SPINAL IMPLANTS AND METHODS OF PROVIDING DYNAMIC STABILITY TO THE SPINE

Inventor: E. Scott Conner, Santa Barbara, CA (US)

Correspondence Address:
KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614 (US)

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ABSTRACT

The present application discloses a plurality of spinal implants and methods for repairing annular defects in intervertebral discs and for providing dynamic stability to the motion segment of the spine in the vicinity of the repaired disc. Each of the implants comprises a head portion and a tail portion. In the illustrated embodiments, the head portion of each implant is enlarged relative to the tail portion. Each of the head portions and tail portions is adapted to support adjacent vertebrae and resist collapse of the intervertebral disc. A tapered portion of each implant engages end plates of the adjacent vertebrae to resist forces tending to push the implant out of the intervertebral space. The tail portion of each implant includes a tail flange (which in some embodiments is of similar diameter to the head portion) that abuts extradiscal lips of the adjacent vertebrae and resists forces tending to push the implant deeper into the intervertebral space.
FIG. 27

FIG. 28
SPINAL IMPLANTS AND METHODS OF PROVIDING DYNAMIC STABILITY TO THE SPINE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to provisional application Ser. No. 60/711,714, filed on Aug. 26, 2005, the entire contents of which are hereby expressly incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention
[0003] The present invention relates to devices and methods for repairing annular defects in intervertebral discs and for providing dynamic stability to the motion segment of the spine in the vicinity of the repaired disc.

[0004] 2. Description of the Related Art

[0005] The vertebral spine is the axis of the skeleton upon which all of the body parts “hang.” In humans, the normal spine has seven cervical, twelve thoracic and five lumbar segments. The lumbar segments sit upon a sacrum, which then attaches to a pelvis, in turn supported by 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.

[0006] Each intervertebral disc primarily serves as a mechanical cushion between the vertebral bones, permitting controlled motions within vertebral segments of the axial skeleton. FIG. 4 illustrates a healthy intervertebral disc 30 and adjacent vertebrae 32. A spinal nerve 34 extends along the spine posteriorly thereof.

[0007] The normal disc is a unique, mixed structure, comprised of three component tissues: The nucleus pulposus (“nucleus”), the annulus fibrosus (“annulus”), and two opposing vertebral end plates. The two vertebral end plates are each composed of thin cartilage overlaying a thin layer of hard, cortical bone which attaches to the spongy, richly vascular, cancellous bone of the vertebral body. The end plates thus serve to attach adjacent vertebrae to the disc. In other words, a transitional zone is created by the end plates between the malleable disc and the bony vertebrae.

[0008] The annulus of the disc is a tough, outer fibrous ring that binds together adjacent vertebrae. This fibrous portion is generally about 10 to 15 millimeters in height and about 15 to 20 millimeters in thickness, although in diseased discs these dimensions may be diminished. The fibers of the annulus consist of 15 to 20 overlapping multiple plies, and are inserted into the superior and inferior vertebral bodies at roughly a 30 degree angle in both directions. This configuration particularly resists torsion, as about half of the unglued fibers will tighten when the vertebrae rotate in either direction, relative to each other. The laminated plies are less firmly attached to each other.

[0009] Immersed within the annulus is the nucleus. The annulus and opposing end plates maintain a relative position of the nucleus in what can be defined as a nucleus cavity. The healthy nucleus is largely a gel-like substance having high water content, and similar to air in a tire; serves to keep the annulus tight yet flexible. The nucleus-gel moves slightly within the annulus when force is exerted on the adjacent vertebrae with bending, lifting, etc.

[0010] Under certain circumstances, an annulus defect (or annulotomy) can arise that requires surgical attention. These annulus defects can be naturally occurring, surgically created, or both. A naturally occurring annulus defect is typically the result of trauma or a disease process, and may lead to a disc herniation. FIG. 5 illustrates a herniated disc 36. A disc herniation occurs when the annulus fibers are weakened or torn and the inner tissue of the nucleus becomes permanently bulged, distended, or extruded out of its normal, internal annular confines. The mass of a herniated or “slipped” nucleus 38 can compress a spinal nerve 40, resulting in leg pain, loss of muscle control, or even paralysis.

[0011] Where the naturally occurring annulus defect is relatively minor and/or little or no nucleus tissue has escaped from the nucleus cavity, satisfactory healing of the annulus may be achieved by immobilizing the patient for an extended period of time. However, many patients require surgery (microdiscectomy) to remove the herniated portion of the disc. FIG. 6 illustrates a disc from which a portion has been removed through a microdiscectomy procedure. After the traditional microdiscectomy, loss of disc space height may also occur because degenerated disc nucleus is removed as part of the surgical procedure. Loss of disc space height can also be a source of continued or new lumbar spine generated pain.

[0012] Further, a more problematic annulus defect concern arises in the realm of annulotomies encountered as part of a surgical procedure performed on the disc space. Alternatively, with discal degeneration, the nucleus loses its water binding ability and deflates, as though the air had been let out of a tire. Subsequently, the height of the nucleus decreases, causing the annulus to buckle in areas where the laminated plies are loosely bonded. As these overlapping laminated plies of the annulus begin to buckle and separate, either circumferential or radial annular tears may occur, which may contribute to persistent and disabling back pain. Adjacent, ancillary spinal facet joints will also be forced into an overriding position, which may create additional back pain.

