchor is disposable within the first opening and a second anchor is disposable within the second opening simultaneously.

(7) In some implementations, the axis of the first opening and the axis of the second opening define an anchor plane that is perpendicular to the alignment axis. The axis of the first opening is disposed at a first angle from 30 degrees to 60 degrees relative to the second surface of the body. The axis of the second opening is disposed at a second angle from 30 degrees to 60 degrees relative to the second surface of the body.

(8) In some implementations, the first angle is 45 degrees and second angle is 45 degrees.

(9) In some implementations, a projection of the axis of the third opening onto the anchor plane is disposed at a third primary angle from 15 degrees to 60 degrees relative to the second surface of the body. A projection of the axis of the fourth opening onto the anchor plane is disposed at a fourth primary angle from 15 degrees to 60 degrees relative to the second surface of the body. A projection of the axis of the fifth opening onto the anchor plane is disposed at a fifth primary angle from 15 degrees to 60 degrees relative to the second surface of the body. A projection of the axis of the sixth opening onto the anchor plane is disposed at a sixth primary angle from 15 degrees to 60 degrees relative to the second surface of the body.

(10) In some implementations, the third primary angle is 30 degrees, fourth primary angle is 30 degrees, fifth primary angle is 30 degrees, and sixth primary angle is 30 degrees.

(11) In some implementations, the axis of the third opening intersects the anchor plane at a third secondary angle of 30 degrees or less, and wherein the axis of the fourth opening intersects the anchor plane at a fourth secondary angle of 30 degrees or less. The axis of the fifth opening intersects the anchor plane at a fifth secondary angle of 30 degrees or less. The axis of the sixth opening intersects the anchor plane at a sixth secondary angle of 30 degrees or less.

(12) In some implementations, the third secondary angle is 15 degrees, the fourth secondary angle is 15 degrees, the fifth secondary angle is 15 degrees, and the sixth secondary angle is 15 degrees.

(13) In some implementations, the axes of the third opening and the fourth opening intersect the anchor plane at a first point that is closer to the second surface than to the first surface. The axes of the fifth opening and the sixth opening intersect the anchor plane at a second point that is closer to the second surface than to the first surface.

(14) In some implementations, the plurality of openings further includes a seventh opening, an eighth opening. The seventh opening and the eighth opening at least partially overlap at the first surface, and the axis of the seventh opening is transverse to the axis of the eighth opening.

- (15) In some implementations, the seventh opening and the eighth opening are configured such that a first anchor is disposable within the seventh opening and a second anchor is disposable within the eighth opening simultaneously.
- (16) In some implementations, the axis of the seventh opening and the axis of the eighth opening extend parallel to the anchor plane, wherein the axis of the seventh opening is disposed at a 45 degree angle relative to the second surface of the body. The axis of the eighth opening is disposed at a 45 degree angle relative to the second surface of the body and at a 90 degree angle relative to the axis of the seventh opening.
- (17) In some implementations, the implant includes an anti-backout device coupled to the first surface of the body, wherein the anti-backout device is positionable to cover a portion of at least the first opening and the second opening.
- (18) In some implementations, the implant includes an interbody device.
- (19) In some implementations, the body includes a molybdenum-rhenium (MoRe) alloy.
- (20) In some implementations, the MoRe alloy is Mo47.5Re.
- (21) In some implementations, the body includes at least 40 weight percent rhenium (Re).
- (22) In some implementations, the body includes a titanium-molybdenum (TiMo) alloy.
- (23) In some implementations, the body comprises a cobalt-chromium (CoCr) alloy.
- (24) In some implementations, the body comprises a titanium (Ti) alloy.
- (25) In some implementations, the body comprises polyether ether ketone (“PEEK”).
- (26) In some implementations, the body defines a plurality of micro-apertures having an average size between about 2 to about 10 micrometers (μm) and a plurality of macro-apertures having an average size between about 300 to about 800 micrometers (μm).
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Description

