United States Patent	12390339
Kind Code	B2
Date of Patent	August 19, 2025
Inventor(s)	Perloff; Jonathan et al.

Expandable interbody spacer

Abstract

Devices and methods for treating one or more damaged, diseased, or traumatized portions of the spine, including intervertebral discs, to reduce or eliminate associated back pain. In one or more embodiments, the present invention relates to an expandable interbody spacer. The expandable interbody spacer may comprise a first jointed arm comprising a plurality of links pivotally coupled end to end. The expandable interbody spacer further may comprise a second jointed arm comprising a plurality of links pivotally coupled end to end. The first jointed arm and the second jointed arm may be interconnected at a proximal end of the expandable interbody spacer. The first jointed arm and the second jointed arm may be interconnected at a distal end of the expandable interbody spacer.

Inventors: **Perloff; Jonathan (Slatington, PA), Rhoda; William (Media, PA), Weiman; Mark (Downingtown, PA), Glerum; Chad (Pennsburg, PA), Dwyer; Edward (Lehighton, PA), Alexander; Victoria (Royersford, PA), Garvey; Brian (Media, PA), Waite; Daniel (Pottstown, PA), Fleming; Conor (Media, PA), Petersheim; Samuel (Elverson, PA), Howell; Bria (Philadelphia, PA), Niemiec; Marcin (Norristown, PA), Kunjachan; Vipin (Norristown, PA), Gray; Jason (East Greenville, PA), Saville; Christopher (Morgantown, PA), Himmelberger; James (Souderton, PA), Gahman; Kevin (Douglassville, PA)**

Applicant: **GLOBUS MEDICAL, INC.** (Audubon, PA)

Family ID: **1000008766395**

Assignee: **Globus Medical Inc. (Audubon, PA)**

Appl. No.: **18/158533**

Filed: **January 24, 2023**

Prior Publication Data

Document Identifier	Publication Date
US 20230157836 A1	May. 25, 2023

Related U.S. Application Data

continuation parent-doc US 16660174 20191022 US 11583409 child-doc US 18158533
continuation parent-doc US 15264677 20160914 US 10485674 20191126 child-doc US 16660174
continuation parent-doc US 13941095 20130712 US 9480573 20161101 child-doc US 15264677
continuation-in-part parent-doc US 13483852 20120530 US 9044342 20150602 child-doc US 13941095

Publication Classification

Int. Cl.: **A61F2/44** (20060101); **A61B17/70** (20060101); **A61F2/46** (20060101); A61F2/28 (20060101); A61F2/30 (20060101)

U.S. Cl.:

CPC **A61F2/4425** (20130101); **A61B17/7097** (20130101); **A61F2/442** (20130101); **A61F2/4455** (20130101); **A61F2/447** (20130101); **A61F2/4611** (20130101); A61F2002/2835 (20130101); A61F2002/30108 (20130101); A61F2002/30143 (20130101); A61F2002/30156 (20130101); A61F2002/30159 (20130101); A61F2002/30166 (20130101); A61F2002/30176 (20130101); A61F2002/30189 (20130101); A61F2002/30266 (20130101); A61F2002/30364 (20130101); A61F2002/30365 (20130101); A61F2002/3037 (20130101); A61F2002/30405 (20130101); A61F2002/30433 (20130101); A61F2002/30462 (20130101); A61F2002/30471 (20130101); A61F2002/30484 (20130101); A61F2002/30492 (20130101); A61F2002/305 (20130101); A61F2002/30507 (20130101); A61F2002/30515 (20130101); A61F2002/30518 (20130101); A61F2002/30525 (20130101); A61F2002/3054 (20130101); A61F2002/30545 (20130101); A61F2002/3055 (20130101); A61F2002/30579 (20130101); A61F2002/30581 (20130101); A61F2002/30588 (20130101); A61F2002/30593 (20130101); A61F2002/30624 (20130101); A61F2002/30772 (20130101); A61F2002/30836 (20130101); A61F2002/30892 (20130101); A61F2002/30904 (20130101); A61F2/44 (20130101); A61F2002/4415 (20130101); A61F2002/4627 (20130101); A61F2002/4677 (20130101); A61F2310/00017 (20130101); A61F2310/00023 (20130101); A61F2310/00179 (20130101)

Field of Classification Search

CPC: A61F (2/44); A61F (2/442); A61F (2/4425); A61F (2/447); A61F (2/46); A61F (2/4611); A61B (17/70); A61B (17/7097)

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Primary Examiner: Beccia; Christopher J

Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS (1) This patent application is a continuation of U.S. patent application Ser. No. 16/660,174 filed on Oct. 22, 2019 which is a continuation of U.S. patent application Ser. No. 15/264,677, filed Sep. 14, 2016, which is a continuation of U.S. patent application Ser. No. 13/941,095, filed Jul. 12, 2013, which is a continuation-in-part application of U.S. patent application Ser. No. 13/483,852, filed May 30, 2012, now U.S. Pat. No. 9,044,342, which are incorporated by reference herein in their entireties for all purposes.

FIELD OF THE INVENTION

(1) The present invention relates to devices and methods for treating one or more damaged, diseased, or traumatized portions of the spine, including intervertebral discs, to reduce or eliminate associated back pain. In one or more embodiments, the present invention relates to an expandable interbody spacer.

BACKGROUND OF THE INVENTION

(2) The vertebrate spine is the axis of the skeleton providing structural support for the other body parts. In humans, the normal spine has seven cervical, twelve thoracic and five lumbar segments. The lumbar spine sits upon the sacrum, which then attaches to the pelvis, and in turn is supported by the hip and leg bones. The bony vertebral bodies of the spine are separated by intervertebral discs, which act as joints but allow known degrees of flexion, extension, lateral bending, and axial rotation.

(3) The typical vertebra has a thick anterior bone mass called the vertebral body, with a neural (vertebral) arch that arises from the posterior surface of the vertebral body. The centers of adjacent vertebrae are supported by intervertebral discs. Each neural arch combines with the posterior surface of the vertebral body and encloses a vertebral foramen. The vertebral foramina of adjacent vertebrae are aligned to form a vertebral canal, through which the spinal sac, cord and nerve rootlets pass. The portion of the neural arch which extends posteriorly and acts to protect the spinal cord's posterior side is known as the lamina. Projecting from the posterior region of the neural arch is the spinous process.

(4) The intervertebral disc primarily serves as a mechanical cushion permitting controlled motion between vertebral segments of the axial skeleton. The normal disc is a unique, mixed structure, comprised of three component tissues: the nucleus pulpous (“nucleus”), the annulus fibrosus (“annulus”) and two vertebral end plates. The two vertebral end plates are composed of thin cartilage overlying a thin layer of hard, cortical bone which attaches to the spongy, richly vascular, cancellous bone of the vertebral body. The end plates thus act to attach adjacent vertebrae to the disc.

(5) The spinal disc and/or vertebral bodies may be displaced or damaged due to trauma, disease, degenerative defects, or wear over an extended period of time. One result of this displacement or damage to a spinal disc or vertebral body may be chronic back pain. A common procedure for treating damage or disease of the spinal disc or vertebral body may involve partial or complete removal of an intervertebral disc. An implant, which may be referred to as an interbody spacer, can be inserted into the cavity created where the intervertebral disc was removed to help maintain height of the spine and/or restore stability to the spine. An example of an interbody spacer that has been commonly used is a cage, which typically is packed with bone and/or bone-growth-inducing materials. However, there are drawbacks associated with conventional interbody spacers, such as cages and other designs. For instances, conventional interbody spacers may be too large and bulky for introduction into the disc space in a minimally invasive manner, such as may be utilized in a posterior approach. Further, these conventional interbody spacers may have inadequate surface area contact with the adjacent endplates if sized for introduction into the disc space in a minimally invasive manner. In addition, conventional interbody spacers designed for introduction into the disc space in a minimally invasive manner may lack sufficient space for packing of bone-growth-inducing material, thus potentially not promoting the desired graft between the adjacent endplates.

(6) Therefore, a need exists for an interbody spacer that can be introduced in a minimally manner that provides a desired amount of surface area contact with the adjacent endplates and has an increased space for packing of bone-growth-inducing material.