[0013] In many cases, to alleviate pain from degenerated or herniated discs, the nucleus is removed and the two adjacent vertebrae surgically fused together. While this treatment may alleviate the pain, all discal motion is lost in the fused segment. Ultimately, this procedure places greater stress on the discs adjacent the fused segment as they compensate for the lack of motion, perhaps leading to premature degeneration of those adjacent discs. A more desirable solution entails replacing, in part or as a whole, the damaged nucleus with a suitable prosthesis having the ability to complement the normal height and motion of the disc while stimulating the natural disc physiology.

[0014] Regardless of whether the annulus defect occurs naturally or as part of a surgical procedure, an effective device and method for repairing such defects, while at the same time providing for dynamic stability of the motion segment, would be of great benefit to sufferers of herniated discs and annulus defects.
SUMMARY OF THE INVENTION

[0015] The preferred embodiments of the present spinal implants and methods of providing dynamic stability to the spine have several features, no single one of which is solely responsible for their desirable attributes. Without limiting the scope of these spinal implants and methods as expressed by the claims that follow, their more prominent features will now be discussed briefly. After considering this discussion, and particularly after reading the section entitled "Detailed Description of the Preferred Embodiments," one will understand how the features of the preferred embodiments provide advantages, which include, inter alia, the capability to repair annular defects and stabilize adjacent motion segments of the spine without substantially diminishing the range of motion of the spine, simplicity of structure and implantation, and a low likelihood that the implant will migrate from the implantation site.

[0016] One embodiment of the present spinal implants and methods of providing dynamic stability to the spine comprises a spinal implant adapted to be implanted in an intervertebral disc located between a first vertebral disc and a second vertebral disc to repair an annular defect in the intervertebral disc, and to provide dynamic stability to a motion segment of a spine in the vicinity of the intervertebral disc. The implant comprises a head portion including at least a first head segment and a second head segment. Each of the first and second head segments has a length greater than zero as measured along a longitudinal axis of the implant. The first head segment has a constant height along its length. The second head segment tapers along at least a portion of its length from a greater height to a lesser height away from the first head segment. The implant further comprises a tail portion extending from the head portion and including at least a first tail segment and a second tail segment. The first tail segment adjoins the second head segment. Each of the first and second tail segments has a length greater than zero as measured along a longitudinal axis of the implant. The first tail segment has a constant height along its length. The second tail segment tapers along at least a portion of its length from a lesser height to a greater height away from the first tail segment.

[0017] Another embodiment of the present spinal implants and methods comprises a spinal implant adapted to be implanted in an intervertebral disc located between a first vertebral disc and a second vertebral disc to repair an annular defect in the intervertebral disc, and to provide dynamic stability to a motion segment of a spine in the vicinity of the intervertebral disc. The implant comprises a head portion including at least a first head segment and a second head segment. Each of the first and second head segments has a length greater than zero as measured along a longitudinal axis of the implant. The first head segment tapers along at least a portion of its length from a greater height to a lesser height away from the second head segment. The second head segment tapers along at least a portion of its length from a greater height to a lesser height away from the first head segment. The implant further comprises a tail portion extending from the head portion and including at least a first tail segment and a second tail segment. The first tail segment adjoins the second head segment. Each of the first and second tail segments has a length greater than zero as measured along a longitudinal axis of the implant. The first tail segment has a constant height along its length. The second tail segment tapers along at least a portion of its length from a lesser height to a greater height away from the first tail segment.

[0018] Another embodiment of the present spinal implants and methods comprises a method of repairing an annular defect in an intervertebral disc located between a first vertebral disc and a second vertebral disc, and providing dynamic stability to a motion segment of a spine in the vicinity of the intervertebral disc. The method comprises the steps of removing at least a portion of the intervertebral disc, preparing an implantation site in the vicinity of the intervertebral disc, and implanting a spinal implant device at the implantation site. The step of preparing the implantation site includes the steps of reaming the implantation site to remove bone material from endplates of each of the first and second vertebral discs and thereby shape a portion of each of the endplates to receive the implant device in a substantially complementary fit, and countersinking the implantation site to remove bone material from extradosal lips of each of the first and second vertebral discs and thereby shape a portion of each of the extradosal lips to receive the implant device in a substantially complementary fit.

[0019] Another embodiment of the present spinal implants and methods comprises a method of repairing an annular defect in an intervertebral disc located between a first vertebral disc and a second vertebral disc, and providing dynamic stability to a motion segment of a spine in the vicinity of the intervertebral disc. The method comprises the steps of removing at least a portion of the intervertebral disc, preparing an implantation site in the vicinity of the intervertebral disc, and implanting a spinal implant device at the implantation site. The implant comprises a head portion including at least a first head segment and a second head segment. Each of the first and second head segments has a length greater than zero as measured along a longitudinal axis of the implant. The first head segment has a constant height along its length. The second head segment tapers along at least a portion of its length from a greater height to a lesser height away from the first head segment. A tail portion extends from the head portion and includes at least a first tail segment and a second tail segment. The first tail segment adjoins the second head segment. Each of the first and second tail segments has a length greater than zero as measured along a longitudinal axis of the implant. The first tail segment has a constant height along its length. The second tail segment tapers along at least a portion of its length from a lesser height to a greater height away from the first tail segment.

[0020] Another embodiment of the present spinal implants and methods comprises a tool for removing bone material from facing endplates of adjacent vertebrae. The tool comprises a head portion that extends from a distal end of a shaft. The head portion includes at least an outwardly tapering segment and an inwardly tapering segment. At least a fraction of the head portion includes a roughened surface and/or blades adapted to remove bone material.

[0021] Another embodiment of the present spinal implants and methods comprises a tool for removing bone material from extradosal lips of adjacent vertebrae. The tool comprises a head portion and a tail portion extending from a distal end of a shaft. The head portion includes at least an outwardly tapering segment and an inwardly tapering seg-
ment. At least a fraction of the tail portion includes a roughened surface adapted to remove bone material.