BRIEF DESCRIPTION OF DRAWINGS

- (1) Example features and implementations are disclosed in the accompanying drawings. However, the present disclosure is not limited to the precise arrangements and instrumentalities shown.
- (2) FIG. 1 is a rear perspective view of the implant.
- (3) FIG. 2 is a front view of the implant of FIG. 1.
- (4) FIG. 3 is a side view of the implant of FIG. 1.
- (5) FIG. 4 is a front perspective view of the implant of FIG. 1 without screws
- (6) FIG. 5 is a cross-sectional view of the implant of FIG. 1 along line A-A.
- (7) FIG. 6 is a front perspective view of an implant, according to another implementation.
- (8) FIG. 7 is a rear perspective view of the implant of FIG. 6.
- (9) FIG. 8 is a front perspective view of the implant of FIG. 6 with the anti-backout device removed.
- (10) FIG. 9 is a front view of the implant of FIG. 6 without screws.

DETAILED DESCRIPTION

- (11) The devices, systems, and methods disclosed herein provide for an implantable interbody device that can be implanted between adjacent vertebrae in the lumbar region of the spine to promote fusion of the vertebrae. The implant includes a plurality of anchor openings at different angles to allow a surgent to determine the optimal anchor location in each case. By partially overlapping the anchor openings of the implant, the implant is able to include more anchor openings to provide more anchoring options.
- (12) Various implementations include an implant. The implant includes a body defining a central opening. The body has a first surface and a second surface spaced apart and opposite from the first surface. The second surface at least partially defines the central opening. The first surface defines a plurality of openings including a first opening and a second opening. Each of the openings extends

along an axis from the first surface to the second surface. The first opening and the second opening at least partially overlap at the first surface, and the axis of the first opening is transverse to the axis of the second opening.

(13) FIGS. **1-6** show an implant **100** according to one implementation. The implant **100** includes a body **110**, a plurality of anchors **199**, a first anti-backout device, and a second anti-backout device. The body **110** is a toroidal shape that defines a central opening **112** to promote bone growth. The body **110** has an inner surface **116** defining the central opening **112**, an outer surface **114** opposite and spaced apart from the inner surface **116**, a superior surface **120** extending between the inner surface **116** and the outer surface **114**, and an inferior surface **122** opposite and spaced apart from the superior surface **120**. A portion of the outer surface **114** includes a first surface **124**, and a portion of the inner surface **116** includes a second surface **126** spaced apart and opposite from the first surface **124**.

(14) The first surface **124** and the second surface **126** each have a width as measured between the superior surface **120** and the inferior surface **122**. The first surface **124** has a width that is greater than the width of the second surface **126** such that the superior surface **120** and the inferior surface **122** form a lordosis angle relative to each other that corresponds with a lordosis angle of the adjacent vertebrae between which the device will be implanted. The lordosis angle of the implant **100** shown in FIGS. **1-9** is 12 degrees, but in other implementations, the lordosis angle is 5 degrees, 20 degrees, or any other angle from 0 degrees to 30 degrees.

(15) The superior surface **120** and inferior surface **122** of the body **110** shown in FIG. **1** define a plurality of micro-apertures **130** and macro-apertures to allow bone growth into the body **110**. Example micro-apertures **130** are shown in detail in FIG. **1**. The micro-apertures **130** are configured to promote on-growth of bone. For example, micro-apertures **130** have an average size of about 6 micrometers (μm). The micro-apertures **130** create channels through which bone can grow to facilitate spinal fusion. It should be understood that material (e.g., bone fusion material), cells, tissue, and/or fluid can flow through the micro-apertures **130**, which facilitates on-growth of bone. In some implementations, the micro-apertures **130** are homogeneous. In other implementations, the micro-apertures **130** have varying sizes and/or shapes (with the average size falling between about 2 μm to about 10 μm). The micro-apertures **130** can optionally be patterned and/or randomly located on the superior surface **120** and inferior surface **122** of the body **110**.

(16) The superior surface **120** and inferior surface **122** of the body **110** also include a plurality of macro-apertures **132**. Example macro-apertures **132** are shown in detail in FIG. **1**. The macro-apertures **132** are configured to promote through-growth of bone. For example, macroapertures **112B** have an average size of about 500 μm . The macro-apertures **132** create channels through which bone can grow to facilitate spinal fusion. It should be understood that material (e.g., bone fusion material), cells, tissue, and/or fluid can flow through the macro-apertures **132**, which facilitates through-growth of bone. In some implementations, the macro-apertures **132** are homogeneous. In other implementations, the macro-apertures **132** have varying sizes and/or shapes (with the average size falling between about 300 μm to about 800 μm). The macro-apertures **132** can optionally be patterned and/or randomly located on the superior surface **120** and inferior surface **122** of the body **110**.