SUMMARY OF THE INVENTION

(7) The present invention relates to an expandable interbody spacer. The expandable interbody spacer may comprise a first jointed arm comprising a plurality of links pivotally coupled end to end. The expandable interbody spacer further may comprise a second jointed arm comprising a plurality of links pivotally coupled end to end. The first jointed arm and the second jointed arm may be interconnected at a proximal end of the expandable interbody spacer. The first jointed arm and the second jointed arm may be interconnected at a distal end of the expandable interbody spacer. The first jointed arm and the second jointed arm may each be configured to fold inward in opposite directions to place the expandable interbody spacer in an expanded position.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) The present invention will be more readily understood with reference to the embodiments thereof illustrated in the attached drawing figures, in which:

(2) FIG. **1** is a top view of an expandable interbody spacer shown in a collapsed position in accordance with embodiments of the present invention;

(3) FIG. **2** is a side view of the expandable interbody spacer of FIG. **1** shown in a collapsed position;

(4) FIG. **3** is a proximal end view of the expandable interbody spacer of FIG. **1** shown in a collapsed position;

(5) FIG. **4** is a distal end view of the expandable interbody spacer of FIG. **1** shown in a collapsed position;

(6) FIG. **5** is an exploded view of the expandable interbody spacer of FIG. **1**;

(7) FIG. **6** is a top view of the expandable interbody spacer of FIG. **1** shown in an expanded position;

(8) FIG. **7** is a right side view of the expandable interbody spacer of FIG. **1** shown in an expanded position;

(9) FIG. **8** is a left side view of the expandable interbody spacer of FIG. **1** shown in an expanded position;

(10) FIG. **9** is a proximal end view of the expandable interbody spacer of FIG. **1** shown in an expanded position;

(11) FIG. **10** is a distal end view of the expandable interbody spacer of FIG. **1** shown in an expanded position;

(12) FIG. **11** is a view showing disc space between adjacent vertebrae in accordance with embodiments of the present invention;

(13) FIG. **12** is a view of a tool for insertion of an expandable interbody spacer in accordance with embodiments of the present invention;

(14) FIG. **13** is a view showing the tool of FIG. **12** introducing an expandable interbody spacer into a disc space in a collapsed position in accordance with embodiments of the present invention;

(15) FIG. **14** is a view showing the tool of FIG. **12** expanding an expandable interbody spacer in a disc space in accordance with embodiments of the present invention;

(16) FIG. **15** is a view showing a funnel for introduction of bone-growth-inducing material into a disc space in accordance with embodiments of the present invention;

(17) FIG. **16** is an exploded view of another embodiment of an expandable interbody spacer;

(18) FIG. **17** is a top view of another embodiment of an expandable interbody spacer shown in a collapsed position;

(19) FIG. **18** is a top view of the expandable interbody spacer of FIG. **17** shown in an expanded position;

(20) FIG. **19** is an exploded view of the expandable interbody spacer of FIG. **17**;

(21) FIG. **20** is an exploded view of a link of a jointed arm of the expandable interbody spacer of FIG. **17**;
(22) FIG. **21** is a top view of another embodiment of an expandable interbody spacer shown in a collapsed position;
(23) FIG. **22** is a top view of the expandable interbody spacer of FIG. **21** shown in an expanded position;
(24) FIG. **23** is a view of the expandable interbody spacer of FIG. **21** shown in a disc space in a collapsed position;
(25) FIG. **24** is a view of the expandable interbody spacer of FIG. **21** shown in a disc space in an expanded position;
(26) FIG. **25** is a top view of a tool shown engaging the expandable interbody spacer of FIG. **21** in accordance with embodiments of the present invention;
(27) FIG. **26** is a view showing the tool of FIG. **24** expanding the expandable interbody spacer of FIG. **24** in a disc space in accordance with embodiments of the present invention;
(28) FIGS. **27**A-**27**C show different views of an expandable interbody spacer having an expandable containment bladder in accordance with embodiments of the present invention;
(29) FIGS. **28**A and **28**B show top views of an expandable spacer utilizing a shim member in accordance with embodiments of the present invention;
(30) FIGS. **29**A and **29**B show top perspective views of an expandable spacer utilizing a translation member in accordance with embodiments of the present invention;
(31) FIGS. **30**A and **30**B show top views of an expandable spacer including a sliding actuation member in accordance with embodiments of the present invention;
(32) FIGS. **31**A and **31**B show different views of an expandable spacer having slidable wings in accordance with embodiments of the present invention;
(33) FIGS. **32**A-**32**D show an expandable spacer comprising an “I-beam” with multiple side slots for receiving complementary side members in accordance with embodiments of the present invention;
(34) FIGS. **33**A and **33**B show different views of a hinged expandable interbody spacer in accordance with embodiments of the present invention;
(35) FIGS. **34**A-**34**D show different views of an alternate hinged expandable interbody spacer in accordance with embodiments of the present invention;
(36) FIGS. **35**A and **35**B show an expandable spacer including a flexible containment member in accordance with some embodiments;
(37) FIG. **36** shows an expandable spacer including a rotating cam to actuate expandable wings in accordance with some embodiments;
(38) FIGS. **37**A and **37**B show an expandable spacer including four wings actuated by a gear mechanism in accordance with some embodiments;
(39) FIGS. **38**A and **38**B show an expandable spacer including deployable pins in accordance with some embodiments;
(40) FIG. **39** shows an expandable spacer expandable via a guide wire in accordance with some embodiments;
(41) FIG. **40** shows an expandable spacer including an add-on member in accordance with some embodiments;
(42) FIG. **41** shows a buildable spacer that can be guided by tracks in a disc space to form a large footprint in a disc space in accordance with some embodiments;
(43) FIGS. **42**A-D show a rotatable spacer capable of expansion following rotation in accordance with some embodiments;
(44) FIGS. **43**A-C show an expandable spacer capable of outward folding in accordance with some embodiments;
(45) FIGS. **44**A and **44**B show a pair of expandable spacers having deployable arms;

(46) FIGS. **45**A-**45**C show an expandable spacer having a rack and pinion actuator in accordance with some embodiments;
(47) FIGS. **46**A-**46**C show an expandable spacer having an outer member with a slidable inner member therein;
(48) FIGS. **47**A and **47**B show an expandable spacer having upper and lower members separated by linking members in accordance with some embodiments;
(49) FIGS. **48**A and **48**B show an expandable spacer comprising a worm gear in accordance with some embodiments;
(50) FIGS. **49**A and **49**B show an expandable spacer having asymmetrical expansion in accordance with some embodiments.
(51) Throughout the drawing figures, it should be understood that like numerals refer to like features and structures.

DETAILED DESCRIPTION OF THE INVENTION

(52) The preferred embodiments of the invention will now be described with reference to the attached drawing figures. The following detailed description of the invention is not intended to be illustrative of all embodiments. In describing preferred embodiments of the present invention, specific terminology is employed for the sake of clarity. However, the invention is not intended to be limited to the specific terminology so selected. It is to be understood that each specific element includes all technical equivalents that operate in a similar manner to accomplish a similar purpose.
(53) Referring to FIGS. **1-10**, an expandable interbody spacer **10** is shown in accordance with embodiments of the present invention. In the illustrated embodiment, the expandable interbody spacer **10** has a proximal end **20** and a distal end **30**. The expandable interbody spacer **10** may include a first jointed arm **40** and a second jointed arm **50** positioned on either side of longitudinal axis **15** of the spacer **10**. The first and second jointed arms **40**, **50** may be interconnected at the proximal end **20**, for example, by a proximal connection member **60**. The first and second jointed arms **40**, **50** may be interconnected at the distal end **30**, for example, by a distal connection member **70**. The first and second jointed arms **40**, **50** The expandable interbody spacer **10** may be made from a number of materials, including titanium, stainless steel, titanium alloys, non-titanium alloys, polymeric materials, plastic composites, polyether ether ketone (“PEEK”) plastic material, ceramic, elastic materials, and combinations thereof. While the expandable interbody spacer **10** may be used with a posterior, anterior, lateral, or combined approach to the surgical site, the spacer **10** may be particularly suited with a posterior approach.
(54) The first jointed arm **40** has a proximal end **80** and a distal end **90**. The proximal end **80** may be pivotally coupled to the proximal connection member **60**. The distal end **90** may be pivotally coupled to the distal connection member **70**. Any of a variety of different fasteners may be used to pivotally couple the proximal end **80** and the distal end **90** and the proximal connection member **60** and the distal connection member **70**, such as pins **100**, for example. In another embodiment (not illustrated), the connection may be a hinged connection. As illustrated, the first jointed arm **40** may comprise a plurality of links that are pivotally coupled to one another. In the illustrated embodiment, the first jointed arm **40** comprises first link **110**, second link **120**, and third link **130**. When the spacer **10** is in a collapsed position, the first link **110**, second link **120**, and third link may be generally axially aligned. As illustrated, the first link **110**, second link **120**, and third link **130** may be connected end to end. When the spacer **10** is in a collapsed position, the first link **110**, second link **120**, and third link **130** may be generally axially aligned. The first link **110** and the second link **120** may be pivotally coupled, and the second link **120** and the third link **130** may also be rotatably coupled. Any of a variety of different fasteners may be used to pivotally couple the links **110**, **120**, **130**, such as pins **100**, for example. In another embodiment (not illustrated), the coupling may be via a hinged connection.
(55) As best seen in FIGS. **1**, **5-7**, **9**, and **10**, an upper surface **140** of the first jointed arm **40** may be defined by the links **110**, **120**, **130**. The upper surface **140** should allow for engagement of the first