Another embodiment of the present spinal implants and methods comprises a tool for removing bone material from extradiscal lips of adjacent vertebrae. The tool comprises a head portion extending from a distal end of a shaft. The head portion includes at least an outwardly tapering segment and an inwardly tapering segment. At least a fraction of the distal end of the shaft includes blades adapted to remove bone material.

Another embodiment of the present spinal implants and methods comprises a tool for measuring a distance between adjacent vertebrae. The tool comprises a substantially cylindrical shaft.

Another embodiment of the present spinal implants and methods comprises a trial implant for measuring an implant space between adjacent vertebrae. The tool comprises a head portion extending from a distal end of a shaft. The head portion includes at least an outwardly tapering segment and an inwardly tapering segment.

BRIEF DESCRIPTION OF THE DRAWINGS

The preferred embodiments of the present spinal implants and methods of providing dynamic stability to the spine, illustrating their features, will now be discussed in detail. These embodiments depict the novel and non-obvious spinal implants and methods shown in the accompanying drawings, which are for illustrative purposes only. These drawings include the following figures, in which like numerals indicate like parts:

FIG. 1 is a front perspective view of one embodiment of the present spinal implants;

FIG. 2 is a front elevational view of the spinal implant of FIG. 1;

FIG. 3 is a right-side elevational view of the spinal implant of FIG. 1;

FIG. 4 is a right-side elevational view of a normal intervertebral disc, the adjacent vertebrae and a spinal nerve;

FIG. 5 is a right-side elevational view of a herniated intervertebral disc, the adjacent vertebrae and a spinal nerve;

FIG. 6 is a right-side elevational view of the disc of FIG. 5 after a microdiscectomy procedure;

FIG. 7 is a right-side elevational view of the disc of FIG. 6 and the implant of FIG. 1;

FIG. 8 is a right-side elevational view of the disc and the implant of FIG. 7, showing the implant implanted within the disc;

FIG. 9 is a right-side elevational view of the disc of FIG. 6 and one embodiment of a reaming tool that may be used during a procedure to implant the implant of FIG. 1;

FIG. 10 is a right-side elevational view of the disc of FIG. 9 after the reaming step, and a countersinking tool that may be used during a procedure to implant the implant of FIG. 1;

FIG. 11 is a right-side elevational view of the disc of FIG. 10 after the countersinking step, and a sizing tool that may be used during a procedure to implant the implant of FIG. 1;

FIG. 12 is a right-side elevational view of the disc of FIG. 11 after the sizing step, and a trial implant that may be used during a procedure to implant the implant of FIG. 1;

FIG. 13 is a right-side elevational view of the disc of FIG. 12 and the implant of FIG. 1, showing the implant implanted within the disc;

FIG. 14 is a front perspective view of another embodiment of the present spinal implants;

FIG. 15 is a front elevational view of the spinal implant of FIG. 14;

FIG. 16 is a right-side elevational view of the spinal implant of FIG. 14;

FIG. 17 is a front perspective view of another embodiment of the present spinal implants;

FIG. 18 is a front elevational view of the spinal implant of FIG. 17;

FIG. 19 is a right-side elevational view of the spinal implant of FIG. 17;

FIG. 20 is a front perspective view of another embodiment of the present spinal implants;

FIG. 21 is a front elevational view of the spinal implant of FIG. 20;

FIG. 22 is a right-side elevational view of the spinal implant of FIG. 20;

FIG. 23 is a front perspective view of another embodiment of a reaming tool that may be used during a procedure to implant the present implants;

FIG. 24 is a right-side elevational view of the reaming tool of FIG. 23;

FIG. 25 is a front perspective view of another embodiment of a countersinking tool that may be used during a procedure to implant the present implants;

FIG. 26 is a right-side elevational view of the countersinking tool of FIG. 25;

FIG. 27 is a front perspective view of another embodiment of a sizing tool that may be used during a procedure to implant the present implants;

FIG. 28 is a right-side elevational view of the sizing tool of FIG. 27;

FIG. 29 is a front perspective view of another embodiment of a trial implant that may be used during a procedure to implant the present implants; and

FIG. 30 is a right-side elevational view of the trial implant of FIG. 29.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. 1-3 illustrate one embodiment of the present spinal implants. The implant 42 is shaped as a contoured plug having an enlarged head portion 44 and a relatively
narrow tail portion 46 (FIG. 3). In the illustrated embodiment, cross-sections taken perpendicularly to a longitudinal axis of the implant 42 are all substantially circular. However, the area of a given cross-section varies along the longitudinal axis.

[0057] With reference to FIG. 3, the head portion 44 includes a substantially flat nose 48 at a first end of a conical segment 50. The conical segment increases in height and cross-sectional area at a substantially constant rate from the nose to a first end of a large cylindrical segment 52. The large cylindrical segment extends at a constant height and cross-sectional area from the conical segment to a first end of a tapered segment 54. The tapered segment decreases in height and cross-sectional area at an increasing rate from the large cylindrical segment to a first end of a small cylindrical segment 56. The small cylindrical segment is substantially smaller in diameter than the large cylindrical segment, and extends at a constant height and cross-sectional area from the tapered segment to a tail flange 58. The tail flange flares outwardly from a minimum height and cross-sectional area at a second end of the small cylindrical segment to a maximum height and cross-sectional area at a second end of the implant 42. The maximum height of the tail flange is approximately equal to that of the large cylindrical segment.