(17) In some implementations, the micro- and/or macro-apertures **130**, **132** can be provided such that the implant **100** has a stiffness equal to or greater than cancellous bone. Alternatively or additionally, the interbody device **100** can optionally have a composite porosity of 75-85% with 300-800 μm pores and 2-10% porosity with 10-50 μm pores. For comparison, cancellous bone has 75-85% porosity with 300-600 μm pores and cortical bone has 5-10% porosity with 10-50 μm pores. By including micro- and macro-apertures **132**, **112B**, highly porous contacting superior surfaces **120** and inferior surfaces **122** are provided. Such porous superior surfaces **120** and inferior surfaces **122** facilitate spinal fusion. Porosity is achieved by providing a plurality of apertures (i.e., both micro- and macro-apertures **130**, **132**) that connect the superior surface **120** and inferior

surface **122**. As described below, the micro- and macro-apertures **130**, **132** can be manufactured using a chemical etching process.

(18) The body **110** includes Mo47.5Re molybdenum-rhenium (MoRe) alloy. But in some implementations, the body **110** includes any molybdenum-rhenium (MoRe) alloy. In other implementations, the body **110** includes any material that includes 40 weight percent rhenium (Re). In other implementations, the body includes polyether ether ketone (“PEEK”), but in other implementations, the body can include any other polymer suitable. In other implementations, the body includes material that includes titanium-molybdenum (TiMo) alloy, cobalt-chromium (CoCr) alloy, titanium (Ti) alloy, or any other material suitable for implantation in a human body. The body **110**, **210** shown in FIGS. **1-9** is sized to be disposed between adjacent vertebrae of the lumbar region of the spine, but in other implementations, the body is sized to be disposed between adjacent vertebrae of the cervical spine.

(19) FIGS. **1-5** show the first surface **124** defining a first opening **140**, a second opening **144**, a third opening **150**, a fourth opening **154**, a fifth opening, and a sixth opening. Each of the openings extends along a separate axis from the first surface **124** to the second surface **126**. Each of the openings is sized to receive a screw **199** and is countersunk to receive a screw head.

(20) Each of the openings partially overlap with another of the openings at the first surface **124**. For example, in FIGS. **1-5**, the first opening **140** and the second opening **144** at least partially overlap at the first surface **124**, the third opening **150** and the fourth opening **154** at least partially overlap at the first surface **124**, and the fifth opening **160** and the sixth opening **164** at least partially overlap at the first surface **124**.

(21) The first surface **124** of the body **110** includes an alignment axis **180** that extends longitudinally along the first surface **124** and runs centrally between sets of overlapping openings on the first surface **124**. Specifically, an intersection point of the axis **142** of the first opening **140** with the first surface **124** and an intersection point of the axis **146** of the second opening **144** with the first surface **124** are equally spaced on opposite sides of the alignment axis **180** from each other. Similarly, an intersection point of the axis **152** of the third opening **150** with the first surface **124** and an intersection point of the axis **156** of the fourth opening **154** with the first surface are equally spaced on opposite sides of the alignment axis **180** from each other. Furthermore, an intersection point of the axis **162** of the fifth opening **160** with the first surface **124** and an intersection point of the axis **166** of the sixth opening **164** with the first surface **124** are equally spaced on opposite sides of the alignment axis **180** from each other.

(22) Although the implementations shown in FIGS. **1-5** show that the intersection point of the axis **142** of the first opening **140** with the first surface **124** and the intersection point of the axis **146** of the second opening **144** with the first surface **124** are equally spaced on opposite sides of the alignment axis **180** from each other, in other implementations, the first opening **140** is a different distance from the alignment axis **180** than the second opening **144**.

(23) Although the implementations shown in FIGS. **1-5** show that the intersection point of the axis **152** of the third opening **150** with the first surface **124** and the intersection point of the axis **156** of the fourth opening **154** with the first surface **124** are equally spaced on opposite sides of the alignment axis **180** from each other, in other implementations, the third opening **150** is a different distance from the alignment axis than the fourth opening **154**.