jointed arm **40** with one of the adjacent vertebral bodies. In some embodiments, the upper surface **140** may include texturing **150** to aid in gripping the adjacent vertebral bodies. Although not limited to the following, the texturing **150** can include teeth, ridges, friction-increasing elements, keels, or gripping or purchasing projections.

(56) As best seen in FIGS. **7**, **9**, and **10** a lower surface **160** of the first jointed arm **40** may be defined by the links **110**, **120**, **130**. The lower surface **160** should allow for engagement of the first jointed arm **40** with one of the adjacent vertebral bodies. In some embodiments, the lower surface **160** may include texturing **170** to aid in gripping the adjacent vertebral bodies. Although not limited to the following, the texturing **170** can include teeth, ridges, friction-increasing elements, keels, or gripping or purchasing projections.

(57) The second jointed arm **50** has a proximal end **180** and a distal end **190**. The proximal end **180** may be pivotally coupled to the distal connection member **70**. The distal end **190** may be pivotally coupled to the distal connection member **70**. Any of a variety of different fasteners may be used to pivotally couple the proximal end **180** and the distal end **190** and the proximal connection member **60** and the distal connection member **70**, such as pins **100**, for example. In another embodiment (not illustrated), the connection may be a hinged connection. As illustrated, the second jointed arm **50** may comprise a plurality of links that are pivotally coupled to one another. In the illustrated embodiment, the second jointed arm **50** comprises first link **200**, second link **210**, and third link **220**. When the spacer **10** is in a collapsed position, the first link **200**, second link **210**, and third link **220** may be generally axially aligned. As illustrated, the first link **200**, second link **210**, and third link **220** may be connected end to end. The first link **200** and the second link **210** may be pivotally coupled, and the second link **210** and the third link **220** may also be pivotally coupled. Any of a variety of different fasteners may be used to pivotally couple the links **200**, **210**, **220**, such as pins **100**, for example. In another embodiment (not illustrated), the coupling may be via a hinged connection.

(58) As best seen in FIGS. **1**, **2**, **6**, and **8-10**, an upper surface **230** of the second jointed arm **50** may be defined by the links **200**, **210**, **220**. The upper surface **230** should allow for engagement of the second jointed arm **50** with one of the adjacent vertebral bodies. In some embodiments, the upper surface **230** may include texturing **240** to aid in gripping the adjacent vertebral bodies. Although not limited to the following, the texturing **240** can include teeth, ridges, friction-increasing elements, keels, or gripping or purchasing projections.

(59) As best seen in FIGS. **8-10**, a lower surface **250** of the second jointed arm **50** may be defined by the links **200**, **210**, and **220**. The lower surface **250** should allow for engagement of the second jointed arm **50** with one of the adjacent vertebral bodies. In some embodiments, the lower surface **250** may include texturing **260** to aid in gripping the adjacent vertebral bodies. Although not limited to the following, the texturing **260** can include teeth, ridges, friction-increasing elements, keels, or gripping or purchasing projections.

(60) With reference now to FIGS. **3**, **5**, and **9**, a bore **270** extends through proximal connection end **60**. The bore **270** may extend generally parallel to the longitudinal axis **12** (see FIG. **1**) of the spacer **10**. The first jointed arm **40** and the second jointed arm **50** may define a hollow interior portion (not shown) that extends axially through the spacer **10**. The bore **270** in the proximal connection end **60** may communicate with this hollow interior portion. As best shown on FIG. **5**, the distal connection end **70** may include an opening **280**. As illustrated, the opening **280** may face inward and may not extend all the way through the distal connection **70**. In one embodiment, the opening **280** may be generally aligned with the bore **270** in the proximal connection end **60** such at a tool (e.g., tool **340** shown on FIG. **12**) inserted into the bore **270** may be received in the opening **280** for placement of the spacer **10** into a disc space and/or expansion of the spacer **10**.

(61) FIGS. **1-4** illustrate the expandable interbody spacer **10** in a collapsed position. In accordance with present embodiments, the expandable interbody spacer **10** may be laterally expanded to an expanded position. FIGS. **6-10** illustrate the expandable interbody spacer **10** in an expanded

position. In the expanded position, the first arm **40** and the second arm **50** have each been folded inward in opposite directions. For example, the proximal end **80** and the distal end **90** of the first arm **40** may be folded closer together. The links **110**, **120**, **130** should pivot with respect to one another when the first arm **40** is folded inward. The proximal end **80** should pivot at the proximal connection end **60**, and the distal end **90** should pivot at the distal connection end **70**. By way of further example, the proximal end **180** and the distal end **190** of the second arm **50** may also be folded together. The links **200**, **210**, **220** should pivot with respect to another when the second arm is folded inward. The proximal end **180** should pivot at proximal connection end **60**, and the distal end **190** should pivot at the distal connection end **70**. After placement in the expanded position, the expandable interbody spacer **10** can be secured in the expanded position to prevent collapse of the expandable interbody spacer **10** upon application of spacer. Any of a variety of different techniques may be used to secure the expandable interbody spacer **10**, including pins or other suitable locking mechanism, for example.

(62) As illustrated by FIG. **6**, the first and second jointed arms **40**, **50** define an interior cavity **290** when in an expanded position. The interior cavity **290** may be filled with a bone-growth-inducing material, such as bone material, bone-growth factors, or bone morphogenic proteins. As will be appreciated by those of ordinary skill in the art, the bone-growth-inducing material should induce the growth of bone material, thus promoting fusion of the adjacent vertebra.

(63) The expandable interbody spacer **10** may be sized to accommodate different applications, different procedures, implantation into different regions of the spine, or size of disc space. For example, the expandable interbody spacer **10** may have a width W**1** (as shown on FIG. **1**) prior to expansion of about 8 to about 22 and alternatively from about 10 to about 13. By way of further example, the expandable interbody spacer **10** may be expanded to a width W**2** (as shown on FIG. **6**) in a range of about 26 to about 42 and alternatively from about 16 to about 32. It should be understood that the width W**1** or W**2** whether prior to, or after, expansion generally refers to the width of the expandable interbody spacer **10** extending transverse to the longitudinal axis **12** of the spacer **10**. In general, the width W**2** of the expandable interbody spacer **10** after expansion should be greater than the width W**1** of the expandable interbody spacer **10** prior to expansion.

(64) In accordance with present embodiments, the expandable interbody spacer **10** may be used in the treatment of damage or disease of the vertebral column. In one embodiment, the expandable interbody spacer **10** may be inserted into a disc space between adjacent vertebrae in which the intervertebral disc has been partially or completely removed. FIG. **11** illustrates a spinal segment **300** into which the expandable interbody spacer **10** (e.g., FIGS. **1-10**) may be inserted. The spinal segment **300** includes adjacent vertebrae, identified by reference numbers **310** and **320**. Each of the adjacent vertebrae **310**, **320** has a corresponding endplate **315**, **325**. The disc space **330** is the space between the adjacent vertebrae **310**, **320**. FIG. **12** illustrates a tool **340** that may be used in the insertion of the expandable interbody spacer **10** into the disc space **330**. The tool **340** includes a shaft **350** having an elongated end portion **360** for coupling to the expandable interbody spacer **10**. The elongated end portion **360** has a distal tip **370**.