[0058] Those of ordinary skill in the art will appreciate that the illustrated shape of the implant 42, including the relative dimensions of the segments 50, 52, 54, 56 and the flange 58, is merely one example. For example, cross-sections of the implant 42 taken along the longitudinal axis may be oval or elliptical or rectangular instead of circular. Also, the ratio of the diameter of the small cylindrical segment 56 to the diameter of the large cylindrical segment 52 may be lesser or greater, for example. Also, the implant 42 need not include the substantially cylindrical segments 52, 56. For example, the implant 42 may continue to taper from the nose 48 all the way to the tapered segment 54, and the small cylindrical segment 56 may be reshaped to resemble adjoining tapered segments joined by a neck of a minimum diameter. Furthermore, the anatomy of annular defects and of vertebral end plates has wide variations. Accordingly, the implant 42 may be manufactured in a variety of shapes and sizes to fit different patients. A plurality of differently sized implants may, for example, be available as a kit to surgeons so that during an implantation procedure a surgeon can select the proper size implant from a range of size choices. FIGS. 14-22, described in more detail below, illustrate implants having sample alternative shapes and sizes.

[0059] The implant 42 is preferably constructed of a durable, biocompatible material. For example, bone, polymers or metals may be used. Examples of suitable polymers include silicone, polyethylene, polypropylene, polyetherketone, polyetherketone resins, etc. In some embodiments, the material is non-compressible, so that the implant 42 can provide dynamic stability to the motion segment, as explained in detail below. In certain other embodiments, the material may be compressible.

[0060] FIG. 6 illustrates an intervertebral disc 60 that has undergone a microdiscectomy procedure. A portion of the disc nucleus has been removed leaving a void 62. As shown in FIGS. 7 and 8, the implant 42 is adapted to be inserted between the neighboring vertebrae 64 to fill the void 62. Once implanted, the contoured body of the implant 42, including the enlarged head portion 44 and the relatively narrow tail portion 46, may provide support to the adjacent vertebrae 64, resisting any tendency of these vertebrae to move closer to one another. However, in many cases the vertebrae 64 are not naturally shaped to provide mating engagement with the implant 42. As FIG. 8 shows, the implant 42 may sometimes be too large to fit within the intervertebral space, causing the neighboring vertebrae 64 to be forced apart.

[0061] To avoid the ill fitting engagement shown in FIG. 8, FIGS. 9-13 illustrate one embodiment of a method for implanting the implant 42 of FIGS. 1-3. In these figures, a portion of the intervertebral disc 60 has been removed through a microdiscectomy procedure. Before any disc material is removed, the implanting physician may visualize the implantation site using, for example, magnetic resonance imaging, or any other visualization technique. The visualization step allows the physician to determine what size and shape of implant is best suited to the procedure, which in turn allows the physician to determine what size and shape of tools to use during the procedure.

[0062] Before the implant 42 is introduced, the intervertebral space 62 and the adjacent vertebrae 64 may be prepared so that the implant 42 will fit properly. For example, each of the adjacent vertebrae 64 includes an end plate 66. In a healthy spine, these end plates abut the intervertebral disc 60. In the spine of FIGS. 9-13, these end plates abut the implant 42 after it is implanted. Accordingly, the end plates may be shaped so that they have a mating or complementary fit with respect to the contoured implant 42 and enable the implant 42 to maintain its desired position within the intervertebral space.

[0063] FIG. 9 illustrates one embodiment of a reaming tool 68 that is adapted to shape the end plates 66 of adjacent vertebrae 64. The reaming tool 68 includes a head portion 70 that extends from a distal end of a shaft 72. The head portion 70 and the shaft 72 may be formed integrally with one another, or the head portion 70 may be secured to the shaft 72 by any known means. The head portion and shaft are preferably rigid, and may be made of a metal, for example. In the illustrated embodiment, the head portion is shaped substantially the same as the implant 42, and includes a conical segment 74, a large cylindrical segment 76, a tapered segment 78, a small cylindrical segment 80 and a tail flange 82. Those of ordinary skill in the art will appreciate that the illustrated shape and size of the head portion 70 is merely an example. However, it is advantageous for the head portion to be of similar size and shape to the implant that will ultimately be implanted in the intervertebral space 62 (whether that size and shape is the same as or different from the implant 42 of FIGS. 1-3).

[0064] At least a leading portion of the conical segment 74 includes a smooth outer surface. This smooth surface facilitates the entry of the head portion 70 into the intervertebral space 62, as described below. The small cylindrical segment 80 and tail flange 82 also each include a smooth outer surface. A trailing portion of the conical segment 74, the large cylindrical segment 76 and the tapered segment 78 each include a roughened surface. This surface may, for example, be knurled or burred. The roughened surface is adapted to remove bone from the vertebral end plates 66 in
order to reshape the end plates so that they have a mating or complementary fit with respect to the contoured implant 42. Those of ordinary skill in the art will appreciate that fewer or more segments of the head portion 70 may be roughened in order to provide desired capabilities for shaping the end plates 66.

[0065] To insert the head portion 70 into the intervertebral space 62, the surgeon positions the nose 84 of the head portion adjacent the extradiscal lips 86 on the adjacent vertebrae 64, as shown in FIG. 9. Then, applying digital pressure along the longitudinal axis of the shaft 72, the surgeon may push the head portion 70 into the void 62 between the adjacent vertebrae. Alternatively, the surgeon may strike a proximal end of the shaft 72 with a mallet to drive the head portion 70 into the void 62. The head portion 70 forces the adjacent vertebral 64 apart as it penetrates. Often, the adjacent vertebrae are resistant to being forced apart and significant force must be applied along the axis of the shaft 72 to force the head portion 70 into the void 62. The smooth surface at the leading end of the conical portion 74, which reduces friction between the head portion and the extradiscal lips 86, facilitates the entry of the head portion into the comparatively small void 62.

