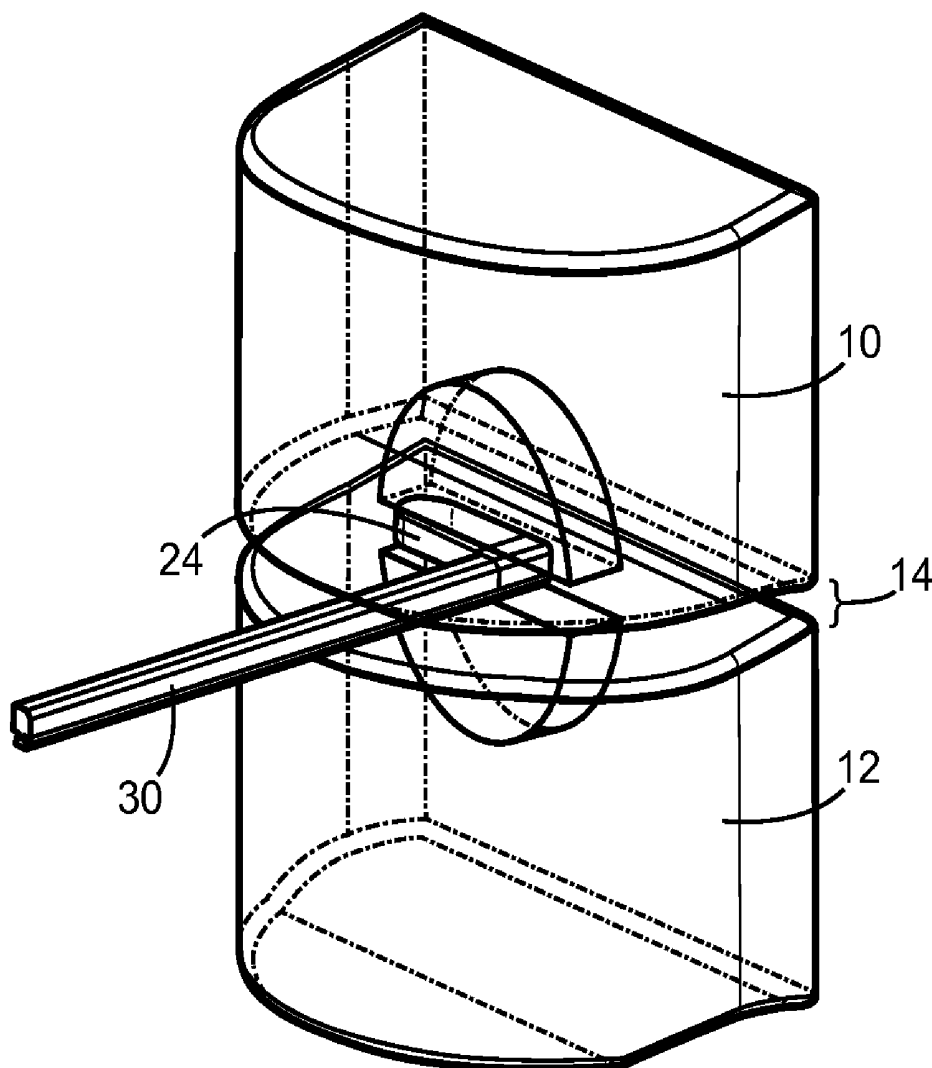


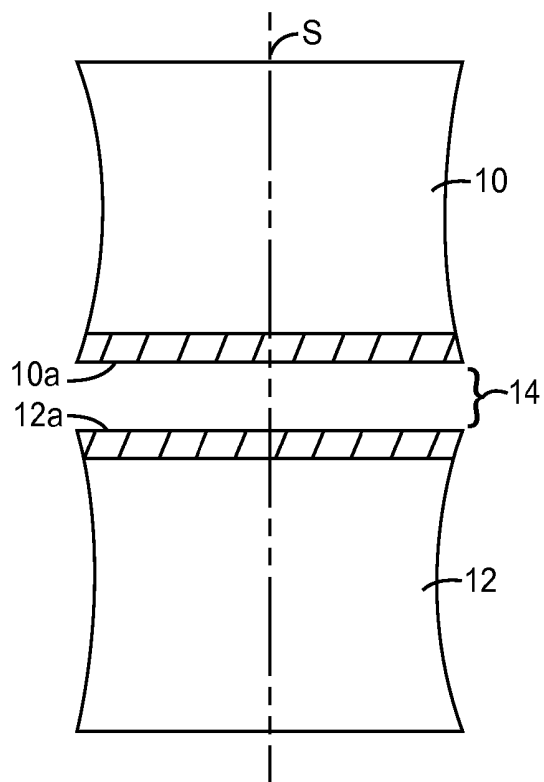


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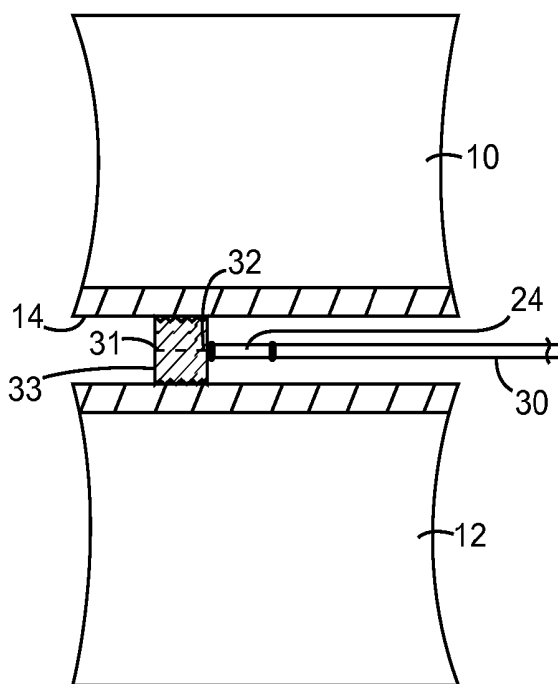
(19) **United States**(12) **Patent Application Publication**  
**Neubardt**(10) **Pub. No.: US 2016/0113779 A1**(43) **Pub. Date: Apr. 28, 2016**(54) **HARVESTING BONE GRAFT MATERIAL  
FOR USE IN SPINAL AND OTHER BONE  
FUSION SURGERIES**(52) **U.S. CL.**  
CPC ..... *A61F 2/4455* (2013.01); *A61B 17/1671*  
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*A61F 2/44* (2006.01)  
*A61B 17/16* (2006.01)(57) **ABSTRACT**

A technique for harvesting bone graft material for spinal and other fusion surgeries. In the disclosed embodiment, a bone cutting blade is placed in a disc space