(65) FIGS. **13** and **14** illustrate introduction of an expandable interbody spacer **10** into the disc space **330** using tool **340**. For illustrative purposes, the upper vertebra **330** shown on FIG. **11** has been removed from FIGS. **13** and **14**. As illustrated, the spacer **10** may be secured to the tool **340**. For example, the elongated end portion **360** of the tool **340** may be disposed through the bore **270** (e.g., see FIG. **5**) in the proximal connection end **60** with the distal tip **370** (e.g., see FIG. **12**) of the end portion **360** secured in the opening **280** (e.g., see FIG. **5**) in the distal connection end **70**. As illustrated by FIG. **13**, the tool **340** may introduce the spacer **10** into the disc space **330** through an access cannula **380**. After introduction into the disc space **330**, the spacer **10** may be laterally expanded. In accordance with present embodiments, the spacer **10** can be laterally expanded by folding the first arm **40** and the second arm **50** inward. By expanding laterally, the spacer **10** has an increased surface area contact with the endplate **325**. In addition, the spacer **10** may engage harder

bone around the apophyseal ring. As previously mentioned, an interior cavity **290** should be formed in the spacer **10** when in the expanded position. The tool **340** may then be detached from the spacer **10** and removed from the cannula **380**. As illustrated by FIG. **15**, a funnel **390** may then be placed on the cannula **380**. Bone-growth inducing material may then be placed into the interior cavity **290** through the cannula **380**. Because the spacer **10** has been laterally expanded, the interior cavity **290** should have a desirable amount of space for packing of the bone-growth-inducing material.

(66) FIG. **16** illustrates an expandable interbody spacer **10** in accordance with an alternative embodiment. In the illustrated embodiment, the expandable interbody spacer **10** comprises a first jointed arm **40** and a second jointed arm **50**. The first jointed arm **40** has a proximal end **80** and a distal end **90**. The first jointed arm **40** comprises a plurality of links **110**, **120**, **130** connected end to end, for example, by pins **100**. The first jointed arm **40** further may comprise washers **105** (e.g., PEEK washers) that may be disposed between the links **110**, **120**, **130** at their connections. The second jointed arm **50** has a proximal end **180** and a distal end **190**. The second jointed arm **50** comprises a plurality of links **200**, **210**, **220** connected end to end, for example, by pins **100**. The second jointed arm **50** further may comprise washers **105** (e.g., PEEK washers) that may be disposed between the links **200**, **210**, **220** at their connections. Washers **105** may also be disposed between the first arm **40** and the proximal connection member **60** and the distal connection member **70** at their respective connections. Washers **105** may also be disposed between the second arm **50** and the proximal connection member **60** and the distal connection member **70** at their respective connections. The washers **105** should have an interference fit to cause friction such that the spacer **10** may hold its shape in the entire range of the expanded implant.

(67) The proximal ends **80**, **180** may be pivotally coupled, for example, by pin **100**, as shown on FIG. **19**. The distal ends **90**, **180** may also be pivotally coupled, for example, by pin **100**, as shown on FIG. **19**. The first jointed arm **40** comprises first link **110** and third link **130**, the first link **110** and the third link **130** being pivotally coupled. In contrast to the first jointed arm **40** of FIGS. **1-10**, there is no second link **120**.

(68) Referring now to FIGS. **17-19**, an expandable interbody spacer **10** is illustrated in accordance with another embodiment of the present invention. In the illustrated embodiment, the expandable interbody spacer **10** comprises a first jointed arm **40** and a second jointed arm **50**. The first jointed arm **40** has a proximal end **80** and a distal end **90**. The second jointed arm **50** has a proximal end **180** and a distal end **190**. The proximal ends **80**, **180** may be pivotally coupled, for example, by pin **100**, as shown on FIG. **19**. The distal ends **90**, **180** may also be pivotally coupled, for example, by pin **100**, as shown on FIG. **19**. The first j ointed arm **40** comprises first link **110** and third link **130**, the first link **110** and the third link **130** being pivotally coupled. In contrast to the first jointed arm **40** of FIGS. **1-10**, there is no second link **120**. As shown by FIG. **20**, the third link **130** may comprise a first link segment **400** and a second link segment **410**, which may be secured to one another by pins **420**, for example. First link segment **400** and second link segment **410** may also have a tongue-and-groove connection, for example a groove **430** in the first link segment **400** may receive a tongue **440** of the second link segment **410**. The second jointed arm comprises first link **200** and third link **220**, the first link **200** and the third link **220** being pivotally coupled. In contrast to the second joint arm **50** of FIGS. **1-10**, there is no second link **210**.

(69) In accordance with present embodiments, lateral expansion of the expandable interbody spacer **10** of FIGS. **17-19** may include folding the first arm **40** and the second arm **50** inward. For example, the proximal end **80** and the distal end **90** of the first arm **40** may be folded together, and the proximal end **180** and the distal end **190** of the second arm **50** may also be folded together.

(70) Referring now to FIGS. **21** and **22**, an expandable interbody spacer **10** is illustrated in accordance with another embodiment of the present invention. In the illustrated embodiment, the expandable interbody spacer **10** has a proximal end **20** and a distal end **30**. The expandable interbody spacer **10** may include a first jointed arm **40** and a second jointed arm **50** positioned on either side of longitudinal axis **12** of the spacer **10**. As illustrated, the expandable interbody spacer

10 further may comprise an internal screw **450**. The internal screw **450** may comprise a head **460** and an elongated body **470**, which may extend generally parallel to the longitudinal axis **12** of the spacer **10**. In some embodiments, the internal screw **450** may extend from the proximal end **20** to the distal end **30** of the spacer **10**. In one embodiment, the elongated body **470** may be retractable. For example, the elongated body **470** may retract into the head **460**, as shown on FIG. **22**.

(71) As illustrated by FIGS. **23** and **24**, the spacer **10** may be introduced into the disc space **330**, wherein the spacer **10** can be laterally expanded. In accordance with present embodiments, the spacer **10** can be laterally expanded by folding the first arm **40** and the second arm **50** inward. In some embodiments, the elongated body **470** may be retracted into the head **460** to cause folding of the first arm **40** and the second arm **50** inward, as the first arm **40** and the second arm **50** are secured to the distal end **480** of the internal screw **450**.

(72) FIG. **25** shows attachment of a tool **490** to the expandable interbody spacer **10** of FIGS. **22** and **23** in accordance with embodiments of the present invention. As illustrated, the tool **490** may have an attachment end **500**, which can be secured to the head **460** of the internal screw **450**. As shown by FIG. **26**, the tool **40** can be used to introduce the spacer **10** into the disc space **330**, wherein the spacer **10** can be laterally expanded.

(73) Additional embodiments of expandable interbody spacers are described herein. FIGS. **27**A and **27**B show top views of an expandable interbody spacer having an expandable containment bladder in accordance with embodiments of the present invention. FIG. **27**A illustrates the spacer **610** in an unexpanded state, while FIG. **27**B illustrates the spacer **610** in an expanded state.

(74) As shown in FIG. **27**A, the spacer **610** comprises an outer body **615** and an inner bladder **618**. The inner bladder **618** can include an opening **620** through which an instrument can be inserted to deliver rods or beads that will result in expansion of the spacer **610**. In some embodiments, the spacer **610** comprises a convex longitudinal surface opposite a concave longitudinal surface. The spacer **610** can be expanded such that it maintains the convex longitudinal surface and concave longitudinal surface, as shown in FIG. **27**B. In other embodiments, expansion of the spacer **610** via rods or beads can result in a configuration that is different from the original shape. Advantageously, the spacer **610** is configured such that a surgeon can deliver rods or beads to thereby transform the spacer **610** into a desired shape to assist in implantation from a variety of different approaches. For example, the spacer **610** can be expanded such that it includes a “banana” type shape that is suitable for transforaminal delivery, or it can be a long, slender shape that is suitable for posterior delivery. In its unexpanded state, the spacer **610** can be easily delivered minimally invasively into a desired anatomical location.