[0066] To remove material from the end plates 66, the surgeon rotates the shaft 72. He or she may apply a rotational force to the shaft using his or her fingers or a gripping instrument. Alternatively, a proximal end of the shaft may engage a powered drill, which may impart a rotational force to the shaft. The rotating shaft 72 rotates the head portion so that the roughened surfaces on the conical portion 74, the large cylindrical segment 76 and the tapered segment 78 scrape material from the end plates 66. The surgeon continues to remove bone material until the end plates achieve a desired surface contour to complement or mate with the implant 42, as shown in FIG. 10. The surgeon then removes the head portion 70 from the void 62 by applying digital pressure along the shaft 72, or by employing an instrument such as a slapper hammer.

[0067] FIG. 10 illustrates one embodiment of a countersinking tool 88 that is adapted to shape the extradiscal lips 86 of the adjacent vertebrae. A surgeon may use the countersinking tool in order to shape the extradiscal lips so that they more closely complement or mate with the tail flange 58 and prevent the implant 42 from being pushed into the intervertebral space 62.

[0068] The countersinking tool 88 includes a head portion 90 that extends from a distal end of a shaft 92. The head portion 90 and the shaft 92 may be formed integrally with one another, or the head portion 90 may be secured to the shaft 92 by any known means. The head portion and shaft are preferably rigid, and may be made of a metal, for example. In the illustrated embodiment, the head portion is shaped substantially the same as the implant 42, and includes a conical segment 94, a large cylindrical segment 96, a tapered segment 98, a small cylindrical segment 100 and a tail flange 102. Those of ordinary skill in the art will appreciate that the illustrated size and shape of the head portion 90 is merely an example.

[0069] The conical segment 94, large cylindrical segment 96, tapered segment 98, and small cylindrical segment 100 each include a smooth outer surface. The smooth surfaces facilitate the entry of the head portion 90 into the intervertebral space 62, as described above with respect to the reaming tool 68. The tail flange 102 includes a roughened surface. This surface may, for example, be knurled or burled. The roughened surface is adapted to remove bone from the extradiscal lips 86 in order to reshape the lips so that they provide a surface that complements or mates with the contoured implant 42.

[0070] The surgeon inserts the head portion 90 into the intervertebral space 62 in the same manner as described above with respect to the head portion 70. The head portion 90 preferably fits within the void 62 such that the roughened surface on the tail flange 102 abuts the extradiscal lips 86. To remove material from the lips 86, the surgeon rotates the shaft 92. As with the reaming tool 68, the surgeon may impart a rotational force to the shaft 92 using his or her fingers, a gripping instrument or a powered drill, for example. The rotating shaft 72 rotates the head portion so that the roughened surface on the tail flange 102 scrapes material from the lips 86. The surgeon continues to remove bone material until the end plates achieve a surface contour to complement or mate with the implant 42, as shown in FIG. 11. The surgeon then removes the head portion 90 from the void 62 in the same manner as described above with respect to the head portion 70.

[0071] After the surgeon has shaped the vertebral end plates and extradiscal lips, he or she may use a sizing tool to measure the width of the opening between the vertebral end plates 66. FIG. 11 illustrates one embodiment of a sizing tool 104. The tool comprises a cylindrical shaft of a known diameter. The surgeon may have several sizing tools of varying diameters close at hand during an implantation procedure. By attempting to insert sizing tools of increasing or decreasing diameters into the opening between the vertebral end plates 66, the surgeon can measure the size of the opening. After measuring the distance between the vertebral end plates 66, the surgeon will select the appropriate size of implant. He or she may begin with a trial implant, such as the implant 106 shown in FIG. 12.

[0072] In the illustrated embodiment, the trial implant 106 is shaped exactly as the implant 42 of FIGS. 1-3, and is secured to the distal end of a shaft 108. The trial implant may be permanently or temporarily secured to the shaft. The surgeon may insert the trial implant 106 into the void 62 in the same manner as described above with respect to the head portions 70, 90. The smooth surface of the trial implant 106 facilitates its entry into the void 62. The conical portion 108 forces the vertebra 64 apart as the surgeon advances the trial implant 108. Then, as the extradiscal lips pass over the large cylindrical segment 110 and reach the tapered segment 112, the vertebrae snap shut around the implant and the extradiscal lips come to rest around the small cylindrical segment 114. If the surgeon determines that the trial implant is the proper size to fit within the void, then he or she will withdraw the trial implant in the same manner as described above with respect to the head portions 70, 90. He or she will then select an implant that is the same size and shape as the trial implant 108, and insert the selected implant into the void 62, as shown in FIG. 13. The implant 42 may be temporarily secured to the distal end of a shaft (not shown), such that the insertion procedure is substantially the same as that described above with respect to the trial implant 108. If the implant is temporarily secured to the distal end of a shaft, it may engage the shaft through a threaded connection, for
example. Once the implant is in place, the surgeon can then remove the shaft by unscrewing it from the implant.