(24) Although the implementations shown in FIGS. **1-5** show that the intersection point of the axis **162** of the fifth opening **160** with the first surface **124** and the intersection point of the axis **166** of the sixth opening **164** with the first surface **124** are equally spaced on opposite sides of the alignment axis **180** from each other, in other implementations, the fifth opening **160** is a different distance from the alignment axis **180** than the sixth opening **164**.

(25) The axis of each opening **142**, **144**, **146**, **148**, **150**, **152** is angled relative to the second surface **126** to provide a surgeon with a plurality of angles through which the anchor **199** can be disposed. The axis **142** of the first opening **140** extends from the first surface **124** to the second surface **126**

in a superior direction, and the axis **146** of the second opening **144** extends between the first surface **124** and the second surface **126** in an inferior direction. The axes **142**, **146** of the first opening **140** and the second opening **144** define an anchor plane **182** that is perpendicular to the alignment axis **180**.

(26) The axis **142** of the first opening **140** is disposed at a first primary angle of 45 degrees relative to the second surface **126** of the body **110**. The axis **146** of the second opening **144** is disposed at a second primary angle of 45 degrees relative to the second surface **126** of the body **110** and transverse to the axis **142** of the first opening **140**.

(27) A projection of the axis **148** of the third opening **150** onto the anchor plane **182** is disposed at a third primary angle of 30 degrees relative to the second surface **126** of the body **110** toward the superior surface **120**. A projection of the axis **156** of the fourth opening **154** onto the anchor plane **182** is disposed at a fourth primary angle of 30 degrees relative to the second surface **126** of the body **110** and transverse to the projection of the axis **152** of the third opening **150** onto the anchor plane **182**.

(28) A projection of the axis **162** of the fifth opening **160** onto the anchor plane **182** is disposed at a fifth primary angle of 30 degrees relative to the second surface **126** of the body **110** toward the superior surface **120**. A projection of the axis **166** of the sixth opening **164** onto the anchor plane **182** is disposed at a sixth primary angle of 30 degrees relative to the second surface **126** of the body **110** and transverse to the projection of the axis **162** of the fifth opening **160** onto the anchor plane **182**.

(29) The third opening **150**, fourth opening **154**, fifth opening **160**, and sixth openings **164** are also angled inwardly toward the anchor plane **182**. The axis **152** of the third opening **150** intersects the anchor plane **182** at a third secondary angle of 15 degrees, and the axis **156** of the fourth opening **154** intersects the anchor plane **182** at a fourth secondary angle of 15 degrees. The axes of the third opening **150** and the fourth opening **154** intersect the anchor plane **182** at a first point that is closer to the second surface **126** than to the first surface **124** such that the axes of the third opening **150** and the fourth opening **154** are angled inwardly. The axis **162** of the fifth opening **160** intersects the anchor plane **182** at a fifth secondary angle of 15 degrees or less, and the axis of the sixth opening **164** intersects the anchor plane **182** at a sixth secondary angle of 15 degrees. The axes **162**, **166** of the fifth opening **160** and the sixth opening **164** intersect the anchor plane **182** at a second point that is closer to the second surface **126** than to the first surface **124** such that the axes of the fifth opening **160** and the sixth opening **164** are angled inwardly.

(30) Although the axes of each of the openings are oriented at specific primary angles in FIGS. 1-5, in some implementations, each of the first, second, third, fourth, fifth, and sixth primary angles are any angle from 15 degrees to 60 degrees.

(31) Although the axes of the third opening **150** and the fourth opening **154** of the implant **100** shown in FIGS. 1-9 intersect the anchor plane **182** at a first point that is closer to the second surface **126** than to the first surface **124**, in some implementations, the first point is closer to the first surface **124** than to the second surface **126** such that one or both of the axes of the third opening **150** and the fourth opening **154** are angled outwardly. In some implementations, one or both of the axes of the third opening **150** and the fourth opening **154** extend parallel to the anchor plane **182**. Although the axes **162**, **166** of the fifth opening **160** and the sixth opening **164** of the implant **100** shown in FIGS. 1-9 intersect the anchor plane **182** at a second point that is closer to the second surface **126** than to the first surface **124**, in some implementations, the second point is closer to the first surface **124** than to the second surface **126** such that one or both of the axes of the fifth opening **160** and the sixth opening **164** are angled outwardly. In some implementations, one or both of the axes **162**, **166** of the fifth opening **160** and the sixth opening **164** extend parallel to the anchor plane **182**.