(75) As shown in FIG. **27**B, the spacer **610** can receive an instrument **690** through the opening **620** in the inner bladder **618**. The instrument **690** can deliver one or more rods or beads **688** that will cause expansion of the inner bladder **618**, as well as the overall spacer **610**. In some embodiments, the instrument **690** can be a curvable instrument that can deliver the beads **688** to desirable locations within the inner bladder **618**, thereby causing selective expansion of the spacer **610**. As shown in FIG. **27**B, in some embodiments, the spacer **610** can substantially maintain the same shape as in the unexpanded state; however, with the addition of the rods or beads **688**, the spacer **610** will be larger and have a much larger footprint than in the unexpanded state. In some embodiments, the overall footprint of the spacer **610** expands along its longitudinal length and/or width, while maintaining a substantially or the same height as the unexpanded spacer **610**. In other embodiments, the overall footprint of the spacer **610** expands along its longitudinal length and/or width, and the height of the spacer **610** also changes during expansion.

(76) FIG. **27**C illustrates a third view of the spacer **610** with the expandable inner bladder **618** inserted between two adjacent vertebrae **310**, **320**. The spacer **610** is configured to receive one or more rods or beads **688** via the delivery instrument **690**. As shown from this view, the delivery instrument **690** can comprise a tubular body that holds the rods or beads **688** in serial formation. The delivery instrument **690** can be accompanied by a pusher instrument **685** that can deliver the

rods or beads **688** out in series. In some embodiments, the delivery instrument **690** can also include an automatic depositor such that multiple rods or beads **688** can be delivered in rapid fashion.

(77) FIGS. **28**A and **28**B show top views of an expandable spacer utilizing a shim member in accordance with embodiments of the present invention. The expandable spacer **710** comprises an outer body **715** having an opening **718**, as shown in FIG. **28**A. In some embodiments, the opening **718** is in communication with a channel **723** having opposing walls **724**, **725** that extends along a longitudinal axis of the expandable spacer **710**. In some embodiments, the channel **723** extends along at least a majority of the length of the expandable spacer. When it is desired to expand the spacer **710**, a shim member **720** can be inserted through the opening **718** and into the channel **723**, as shown in FIG. **28**B. The addition of the shim member **720** causes the spacer **710** to expand by a distance as measured by the increase in distance between the opposing walls **724**, **725** of the channel, thereby advantageously increasing the footprint of the spacer **710** once implanted in a desired location. In some embodiments, the shim member **720** is tapered such that the tapering facilitates ease of insertion in the channel **723**.

(78) FIGS. **29**A and **29**B show top perspective views of an expandable spacer utilizing a translation member in accordance with embodiments of the present invention. FIG. **29**A illustrates the spacer **810** in a closed configuration, while FIG. **29**B illustrates the spacer **810** in an open or expanded configuration.

(79) The expandable spacer **810** comprises an upper endplate **812** and a lower endplate **814**. Each of the upper endplate **812** and the lower endplate **814** can include surface texturing **815** thereon to assist in engagement with an adjacent vertebra. In some embodiments, the surface texturing **815** comprises protrusions, teeth, ridges or ribbing. Each of the endplates **812**, **814** is formed of two separate members that can be separated from one another laterally in a “v” configuration, as shown in FIG. **29**B. With reference to the upper endplate **812**, the upper endplate **812** includes a first endplate portion **822** and a second endplate portion **824** that can be separated from one another along a midline **805** that extends through the spacer **810**. In some embodiments, at least one of the first endplate portion **822** and the second endplate portion **824** can be connected via a hinge member **855** such that at least one of the endplate portions pivots away from one another. As shown in FIG. **29**B, the first endplate portion **822** and the second endplate portion **824** of the upper endplate **812** transition into corresponding members found along the lower endplate **814**. In some embodiments, the expandable spacer **810** comprises one or more side slots **828** that can be engaged by an installation instrument to assist in delivery of the spacer **810** to a desired anatomical location.

(80) In order to expand the spacer **810**, the spacer **810** includes a translation member **830** and an actuation member **840**, as shown in FIG. **29**B. The translation member **830** can comprise one or more ramps that engage side ramps formed along inner sidewalls of the spacer **810**. As shown in FIG. **29**B, the spacer **810** can include at least a pair of ramps **832**, **834** that engage with corresponding ramps formed along the inner sidewalls of the spacer **810**. As the translation member **830** is translated (e.g., in a first direction), the ramps **832**, **834** slide along corresponding ramps formed along the inner sidewalls of the spacer **810**, thereby causing expansion of the implant. Translation of the translation member **830** in an opposite direction (e.g., in a second direction) causes contraction of the implant. In some embodiments, the spacer **810** includes more than just the ramps **832**, **834**. For example, the ramps **832**, **834** can be connected via a bridge member **836** to additional ramps along a longitudinal axis of the spacer **810**. In some embodiments, ramps **832**, **834** are connected via a bridge member **836** to a second pair of ramps that can help with expansion of the spacer **810**.

(81) In order to move the translation member **830**, in some embodiments, the translation member **830** is operably attached to an actuation member **840**. The actuation member **840** can comprise an actuation or set screw **840**. In some embodiments, the actuation member **840** includes an opening, such as a hex screw opening, for allowing rotation of the actuation member **840**. Rotation of the actuation member **840** in a first direction causes lateral translation of the translation member **830** in

the first direction, thereby causing sliding engagement between the ramps **832**, **834** of the translation member **830** and ramps of the inner sidewalls, and thus outward expansion of the first endplate portion and second endplate portion. Advantageously, as shown in FIG. **29**B, the first endplate portion **822** separates from the second endplate portion **824** in a v-shape, thereby enlarging the footprint of the implant. This advantageously creates an implant with greater load stability, as well as an increased region through which to deposit bone graft material.
(82) FIGS. **30**A and **30**B show top views of an expandable spacer including a sliding actuation member in accordance with some embodiments. The expandable spacer **910** includes a pair of upper wing members **912** and a pair of lower wing members **914**. As shown in FIG. **30**A, an upper wing member **912** and a lower wing member **914** is operably attached to sliding actuation member **920**. FIG. **30**A illustrates the expandable spacer in an unexpanded configuration. When the spacer is ready for expansion, the sliding actuation member **920** can slide in between the upper wing member **912** and the lower wing member **914**, thereby causing the wing members to open outwardly, as shown in FIG. **30**B. In some embodiments, the wing members can expand from approximately 12 mm to 20 or more millimeters just by expansion of the wing members.
(83) FIGS. **31**A and **31**B show an alternative embodiment of an expandable spacer having slidable wings in accordance with embodiments of the present invention. The spacer **1010** can be composed of slidable wings **1012**, **1013**, **1014**, **1015**. As shown in FIG. **31**A, slidable wings **1012**, **1013** are on a left side of the spacer **1010**, while slidable wings **1014**, **1015** are on a right side of the spacer **1010**. The spacer **1010** can be delivered to a disc space in a non-expanded, minimally invasive state, as shown in FIG. **31**A. Once in the disc space, the wings **1012**, **1013**, **1014**, **1015** of the expandable spacer can be outwardly deployed, thereby causing expansion of the device. In some embodiments, the wings can be complimentary and symmetrical to one another prior to deployment. To deploy the wings, a pre-attached block member **1022**, **1023** can be actuated to open the wings. As shown in FIG. **31**A, block member **1022** can operate wings **1012**, **1013**, while block member **1023** can operate wings **1014**, **1015**. FIG. **31**B shows the wings separated and in an expanded state following actuation by the block members.
(84) FIGS. **32**A-**32**D show an expandable spacer comprising an “I-beam” with multiple side slots for receiving complementary side members in accordance with embodiments of the present invention. The spacer **1110** can comprise a central I-beam **1111** with one or more side slots **1116** that receive protruding portions from adjacent side members **1112**, **1114**. As shown in FIG. **32**A, the I-beam and its side members **1112**, **1114** complement each other. The I-beam can include a slot **1118** for receiving an actuation member to outwardly expand the side members **1112**, **1114**. In some embodiments, in a contracted configuration, the side slots **1116** of the I-beam receive the protruding portions **1119** of the adjacent side members **1112**, **1114**. Upon expansion, the protruding portions **1119** of the adjacent side members will be offset with the side slots **1116** of the I-beam. To offset the protruding portions **1119** of the adjacent side members from the side slots **1116**, the I-beam can be slid in a first direction such that the protruding portions move away from the slots. In some embodiments, the protruding portions **1119** can be tapered to allow sliding between the I-beam and the protruding portions. In other embodiments, the actuation member can be any of the actuation components discussed herein for expanding and/or contracting the spacers.
(85) FIGS. **33**A and **33**B show different views of a hinged expandable interbody spacer in accordance with embodiments of the present invention. FIG. **33**A illustrates the spacer **1210** in an unexpanded state and FIG. **33**B illustrates the spacer **1210** in an expanded state within a vertebral space **3**. As shown in FIG. **33**A, the spacer **1210** can comprises two expandable portions **1212**, **1214** that are connected to each either by a hinge joint **1210**. In the unexpanded state, the two expandable portions **1212**, **1214** of the spacer **1210** can be positioned side-by-side or adjacent to one another. In some embodiments, inner facing side surfaces of the two expandable portions **1212**, **1214** are in direct contact with one another in the unexpanded state.
(86) To expand the spacer **1210**, a wedge member **1219** can be delivered in between the two