[0073] The implant 42 advantageously stabilizes the region of the spine where it is implanted without substantially limiting the mobility of the region. As shown in FIG. 13, the conical segment 50, the large cylindrical segment 52, the tapered segment 54 and the small cylindrical segment 56 each abut and support the vertebral end plates 66, preventing the vertebrae 64 from moving closer to one another. Further, interengagement of the shaped end plates 66 and the tapered segment 54 resists any forces tending to push the implant 42 out of the intervertebral space, while interengagement of the tail flange 58 and the shaped extradiscal lips 86 resists any forces tending to push the implant 42 deeper into the intervertebral space. The border of the defect in the disk annulus (not visible in FIG. 13) comes to rest on the small cylindrical segment 56 and the tail flange 58, thus preventing any disc nucleus from being squeezed out of the defect.

[0074] Those of skill in the art will appreciate that the implantation procedure described above could be performed using a guard device that would not only prevent surrounding tissue from interfering with the procedure, but also protect the surrounding tissue from damage. For example, a tubular guard (not shown) may be employed around the implantation site. The guard would prevent surrounding tissue from covering the implantation site, and prevent the implantation instruments from contacting the surrounding tissue.

[0075] In certain embodiments of the present methods, the spacing between adjacent vertebrae is preferably maintained. Thus, the spacing between adjacent vertebrae after one of the present implants has been inserted therebetween is preferably approximately the same as the spacing that existed between those same vertebrae prior to the implantation procedure. In such a method it is unnecessary for the implanting physician to distract the vertebrae prior to introducing the implant. As described above, the increasing size of the conical segment and the large cylindrical segment of the implant temporarily distracts the vertebrae as it passes between the discal lips thereof, after which the vertebrae snap shut around the implant. In certain other embodiments of the present methods, however, it may be advantageous to increase the spacing of the adjacent vertebrae through the implantation procedure, so that the spacing between the adjacent vertebrae after the implant has been inserted therebetween is greater than the spacing that existed between those same vertebrae prior to the implantation procedure. In such embodiments, the implanting physician may distract the adjacent vertebrae prior to implanting the implant in order to achieve the desired spacing.

[0076] FIGS. 14-22 illustrate alternative embodiments of the present spinal implants. These alternative embodiments are adapted for use in spinal discs where the patient’s anatomy is better suited to an implant having a different size and/or shape. For example, FIGS. 14-16 illustrate a spinal implant 116 having an enlarged head portion 118 and a relatively narrow tail portion 120 (FIG. 16). As in the implant 42 of FIGS. 1-3, the head portion 118 of the implant 116 of FIGS. 14-16 includes a substantially flat nose 122, a conical segment 124, a large cylindrical segment 126 and a tapered segment 128. The tail portion 120 includes a small cylindrical segment 130 and a tail flange 132. In comparing the embodiment of FIGS. 1-3 to the embodiment of FIGS. 14-16, the conical segment 50 is longer than the conical segment 124, and the large cylindrical segment 52 is wider in diameter than the large cylindrical segment 126. The tail flange 58 is also somewhat wider in diameter than the tail flange 132. Thus, the implant 116 of FIGS. 14-16 is adapted for implantation in an intervertebral disc having a relatively small diameter, or where it is advantageous for the implant 116 to penetrate only a relatively short distance into the disc.

[0077] FIGS. 17-19 illustrate a spinal implant 134 having an enlarged head portion 136 and a relatively narrow tail portion 138 (FIG. 19). Cross-sections taken perpendicularly to a longitudinal axis of the implant are all substantially circular, however, the area of a given cross-section varies along the longitudinal axis. As in the implants described above (and as with all implants described herein and encompassed by the claims below), the cross-sectional shape of the implant 134 need not be circular, and could be, for example, elliptical or oval. Further, the cross-sectional shapes of the implants described herein may vary along the longitudinal axis.

[0078] The head portion 136 includes a substantially flat nose 140 at a first end of a conical segment 142. The conical segment increases in height and cross sectional area at a substantially constant rate from the nose to a first end of a large cylindrical segment 144. The large cylindrical segment extends at a constant height and cross-sectional area from the conical segment to a first end of a tapered segment 146. The tapered segment decreases in height and cross-sectional area at an increasing rate from the large cylindrical segment to a first end of a small cylindrical segment 148. The small cylindrical segment is substantially smaller in height than the large cylindrical segment, and extends from the tapered segment to a tail flange 150. The tail flange flares outwardly from a minimum height and cross-sectional area at a second end of the small cylindrical segment to a maximum height and cross-sectional area at a second end of the implant 134. The maximum height of the tail flange is approximately equal to that of the large cylindrical segment.

[0079] A comparison between the implant 116 of FIGS. 14-16 and the implant 134 of FIGS. 17-19 reveals that the implant 134 of FIGS. 17-19 has a longer large cylindrical segment 144 and a longer small cylindrical segment 148. The remaining segments in the implant 134 are substantially similar to their counterparts in the implant 116. The implant 134 of FIGS. 17-19 is thus adapted for implantation in an intervertebral disc where it is advantageous for the implant 134 to penetrate a greater distance into the disc as compared to the implant 116 of FIGS. 14-16.

[0080] FIGS. 20-22 illustrate a spinal implant 152 having a shape that is similar to the implant 42 of FIGS. 1-3. The implant 152 includes an enlarged head portion 154 and a relatively narrow tail portion 156 (FIG. 22). As in the implant 42 of FIGS. 1-3, the head portion 154 of the implant 152 of FIGS. 20-22 includes a substantially flat nose 158, a conical segment 160 and a tapered segment 162. However, the implant 152 does not include a large cylindrical segment. Instead, the conical segment directly adjoins the tapered segment, and the tapered segment tapers at a more gradual rate as compared to the tapered segment 54 of the implant 42 of FIGS. 1-3. The head portion 154 achieves a maximum height at the junction between the conical segment 160 and
the tapered segment 162. This area of maximum height is adapted to provide stability to the adjacent vertebrae. As with the implant 42 of FIGS. 1-3, the tail portion 156 of the implant 152 of FIGS. 20-22 includes a small cylindrical segment 164 and a tail flange 166.