(32) Although the body **110** of the implant **100** shown in FIGS. 1-9 defines six openings, in some implementations, the implant **100** has any number of two or more openings. For example, an

implant **200** is shown in the implementation shown in FIGS. **6-9**, where the plurality of openings defined by the body **210** further includes a seventh opening **270** and an eighth opening **274**. Like the first opening **240** and the second opening **244**, the seventh opening **270** and the eighth opening **274** at least partially overlap at the first surface **224** and are configured such that a first anchor **299** is disposable within the seventh opening **270** and a second anchor **299** is disposable within the eighth opening **274** simultaneously.

(33) The axis **272** of the seventh opening **270** is transverse to the axis **276** of the eighth opening **274**, and the axes of the seventh opening **270** and eighth opening **274** extend parallel to the anchor plane **282**. The axis **272** of the seventh opening **270** is disposed at a 45 degree angle relative to the second surface **226** of the body **210**, and the axis **276** of the eighth opening **274** is disposed at a 45 degree angle relative to the second surface **126** of the body **210**. But in other implementations, the seventh opening **270** and the eighth opening **274** can be disposed at any angle between 15 and 60 degrees relative to the second surface **126** of the body **210**. And, the eighth opening **274** can be disposed at any angle relative to the axis **272** of the seventh opening **270**.

(34) Although anchors **199**, **299** shown in FIGS. **1-9** are inserted through the first surface **124**, **224** and the second surface **126**, in some implementations, any portion of the outer surface of the body defines anchor openings for receiving screws or other types of anchors and the openings extend to the opposite portion of the inner surface.

(35) In the implementation shown in FIGS. **1-3** and **6-8**, the openings of the device are configured to accept bi-directional bone screws **199**, **299**. But, in other implementations, the openings are configured to accept single direction screws, blades, or any other fastener or anchor suitable to couple an implant to a spinal column.

(36) FIGS. **1-3** show that a first anchor **199** is disposable within the first opening **140**, and a second anchor **199** is disposable within the second opening, simultaneously. FIGS. **6-8** show that a third anchor **199** is disposable within the seventh opening **270**, and a fourth anchor **199** is disposable within the eighth opening **274**, simultaneously. Because of the spacing of the third opening **150** and the fourth opening **154**, and the spacing of the fifth opening **160** and the sixth opening **164**, only one anchor **199** is disposable within one of the third opening **150** and the fourth opening **154** at a time, and only one anchor **199** is disposable within one of the fifth opening **160** and the sixth opening **164** at a time. However, in other implementations, the third and fourth openings **150**, **154** are configured to each receive an anchor **199** simultaneously, the fourth and fifth openings **154**, **160** are configured to each receive an anchor **199** simultaneously, or both.

(37) FIGS. **1-3** show an implementation that includes a first anti-backout device **190** and a second anti-backout device **190'** coupled to the first surface **124** of the body. The anti-backout devices are positionable to cover a portion of at least the first opening **140**, the second opening, the third opening **150**, and the fourth opening **154**. The second anti-backout device is positionable to cover a portion of the fifth opening **160** and the sixth opening **164**. The anti-backout devices **190**, **190'** each have an anti-backout body **196**, **196'**. The first anti-backout device **190** has two locking tabs **194** extending radially from the anti-backout body **196**. The second anti-backout device **190'** has one locking tab **194'** extending radially from the anti-backout body **196'**. The anti-backout bodies **196**, **196'** are rotatably coupled to the first surface **124**, and the anti-backout devices **190**, **190'** are rotatable relative to the first surface **124** from a first position (not shown) to a second position (shown in FIGS. **1-3**). The locking tabs **194**, **194'** are structured such that, when the anti-backout devices **190**, **190'** are in the first position, none of the locking tabs **194**, **194'** are covering any portion of the first, second, third, fourth, fifth, or sixth openings **140**, **144**, **150**, **154**, **160**, **164**. After each anti-backout device **190**, **190'** has been rotated from the first position to the second position, each of the locking tabs **194**, **194'** is at least partially covering one of the six openings **140**, **144**, **150**, **154**, **160**, **164** such that the locking tabs **194**, **194'** are in a position to prevent the fasteners **150** disposed in each of the openings **130**, **140**, **144**, **150**, **154**, **160**, **164** from coming out of the fastener's **150** respective opening **130**, **140**, **144**, **150**, **154**, **160**, **164** (also called "backing out").