expandable portions **1212**, **1214**. The wedge member **1219** can be inserted where the inner side surfaces of the expandable portions **1212**, **1214** meet, thereby separating the first expandable portion **1212** from the second expandable portion **1214**. As the first expandable portion **1212** and the second expandable portion **1214** are connected via a hinge **1215**, the spacer **1210** will assume an expanded v-shape upon expansion, as shown in FIG. **33**B. In some embodiments, the wedge member **1219** can comprise a triangular wedge member. As shown in FIG. **33**B, the wedge member **1219** can be placed substantially adjacent to or in contact with the hinge **1215** in some embodiments. In some embodiments, in the expanded configuration, the wedge member **1219** can advantageously remain embedded within the v-shape of the expanded spacer **1210**, thereby preventing closing or contraction of the expanded configuration.

(87) In some embodiments, the wedge member **1219** can be accompanied by an insertion instrument **1223** to assist in delivery of the wedge member **1219**. The wedge member **1219** can comprise a proximal end and a distal end that is directly adjacent and/or in contact with the expandable portions **1212**, **1214**. The insertion instrument **1223** includes a sleeve to guide the wedge member **1219** to a desired location between the hinged expandable portions **1212**, **1214**.

(88) FIGS. **34**A-**34**D show different embodiments of an alternative hinged spacer **1310** in accordance with some embodiments. FIG. **34**A illustrates a hinged spacer **1310** in an unexpanded configuration, while FIG. **34**B illustrates the hinged spacer **1310** in an expanded configuration. The hinged spacer **1310** comprises a first expandable portion **1312**, a second expandable portion **1313**, and a third expandable portion **1314** that are connected to one another via hinges **1315**, **1316**.

(89) In order to expand the hinged spacer **1310**, the spacer **1310** advantageously provides a holding point **1322** and a pushing point **1324** (as shown in FIG. **34**C). The holding point **1322** is a point at which an insertion instrument can steadily hold the spacer **1310**. In some embodiments, an insertion instrument will hold the spacer **1310** by gripping a surface. In other embodiments, an insertion instrument can engage the spacer **1310** via one or more insertion surfaces (e.g., a threaded hole) that are formed in the holding point **1322**. While the spacer **1310** is being held at its holding point **1322**, the insertion instrument can further comprise a pusher that expands the spacer **1310** by applying a force on the surface of the pushing point **1324**. In some embodiments, a pushing instrument that is separate from the insertion instrument can be used (e.g., inserted through the insertion instrument) such that it causes expansion of the spacer **1310**. As shown in FIGS. **34**C and **34**D, the expandable spacer **1310** can advantageously be expanded in situ.

(90) FIGS. **35**A and **35**B show an expandable spacer including a flexible containment member in accordance with some embodiments. FIG. **35**A illustrates the spacer **1410** in an unexpanded state, while FIG. **35**B illustrates the spacer **1410** in an expanded state within a disc space **3**. The expandable spacer **1410** can comprise a flexible containment structure **1411** that includes one or more channels **1413** for receiving blocks **1422**. Insertion of the blocks **1422** causes the channels to fill, thereby causing expansion of the spacer **1410**. Advantageously, the flexible containment structure **1411** can be inserted into a disc space with few if any blocks such that the spacer **1410** can be inserted through as small an incision as possible. After the spacer **1410** is placed in a desired position in a disc space, blocks **1422** can be added into the flexible containment structure **1411** to fill the channels, thereby causing expansion of the spacer **1410** in situ.

(91) The flexible containment structure **1411** of the spacer **1410** can comprises one or more channels to accommodate the blocks. As shown in FIG. **35**B, the flexible containment structure **1411** can include a number of channels **1412**, **1414**, **1416**, **1418**. In some embodiments, the channels are of a same size and shape, while in other embodiments, the channels can be of a different size and shape in order to more closely approximate the desired anatomical shape of the disc space. In some embodiments, the flexible containment structure **1411** can be comprised of a flexible material, such as a plastic, a rubber, or other elastomeric material. In some embodiments, the flexible containment structure **1411** can comprise a woven or braided member that expands with the addition of the blocks.

(92) To assume their expanded configuration, the channels **1412**, **1414**, **1416**, **1418** of the flexible containment structure **1411** are configured to receive one or blocks **1422** in each of the channels in order to for them to reach their maximum size. In some embodiments, the channels can each receive the same number of blocks, while in other embodiments (as shown in FIG. **35**B), the channels can receive different numbers of blocks. Advantageously, by providing channels that accommodate a different number of blocks, a specific anatomical footprint can be achieved within the disc space that caters to different patients of different sizes. In some embodiments, the blocks **1422** can be formed of a polymeric material, such as PEEK.
(93) In some embodiments, an instrument is capable of directing the blocks **1422** to individual channels in order to cause selective expansion of the implant **1410**. In other embodiments, the blocks **1422** fill the channels themselves without any specific directing by an instrument. The channels can be made of a distinct size such that upon filling, the blocks **1422** will fill other regions of the implant **1410**, without having to be directed by an insertion instrument.
(94) FIG. **36** shows an expandable spacer **1510** including a rotating cam to actuate expandable wings in accordance with some embodiments. Rotation of the cam **1520** in a first direction causes wings **1522**, **1524** to outwardly expand, wherein rotation of the cam **1520** in a second direction opposite the first causes wings **1522**, **1524** to inwardly contract.
(95) FIGS. **37**A and **37**B show an expandable spacer including four wings actuated by a gear mechanism in accordance with some embodiments. The spacer **1610** comprises four wings **1622**, **1624**, **1626**, **1628** that can be kept in a contracted state (FIG. **37**A) and then expanded into an expanded state (FIG. **37**B) using a gear mechanism **1630**. Advantageously, the gear mechanism, which can include levers, pivoting arms, etc., can control the expansion of the wings such that the wings need not be fully expanded. In other words, the expandable spacer **1610** can have a series of increased expansion widths, rather than just a single contracted state and a single expanded state.
(96) FIGS. **38**A and **38**B show an expandable spacer **1710** comprising deployable pins in accordance with some embodiments. In contrast to prior spacers that expand to provide a greater footprint in a disc space, the present spacer **1710** (via its pins **1722**) expands in a superior and/or inferior direction in order to conform superior and inferior endplates **1712**, **1714** of the spacer **1710** with adjacent vertebrae.
(97) FIG. **38**A illustrates the spacer **1710** in an unexpanded state. The spacer **1710** comprises a superior endplate **1712** and an inferior endplate **1714** having a plurality of holes or openings **1721** therethrough. Within the openings **1721** are a plurality of deployable pins **1722** that can outwardly expand through the openings **1721** in order to increase the height of the spacer within the disc space. In some embodiments, the spacer **1710** body can comprise a port **1715** for receiving an expandable member **1718** (shown in FIG. **38**B) that can outwardly deploy the pins to increase the height of the spacer **1710**.
(98) FIG. **38**B illustrates the spacer **1710** in an expanded state. From this view, one can see an expandable member **1718** within the body of the spacer **1710**. Expansion of the expandable member **1718** within the body of the spacer **1710** causes the deployable pins **1722** to expand outwardly, thereby increasing the height of the spacer **1710**. In some embodiments, the expandable member **1718** can comprise a balloon member. In some embodiments, an expansion instrument is insertable through the port **1715**. The expansion instrument is capable of inflating or enlarging the expandable member **1718**. As the expandable member **1718** expands, exterior surfaces of the expandable member **1718** push against the deployable pins **1722**, thereby causing the pins **1722** to protrude outwardly and cause overall height expansion of the spacer **1710**.
(99) FIG. **39** shows an expandable spacer expandable via a guide wire in accordance with some embodiments. The spacer **1810** comprises two or more linked members that can be fed into a disc space via a guide wire. Advantageously, the spacer **1810** can be inserted into a small incision that is about the width of a single linked member. The linked members can be attached to a guide wire or k-wire **1826** that extends through each of the linked members. As the spacer **1810** is fed into the

disc space, the natural anatomy of the disc space causes the linked members to curve and expand to widen the footprint of the device. As shown in FIG. **39**, the spacer **1810** can comprise at five linked members **1812**, **1814**, **1816**, **1818**, **1820**. In other embodiments, the spacer **1810** comprises less than five linked members or greater than five linked members. The linked members can be connected to adjacent members via a joint **1824** (such as a hinge joint). Each of the linked members can include an opening for receiving the k-wire **1826**. Following expansion of the implant in situ, the k-wire **1826** can be removed, thereby leaving the implant in place. The k-wire **1826** can be delivered by an instrument **1830**.