[0081] Those of skill in the art will appreciate that the relative dimensions shown in the figures are not limiting. For example, in FIG. 13 the implant 42 is illustrated as having certain dimensions relative to the dimensions of the vertebrae 64. In fact, the size of the implant relative to the vertebrae will be chosen based upon a variety of factors, including the patient's anatomy and the size of the annular defect to be repaired. In certain applications the implant may be significantly smaller relative to the vertebrae, and may extend significantly less than halfway toward a vertical centerline of the intervertebral disc. In certain other applications the implant may be significantly larger relative to the vertebrae, and may extend almost all the way across the intervertebral disc.

[0082] FIGS. 23 and 24 illustrate an alternative reaming tool 168 that may be used to shape the end plates of adjacent vertebrae. The reaming tool 168, which is similar to the reaming tool 68 described above and pictured in FIG. 9, includes a head portion 170 that extends from a distal end of a shaft 172. The head portion 170 and the shaft 172 may be formed integrally with one another, or the head portion 170 may be secured to the shaft 172 by any known means. The head portion 170 and shaft 172 are preferably rigid, and may be made of a metal, for example. In the illustrated embodiment, the head portion 170 is shaped similarly to the implant 42, and includes a conical segment 174, a large cylindrical segment 176, a tapered segment 178 and a small cylindrical segment 180 (FIG. 24). Those of ordinary skill in the art will appreciate that the illustrated size and shape of the head portion 170 is merely an example. However, it is advantageous for the head portion 170 to be of similar size and shape to the implant that will ultimately be implanted in the intervertebral space (whether that size and shape is the same as or different from the implant 42 of FIGS. 1-3). In the illustrated embodiment, the shaft 172 has a greater width relative to the head portion 170 as compared to the reaming tool 68 described above, thereby making the reaming tool 168 easier to grip.

[0083] A plurality of curved blades 182 (FIG. 23) extend along the surfaces of the conical segment 174, the large cylindrical segment 176, the tapered segment 178 and the small cylindrical segment 180, giving the head portion 170 a scalloped surface. The blades 182 extend in a substantially helical pattern along a longitudinal axis of the head portion 170. Each pair of adjacent blades 182 is separated by a cavity 183. The blades 182 are adapted to remove bone from the vertebral end plates 66 in order to reshape the end plates so that they provide a surface that is complementary to the contoured implant 42. Operation of the reaming tool 168 is substantially identical to operation of the reaming tool 68 described above. The blades 182 scrape bone material away as the reaming tool 168 is rotated, and the cavities 183 provide a volume to entrain removed bone material.

[0084] FIGS. 25 and 26 illustrate an alternative countersinking tool 184 that may be used to shape the extradiscal lips of adjacent vertebrae. The countersinking tool 184, which is similar to the countersinking tool 88 described above and pictured in FIG. 10, includes a head portion 186 that extends from a distal end of a shaft 188. The head portion 186 and the shaft 188 may be formed integrally with one another, or the head portion 186 may be secured to the shaft 188 by any known means. The head portion 186 and shaft 188 are preferably rigid, and may be made of a metal, for example. In the illustrated embodiment, the head portion 186 is shaped similarly to the implant 42. Those of ordinary skill in the art will appreciate that the illustrated size and shape of the head portion 186 is merely an example. However, it is advantageous for the head portion 186 to be of similar size and shape to the implant that will ultimately be implanted in the intervertebral space (whether that size and shape is the same as or different from the implant 42 of FIGS. 1-3). In the illustrated embodiment, the shaft 188 has a greater width relative to the head portion 186 as compared to the countersinking tool 88 described above, thereby making the countersinking tool 184 easier to grip.

[0085] A plurality of curved blades 190 extend around a distal end 192 of the shaft 188, adjacent the head portion 186. An edge of each blade 190 faces the head portion 186, and each pair of adjacent blades 190 is separated by a wedge-shaped cavity 194. The blades 190 are adapted to remove bone from the extradiscal lips of adjacent vertebrae in order to reshape the vertebrae so that they provide a surface that is complementary to the contoured implant 42. Operation of the countersinking tool 184 is substantially identical to operation of the countersinking tool 88 described above. The blades 190 scrape bone material away as the countersinking tool 184 is rotated, and the cavities 194 provide a volume to entrain removed bone material.

[0086] FIGS. 27 and 28 illustrate another embodiment of a sizing tool 196. The tool comprises a cylindrical shaft 198 of a known diameter that extends from a distal end 200 of a handle portion 202. Operation of the sizing tool 196 is substantially identical to operation of the sizing tool 104 described above. However, the sizing tool 196 of FIGS. 27 and 28 advantageously has a handle portion 202 that is wider than the cylindrical shaft 198, thereby making the sizing tool 196 easier to grip.

[0087] FIGS. 29 and 30 illustrate another embodiment of a trial implant 204. The trial implant 204, which comprises an implant portion 206 and a handle portion 208, is similar to the trial implant 106 described above. However, the trial implant 204 of FIGS. 29 and 30 advantageously has a wider handle portion 204, thereby making the trial implant 204 easier to grip.