(38) FIGS. 6-7 show another implementation of an anti-backout device **290** coupled to the first surface **124** of the body **210**. The anti-backout device **290** is positioned onto the first surface **224** such that the anti-backout device **290** at least partially overlaps with each of the eight openings **240, 244, 250, 254, 260, 264**. The anti-backout device **290** has an anti-backout body **296** and two locking tabs **294** extending radially from the body **292**. The anti-backout device defines a first fastening hole **292**, and the first surface **224** of the body defines a second fastening hole **293**. A screw **299** extends through the first opening **240** and the second opening **244** to couple the anti-backout device to the first surface **224**. When the anti-backout device is coupled to the first surface **224** of the body **210**, each of the locking tabs **294** is at least partially covering each of the eight openings **240, 244, 250, 254, 260, 264, 270, 274** such that the locking tabs **294** are in a position to prevent the fasteners **150** disposed in each of the eight fastener openings **240, 244, 250, 254, 260, 264, 270, 274** from backing out.

(39) During an implanting procedure, the surgeon selects an implant **100** with a specific lordosis angle to compliment the curvature of the patient's spine where the implant will be inserted. The implant **100** is inserted between two adjacent lumbar vertebrae (L1-S1) from anterior to posterior of the patient such that the second surface **126** faces toward the posterior of the patient and the superior surface **120** faces the head of the patient.

(40) Once the implant **100** is disposed between the adjacent vertebrae, screws **199** are inserted through the openings of the implant **100** and secured into selected sections of the spine. A surgeon observing the spine of the patient identifies any existing hardware or conditions in the patient's spine and determines which openings of the implant **100** to use for coupling the implant **100** to the vertebrae. The multiple openings extending at various angles provides the surgeon with multiple options for anchor points in the spine. At least a first anchor **199** is inserted through one of the first, third, or fifth opening **160** s to couple the implant **100** to the superior vertebrae, and at least a second anchor **199** is inserted through one of the second, fourth, or sixth openings **144, 154, 164** to couple the implant **100** to the inferior vertebrae. Third and fourth anchors **199** can be inserted into the remaining openings to further secure the implant **100** to the superior and inferior vertebrae. The screws **199** are advanced into the spine until the screw heads no longer protrude from the first surface **124**.

(41) The anti-backout device(s) are secured into place to prevent the screws **199** from backing out. The anti-backout devices shown in FIGS. 1-3 are secured by rotating the anti-backout devices such that a portion of each kicking tab **194, 194'** overlaps with each of the openings. If a device including the anti-backout device shown in FIGS. 6-7 is being used, then the anti-backout device is positioned onto the first surface **224** such that the anti-backout device at least partially overlaps with each of the eight openings. A bolt **298** is then inserted through the fastening hole **292** in the anti-backout device **290** and into a second fastener opening **293** in the body **210** of the implant **100** device to couple the anti-backout device to the body **210**.

(42) A number of implementations have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the claims. Accordingly, other implementations are within the scope of the following claims.