(100) FIG. **40** shows an expandable spacer including an add-on member in accordance with some embodiments. This spacer **1910** includes a first member **1912** and a second member **1914** that can be inserted into a disc space **3** on their own. As shown in FIG. **40**, the first member **1912** and the second member **1914** can be elongated members in the form of rods that are joined together at a hinge or joint **1922**. The first member **1912** and the second member **1914** can be inserted in a configuration whereby the two members are in contact with each other. Once the first member **1912** and the second member **1914** are inserted into the disc space **3**, the two members can be expanded into a V-shape configuration, such that they are ready to receive a third add-on member **1916**.

(101) The third add-on member **1916** can be inserted into the disc space **3** and can be attached to the first member **1912** and second member **1914** at respective joints or hinges **1924**, **1926**. In some embodiments, the third add-on member **1916** can be snap-fitted to the first two members. In other embodiments, the first member **1912** and the second member **1914** include openings near the joints **1924**, **1926** for receiving the third add-on member **1916** easily therethrough. With the third add-on member **1916**, the implant can assume the shape of a triangle that advantageously has a large footprint within the disc space **3**. Bone graft material can be provided into the completed spacer **1910**, thereby helping to aid in a fusion process within the disc space.

(102) FIG. **41** shows a buildable spacer **2010** that can be guided by tracks in a disc space to form a large footprint in a disc space in accordance with some embodiments. In this embodiment, multiple tracks **2022**, **2024**, **2026** can be formed within a disc space **3** to guide individual spacer members **2012**, **2014** into desired positions within the disc space. The tracks **2022**, **2024**, **2026** can be pre-laid within a disc space prior to inserting the spacer members **2012**, **2014**. In some embodiments, the tracks **2022**, **2024**, **2026** can compose tracks formed by the disc space itself (e.g., a surgeon can form the tracks out of the cut bone), while in other embodiments, the tracks **2022**, **2024**, **2026** can be formed by inserted materials within the disc space, such as metals, polymers or bone material. Once the tracks **2022**, **2024**, **2026** have been laid, individual spacer members **2012**, **2014** in the form of elongated members or rods can be inserted and guided by the individual tracks, thereby creating a spacer with an expanded footprint in situ. Advantageously, in some embodiments, the spacer members **2012**, **2014** can be inserted individually into the disc space, thereby requiring a small incision. As the spacer members **2012**, **2014** are guided in the track, the spacer **2010** size is increased. In some embodiments, there are more tracks than spacer members, thereby advantageously providing multiple options for configuring the implant in situ.

(103) FIGS. **42**A-D show a rotatable spacer capable of expansion following rotation in accordance with some embodiments. The spacer **2110** comprises a pair of expandable panels **2130**, **2132** that are capable of expansion following rotation of the spacer **2110** in a disc space. The spacer **2110** includes a leading edge **2112**, a trailing edge **2114**, a bottom surface **2121** and a top surface **2123**. The spacer **2110** can be inserted in a first direction in a minimally invasive manner via its leading edge **2112**. Once within the disc space, the spacer **2110** can be rotated, such as 90 degrees. After rotation, the panels **2130**, **2132** of the spacer **2110** can be advantageously expanded, thereby exposing a graft slot **2135** therein. In some embodiments, the footprint of the spacer **2110** can increase by at least 20-30 percent. For example, in some embodiments, the width of the spacer **2110** can expand from an initial 20 mm width to at least a 30 mm width, with a desirable volume in the middle of the spacer **2110** for receiving graft material.

(104) FIGS. **43**A-C show an expandable spacer capable of outward folding in accordance with some embodiments. The spacer **2210** comprises a first section **2212** and a second section **2214** that are operably connected via a joint or hinge **2218**. As shown in FIG. **43**A, the spacer **2210** can have a minimally invasive configuration whereby the first section **2212** and the second section **2214** are inwardly folded together.
(105) Once the spacer **2210** is inserted into a disc space, the spacer **2210** can be expanded whereby its first section **2212** and second section **2214** are outwardly folded. As shown in FIG. **43**B, the spacer **2210** in its expanded state can reveal surface protrusions or teeth **2220** along at least portion of the first and second sections **2212**, **2214**. In some embodiments, the surface protrusions **2220** extend along a majority of the perimeter of each of the first and second sections **2212**, **2214**. These surface protrusions **2220** advantageously provide a gripping surface to prevent extrusion of the spacer **2210** once it has been expanded within a disc space.
(106) FIG. **43**C illustrates an alternative embodiment of the spacer **2210**. In some embodiments, the expanded spacer **2210** can reveal multiple embedded layers. The spacer **2210** can have first and second outer sections **2212***a*, **2214***a*, first and second mid sections **2212***b*, **2214***b* and first and second inner sections **2212***c*, **2214***c*. Each of these sections can include surface protrusions or teeth. With the multiple embedded layers, the spacer **2210** advantageously provides greater surface area for engagement with adjacent vertebrae and also a greater covered footprint for better loading distribution.
(107) FIGS. **44**A and **44**B show a pair of expandable spacers having deployable arms. The spacers **2310** comprise an elongated body **2312** having one or more arms **2314** extending from the body **2312**. In some embodiments, the arms **2314** are flexible members that can be bent along the length of the body **2312** prior to deployment, thereby providing for minimally invasive insertion. In other embodiments, the arms **2314** are more rigid members that can be deployed via an instrument that can be inserted through the body **2312** of the spacer **2310**. For example, when the arms **2314** are ready for deployment, an instrument can be inserted along the length of the body **2312** to release or outwardly rotate the deployable arms **2314**. In other embodiments, the arms **2314** can be inflatable, such as by adding an expandable medium into the arms.
(108) FIG. **44**A shows the spacer **2310** in an unexpanded configuration, while FIG. **44**B shows the spacer **2310** in an expanded configuration with the arms **2314** deployed. With the arms outwardly deployed, the spacer **2310** advantageously has a larger footprint in a disc space compared to when it is first inserted into the disc space. In addition, in some embodiments, one or more arms **2314** can include one or more ports **2320**. Advantageously, these ports **2320** can serve as graft windows, such that graft material can be delivered therein. While the illustrated embodiment shows the arms **2314** as having a single port in each arm, in other embodiments, two or more ports can reside on the arms. Moreover, in some embodiments, the elongated body **2312** can also include ports or graft windows for receiving bone graft material therein.
(109) FIGS. **45**A-**45**C show an expandable spacer having a rack and pinion actuator in accordance with some embodiments. The spacer **2510** comprises two or more linking members **2512** that are joined together at joints or hinges. In some embodiments, the spacer **2510** can include a rack and pinion actuator that allows the spacer to be pulled in the direction **2518**. The rack and pinion actuator advantageously allows the spacer to expand incrementally, thereby allowing a surgeon to control the shape of the spacer within different types of patients. In some embodiments, the rack and pinion spacer will be controlled to sit on an apophyseal ring of the patient, thereby providing desirable load distribution when in use. In some embodiments, the spacer **2510** can include a graft window **2517** that can receive graft material therein.
(110) FIGS. **46**A-**46**C show an expandable spacer having an outer member with a slidable inner member therein. The spacer **2610** comprises an outer member **2612** including an inner member **2614** capable of sliding in and out of the outer member **2612**. As shown in FIG. **47**A, the spacer **2610** can have a first, unexpanded configuration whereby the inner member **2614** is substantially

within the body of the outer member **2612**. After being inserted into a disc space, the inner member **2614** can be slid outward from the outer member **2612**, thereby causing expansion of the spacer **2610** and a greater footprint.