SCOPE OF THE INVENTION

[0088] The above presents a description of the best mode contemplated for carrying out the present spinal implants and methods of providing dynamic stability to the spine, and of the manner and process of making and using them, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains to make and use these spinal implants and methods. These spinal implants and methods are, however, susceptible to modifications and alternate constructions from that discussed above that are fully equivalent. Consequently, these spinal implants and methods are not limited to the particular embodiments disclosed. On the contrary, these spinal implants and methods cover all modifications and alternate constructions com-
ing within the spirit and scope of these spinal implants and methods are as generally expressed by the following claims, which particularly point out and distinctly claim the subject matter of these spinal implants and methods.

What is claimed is:

1. A spinal implant adapted to be implanted in an intervertebral disc located between a first vertebral disc and a second vertebral disc to repair an annular defect in the intervertebral disc, and to provide dynamic stability to a motion segment of a spine in the vicinity of the intervertebral disc, comprising:

   a head portion including at least a first head segment and a second head segment, each of the first and second head segments having a length greater than zero as measured along a longitudinal axis of the implant, the first head segment having a constant height along its length, the second head segment tapering along at least a portion of its length from a greater height to a lesser height away from the first head segment; and

   a tail portion extending from the head portion and including at least a first tail segment and a second tail segment, the first tail segment adjoining the second head segment, each of the first and second tail segments having a length greater than zero as measured along a longitudinal axis of the implant, the second tail segment tapering along at least a portion of its length from a lesser height to a greater height away from the first tail segment.

2. The spinal implant of claim 1, wherein the first tail segment has a constant height along its length.

3. The spinal implant of claim 1, wherein upon permanent implantation within the intervertebral disc the head portion abuts and supports facing endplates of the first and second vertebral discs to aid in preventing collapse of the intervertebral disc while providing dynamic stability to the motion segment, and the tail portion abuts and supports the facing endplates to further aid in preventing collapse of the intervertebral disc while providing dynamic stability to the motion segment, and also abuts extradiscal lips of the first and second vertebral discs to thereby prevent the implant from penetrating the intervertebral disc beyond a desired amount.

4. The spinal implant of claim 1, wherein the head portion further includes at least a third head segment that extends from the first head segment opposite the second head segment.

5. The spinal implant of claim 4, wherein the third head segment tapers along at least a portion of its length from a greater height to a lesser height away from the first head segment.

6. The spinal implant of claim 1, wherein cross-sections of the implant taken along the longitudinal axis thereof are circular, oval, elliptical or rectilinear.

7. The spinal implant of claim 1, wherein the implant is constructed of one or more of bone, polymers or metals.

8. A spinal implant adapted to be implanted in an intervertebral disc located between a first vertebral disc and a second vertebral disc to repair an annular defect in the intervertebral disc, and to provide dynamic stability to a motion segment of a spine in the vicinity of the intervertebral disc, comprising:

   a head portion including at least a first head segment and a second head segment, each of the first and second head segments having a length greater than zero as measured along a longitudinal axis of the implant, the first head segment tapering along at least a portion of its length from a greater height to a lesser height away from the second head segment, the second head segment tapering along at least a portion of its length from a greater height to a lesser height away from the first head segment; and

   a tail portion extending from the head portion and including at least a first tail segment and a second tail segment, the first tail segment adjoining the second head segment, each of the first and second tail segments having a length greater than zero as measured along a longitudinal axis of the implant, the first tail segment having a constant height along its length, the second tail segment tapering along at least a portion of its length from a lesser height to a greater height away from the first tail segment.

9. The spinal implant of claim 8, wherein the tapered portion of the first head segment tapers at a constant rate.

10. The spinal implant of claim 8, wherein the tapered portion of the second head segment tapers at a rate that increases away from the first head segment.

11. The spinal implant of claim 8, wherein the head portion further includes at least a third head segment having a length greater than zero that is interposed between the first head segment and the second head segment.

12. The spinal implant of claim 11, wherein the third head segment has a constant height along its length.

13. A method of repairing an annular defect in an intervertebral disc located between a first vertebral disc and a second vertebral disc, and providing dynamic stability to a motion segment of a spine in the vicinity of the intervertebral disc, the method comprising the steps of:

   - removing at least a portion of the intervertebral disc;
   - preparing an implantation site in the vicinity of the intervertebral disc; and
   - implanting a spinal implant device at the implantation site;

   wherein the step of preparing the implantation site includes the steps of:

   - reaming the implantation site to remove bone material from endplates of each of the first and second vertebral discs and thereby shape a portion of each of the endplates to receive the implant device in a substantially complementary fit; and
   - countersinking the implantation site to remove bone material from extradiscal lips of each of the first and second vertebral discs and thereby shape a portion of each of the extradiscal lips to receive the implant device in a substantially complementary fit.

14. The method of claim 13, further comprising the step of measuring a distance between the endplates to determine an appropriate size for the implant device.

15. A method of repairing an annular defect in an intervertebral disc located between a first vertebral disc and a second vertebral disc, and providing dynamic stability to a motion segment of a spine in the vicinity of the intervertebral disc, the method comprising the steps of:
removing at least a portion of the intervertebral disc; preparing an implantation site in the vicinity of the intervertebral disc; and implanting a spinal implant device at the implantation site; wherein the implant comprises a head portion including at least a first head segment and a second head segment, each of the first and second head segments having a length greater than zero as measured along a longitudinal axis of the implant, the first head segment having a constant height along its length, the second head segment tapering along at least a portion of its length from a greater height to a lesser height away from the first head segment, and a tail portion extending from the head portion and including at least a first tail segment and a second tail segment, the first tail segment adjoining the second head segment, each of the first and second tail segments having a length greater than zero as measured along a longitudinal axis of the implant, the first tail segment having a constant height along its length, the second tail segment tapering along at least a portion of its length from a lesser height to a greater height away from the first tail segment.

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