(43) Certain terminology is used herein for convenience only and is not to be taken as a limitation on the present claims. In the drawings, the same reference numbers are employed for designating the same elements throughout the several figures. A number of examples are provided, nevertheless, it will be understood that various modifications can be made without departing from the spirit and scope of the disclosure herein. As used in the specification, and in the appended claims, the singular forms "a," "an," "the" include plural referents unless the context clearly dictates otherwise. The term "comprising" and variations thereof as used herein is used synonymously with the term "including" and variations thereof and are open, non-limiting terms. Although the terms "comprising" and "including" have been used herein to describe various implementations, the terms "consisting essentially of" and "consisting of" can be used in place of

“comprising” and “including” to provide for more specific implementations and are also disclosed. (44) Disclosed are materials, systems, devices, methods, compositions, and components that can be used for, can be used in conjunction with, can be used in preparation for, or are products of the disclosed methods, systems, and devices. These and other components are disclosed herein, and it is understood that when combinations, subsets, interactions, groups, etc. of these components are disclosed that while specific reference of each various individual and collective combinations and permutations of these components may not be explicitly disclosed, each is specifically contemplated and described herein. For example, if a device is disclosed and discussed each and every combination and permutation of the device, and the modifications that are possible are specifically contemplated unless specifically indicated to the contrary. Likewise, any subset or combination of these is also specifically contemplated and disclosed. This concept applies to all aspects of this disclosure including, but not limited to, steps in methods using the disclosed systems or devices. Thus, if there are a variety of additional steps that can be performed, it is understood that each of these additional steps can be performed with any specific method steps or combination of method steps of the disclosed methods, and that each such combination or subset of combinations is specifically contemplated and should be considered disclosed.

Claims

1. An implant comprising a body defining a central opening; said body has a first surface and a second surface spaced apart and opposite from the first surface; said second surface at least partially defines said central opening; said first surface defines a plurality of openings including a first opening, a second opening, a third opening, a fourth opening, a fifth opening and a sixth opening; each of said openings extends along an axis from said first surface to said second surface; said first opening and said second opening at least partially overlap at said first surface; said axis of said first opening is non-parallel to said axis of said second opening; said third opening and said fourth opening at least partially overlap at said first surface; said axis of said third opening is non-parallel to said axis of said fourth opening; said fifth opening and said sixth opening at least partially overlap at said first surface; said axis of said fifth opening is non-parallel to said axis of said sixth opening.
2. The implant as defined in claim 1, wherein said axis of said first opening is transverse to said axis of said second opening.
3. The implant as defined in claim 2, wherein said axis of said third opening is transverse to said axis of said fourth opening.
4. The implant as defined in claim 2, wherein said axis of said fifth opening is transverse to said axis of said sixth opening.
5. The implant as defined in claim 4, wherein said first surface of said body further includes an alignment axis; an intersection point of said axis of said first opening with said first surface and an intersection point of said axis of said second opening with said first surface are equally spaced on opposite sides of said alignment axis from each other; an intersection point of said axis of said third opening with said first surface and an intersection point of said axis of said fourth opening with said first surface are equally spaced on opposite sides of said alignment axis from each other.
6. The implant as defined in claim 5, further comprising an anti-backout device coupled to said first surface of said body; said anti-backout device is configured to be positionable to cover a portion of at least one of said first, second, third or fourth openings.
7. The implant as defined in claim 6, wherein said implant comprises an interbody device.
8. The implant as defined in claim 7, wherein said body is at least partially formed of one or more materials selected from the group consisting of molybdenum-rhenium (MoRe) alloy, titanium-molybdenum (TiMo) alloy, titanium (Ti) alloy, and polyether ether ketone (“PEEK”).
9. The implant as defined in claim 8, wherein said body includes a plurality of micro-apertures and

a plurality of macro-apertures; each of said micro-apertures has an average size of 2-10 micrometers (μm); each of said macro-apertures has an average size of 300-800 micrometers (μm).

10. The implant as defined in claim 1, wherein said axis of said third opening is transverse to said axis of said fourth opening.

11. The implant as defined in claim 1, wherein said axis of said fifth opening is transverse to said axis of said sixth opening.

12. The implant as defined in claim 1, wherein said first surface of said body further includes an alignment axis; an intersection point of said axis of said first opening with said first surface and an intersection point of said axis of said second opening with said first surface are equally spaced on opposite sides of said alignment axis from each other; an intersection point of said axis of said third opening with said first surface and an intersection point of said axis of said fourth opening with said first surface are equally spaced on opposite sides of said alignment axis from each other.

13. The implant as defined in claim 1, further comprising an anti-backout device coupled to said first surface of said body; said anti-backout device is configured to be positionable to cover a portion of at least one of said first, second, third or fourth openings.