(111) FIG. **46**C shows a side view of the expandable spacer and a mechanism for sliding the inner member **2614** out of the outer member **2612** according to some embodiments. In some embodiments, in order to slide the inner member **2614** in and out of the outer member **2612**, the inner member **2614** can include pin members **2624** that ride in slots **2622** formed in the outer member **2612**, until a desired expansion of the inner member **2614** is reached. In some embodiments, the pin members **2624** can be locked at any point along the length of the slots, such as by rotating the pin members **2624**. In other embodiments, the pin members **2624** have designated unlocking/locking points, located at designated parts of the slots **2622**.

(112) FIGS. **47**A and **47**B show an expandable spacer having upper and lower members separated by linking members in accordance with some embodiments. The expandable spacer **2710** comprises an upper member **2712** and a lower member **2714**. FIG. **47**A shows the upper member **2712** and the lower member **2714** in a first initial configuration whereby the lower member **2714** is positioned near or adjacent to the upper member **2712**. To separate the lower member **2714** from the upper member **2712** and form a larger footprint, the lower member **2714** can be moved away from the upper member **2712** via linking members **2722** and **2724**. In some embodiments, the linking members **2722**, **2724** can be moved by moving respective pins **2732**, **2734** along slots **2742**, **2744** formed in the upper member **2712**. In other embodiments, the lower member **2714** can be moved away from the upper member **2712** via a gear mechanism, such as a gear drive (e.g., a worm gear).

(113) FIGS. **48**A and **48**B show an expandable spacer comprising a worm gear in accordance with some embodiments. The expandable spacer **2810** comprises six linking members **2812** that can expand via a worm gear **2840**. The worm gear **2840** can be engaged by an instrument **2850**, such as a worm drive. Rotation of the instrument **2850** causes actuation of the worm gear **2840**, thereby causing expansion of the linking members **2812**. As shown in FIG. **48**B, the expandable spacer **2810** can be expanded such that it forms a ring member having a larger footprint than its initial configuration. In some embodiments, the worm gear **2840** can be built into the spacer **2810**, while in other embodiments, the worm gear **2840** can be removeably attached to the spacer **2810**.

(114) FIGS. **49**A and **49**B show an expandable spacer having asymmetrical expansion in accordance with some embodiments. The spacer **2910** includes five different linking members **2912**, **2913**, **2914**, **2915** and **2916** that are connected to one another via a joint or hinge. In some embodiments, the linking members can be connected to one another via a click fit. FIG. **49**A shows the spacer **2910** in its initial, non-expanded configuration and attached to an instrument **2930**. The instrument **2930** can deliver the spacer **2910** into a disc space, whereby the spacer **2910** can be pulled in the direction **2922**, thereby causing expansion of the spacer **2910**, as shown in FIG. **49**B. Advantageously, expansion of the spacer **2910** can be asymmetrical to accommodate a desirable footprint within a disc space.

(115) The described embodiments are capable of insertion into a disc space, and subsequent expansion. In some embodiments, the implants will be expanded into a desirable lordotic form. In some embodiments, the implants will be expanded such that the footprint is increased. The implants can be expanded such that they rest on an apophyseal ring of a patient. While the above descriptions describe numerous embodiments, one skilled in the art will appreciate that any of the embodiments discussed above are unique and novel features that may be combinable with one another.

(116) While the invention herein disclosed has been described by means of specific embodiments and applications thereof, numerous modifications and variations can be made thereto by those skilled in the art without departing from the scope of the invention as set forth in the claims.

Claims

1. An expandable interbody spacer system comprising: a first jointed arm comprising a first plurality of links coupled end to end; a second jointed arm comprising a second plurality of links coupled end to end; an elongate screw having a head portion positioned outside of the first and second jointed arms and an elongate body, the head portion having a proximal end, a distal end, and a curved outer surface in between the proximal end and the distal end; and an insertion tool for inserting the expandable interbody spacer into an intervertebral space and having first and second tool arms configured to engage a groove disposed around the curved outer surface of the head portion to secure the insertion instrument to the expandable interbody spacer, wherein the first jointed arm and the second jointed arm are interconnected at a proximal end of the expandable interbody spacer, wherein the first jointed arm and the second jointed arm are interconnected at a distal end of the expandable interbody spacer, and wherein the first jointed arm and the second jointed arm are each configured to move in opposite directions to place the expandable interbody spacer in an expanded position.
2. The expandable interbody spacer system of claim 1, wherein the expandable interbody spacer further comprises a proximal connection member interconnecting the first and second jointed arms, wherein a proximal end of each of the first and second jointed arms is coupled to the proximal connection member.
3. The expandable interbody spacer system of claim 2, wherein the proximal connection member comprises a bore that communicates with a hollow interior portion of the expandable interbody spacer defined by the first and second jointed arms, the hollow interior portion extending axially through the expandable interbody spacer.
4. The expandable interbody spacer system of claim 1, wherein the expandable interbody spacer further comprises a distal connection member interconnecting the first and second jointed arms, wherein a distal end of each of the first and second jointed arms is coupled to the distal connection member.
5. The expandable interbody spacer system of claim 1, wherein the first jointed arm comprises upper and lower surfaces defined by the first plurality of links configured to engage adjacent vertebrae, and wherein the second jointed arm comprises upper and lower surfaces defined by the second plurality of links configured to engage adjacent vertebrae.
6. The expandable interbody spacer system of claim 1, wherein the expandable interbody spacer has a width of about 8 mm to about 22 mm prior to expansion and a width of about 26 mm to about 42 mm after expansion.
7. The expandable interbody spacer system of claim 1, wherein the first plurality of links comprises three links, and wherein the second plurality of links comprises three links, wherein washers are disposed between adjacent ones of the links.
8. The expandable interbody spacer system of claim 1, wherein one of the first plurality of links of the first jointed arm comprises a first link segment coupled to a second link segment, the first link segment and the second link segment having a tongue-and-groove connection.
9. The expandable interbody spacer system of claim 1, comprising an internal screw extending axially through the expandable interbody spacer from a proximal end to a distal end.
10. The expandable interbody spacer system of claim 1, wherein an exterior sidewall of at least one of the second plurality of links is straight and transitions into a second rounded portion.
11. An expandable interbody spacer system comprising: a first jointed arm comprising a first plurality of links coupled end to end, wherein the first plurality of links define upper and lower surfaces configured to engage adjacent vertebrae, wherein an exterior sidewall of at least one of the first plurality of links is straight and transitions into a rounded portion; a second jointed arm comprising a second plurality of links coupled end to end, wherein the second plurality of links

define upper and lower surfaces configured to engage adjacent vertebrae, wherein an exterior sidewall of at least one of the second plurality of links is straight; and an elongate body extending through a proximal end, into an interior region, and into a distal end of the interbody spacer, wherein the elongate body is configured to expand the interbody spacer, the elongate body including a head portion having a proximal end, a distal end, and a curved outer surface in between the proximal end and the distal end of the head portion; and an insertion tool for inserting the expandable interbody spacer into an intervertebral space and having first and second tool arms configured to engage a groove disposed around the curved outer surface of the head portion to secure the insertion instrument to the expandable interbody spacer, wherein the first jointed arm and the second jointed arm are interconnected at the proximal end and the distal end of the interbody spacer.

12. The expandable interbody spacer system of claim 11, wherein the interior region is a hollow interior portion defined by the first and second jointed arms.

13. The expandable interbody spacer system of claim 12, wherein the second jointed arm comprises an opening that extends through the rounded portion of the spacer.

14. The expandable interbody spacer system of claim 13, wherein the opening faces inward into the spacer and does not extend entirely through the second jointed arm.

15. The expandable interbody spacer system of claim 11, wherein the upper and lower surfaces of the first jointed arm comprise texturing to aid in gripping the vertebrae, and wherein the upper and lower surfaces of the second jointed arm comprise texturing to aid in gripping the vertebrae.