14. The implant as defined in claim 1, wherein said implant comprises an interbody device.

15. The implant as defined in claim 1, wherein said body is at least partially formed of one or more materials selected from the group consisting of molybdenum-rhenium (MoRe) alloy, titanium-molybdenum (TiMo) alloy, titanium (Ti) alloy, and polyether ether ketone ("PEEK").

16. The implant as defined in claim 1, wherein said body includes a plurality of micro-apertures and a plurality of macro-apertures; each of said micro-apertures has an average size of 2-10 micrometers (μm); each of said macro-apertures has an average size of 300-800 micrometers (μm).

17. An interbody device comprising a body defining a central opening; said body having a first surface and a second surface spaced apart and opposite from said first surface; said first surface includes first, second third and fourth sides; said second surface at least partially defines said central opening; said first side of said first surface includes a first opening, a second opening, a third opening, a fourth opening, a fifth opening and a sixth opening; each of said first, second, third, fourth, fifth and sixth openings extends along an axis from said first surface to said second surface; said first opening and said second opening at least partially overlap at said first surface; said axis of said first opening is non-parallel to said axis of said second opening; said third opening and the fourth opening at least partially overlap at said first surface; said axis of said third opening is non-parallel to said axis of said fourth opening; said first surface of said body further includes an alignment axis; an intersection point of said axis of said first opening with said first surface and an intersection point of said axis of said second opening with said first surface are equally spaced on opposite sides of said alignment axis from each other; an intersection point of said axis of said third opening with said first surface and an intersection point of said axis of said fourth opening with said first surface are equally spaced on opposite sides of said alignment axis from each; said fifth opening and said sixth opening at least partially overlap at said first surface; said axis of said fifth opening is non-parallel to said axis of said sixth opening.

18. The interbody device as defined in claim 17, wherein said axis of said first opening is transverse to said axis of said second opening.

19. The interbody device as defined in claim 18, wherein said axis of said third opening is transverse to said axis of said fourth opening.

20. The interbody device as defined in claim 19, wherein said axis of said fifth opening is transverse to said axis of said sixth opening.

21. The interbody device as defined in claim 20, wherein an intersection point of said axis of said fifth opening with said first surface and an intersection point of said axis of said sixth opening with said first surface are equally spaced on opposite sides of said alignment axis from each other.

22. The interbody device as defined in claim 21, further comprising an anti-backout device coupled to said first surface of said body; said anti-backout device is configured to be positionable to cover

a portion of at least one of said first, second, third or fourth openings.

23. The interbody device as defined in claim 22, wherein said body is at least partially formed of one or more materials selected from the group consisting of molybdenum-rhenium (MoRe) alloy, titanium-molybdenum (TiMo) alloy, titanium (Ti) alloy, and polyether ether ketone ("PEEK").

24. The interbody device as defined in claim 23, wherein said body includes a plurality of micro-apertures and a plurality of macro-apertures; each of said micro-apertures has an average size of 2-10 micrometers (μm); each of said macro-apertures has an average size of 300-800 micrometers (μm).

25. The interbody device as defined in claim 17, wherein said axis of said third opening is transverse to said axis of said fourth opening.

26. The interbody device as defined in claim 17, wherein said axis of said fifth opening is transverse to said axis of said sixth opening.

27. The interbody device as defined in claim 26, wherein an intersection point of said axis of said fifth opening with said first surface and an intersection point of said axis of said sixth opening with said first surface are equally spaced on opposite sides of said alignment axis from each other.

28. The interbody device as defined in claim 17, further comprising an anti-backout device coupled to said first surface of said body; said anti-backout device is configured to be positionable to cover a portion of at least one of said first, second, third or fourth openings.

29. The interbody device as defined in claim 17, wherein said body is at least partially formed of one or more materials selected from the group consisting of molybdenum-rhenium (MoRe) alloy, titanium-molybdenum (TiMo) alloy, titanium (Ti) alloy, and polyether ether ketone ("PEEK").

30. The interbody device as defined in claim 17, wherein said body includes a plurality of micro-apertures and a plurality of macro-apertures; each of said micro-apertures has an average size of 2-10 micrometers (μm); each of said macro-apertures has an average size of 300-800 micrometers (μm).