between two vertebrae to be fused. The blade cuts into the vertebrae and forms solid segments of autologous bone inside each vertebra. Each bone segment is urged out of its associated vertebra until a first portion of the segment enters the opposite vertebra, an intermediate portion spans the disc space, and a second portion remains in the associated vertebra. Each segment thus forms a strut graft to promote a healthy and permanent fusion. In another embodiment, a wire is placed in the disc space and rotated to cut grooves in the vertebrae, causing a slurry of morselized cortical and cancellous bone to ooze into a cage that is placed in the disc space. The slurry heals to fuse the vertebrae solidly and permanently.

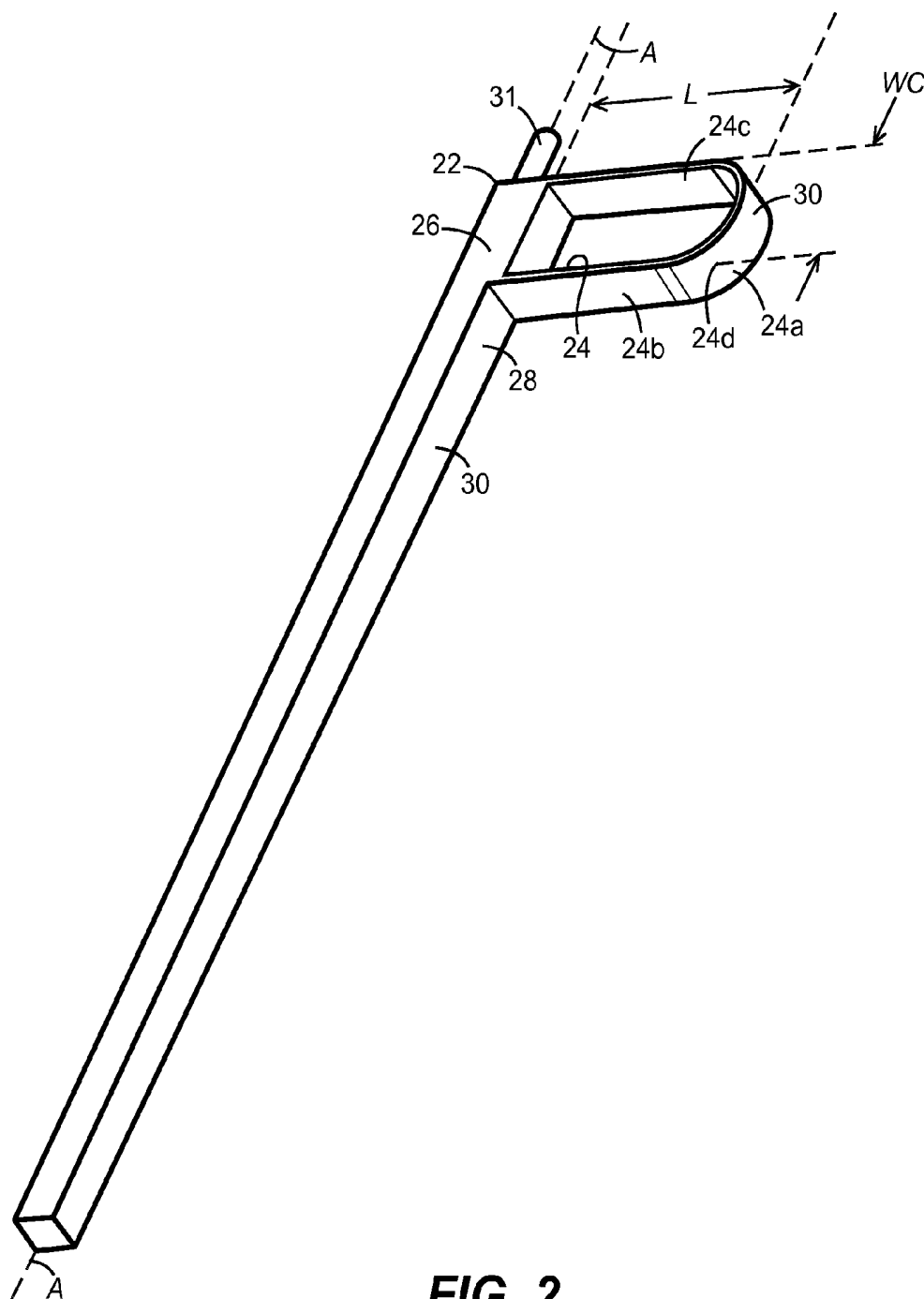


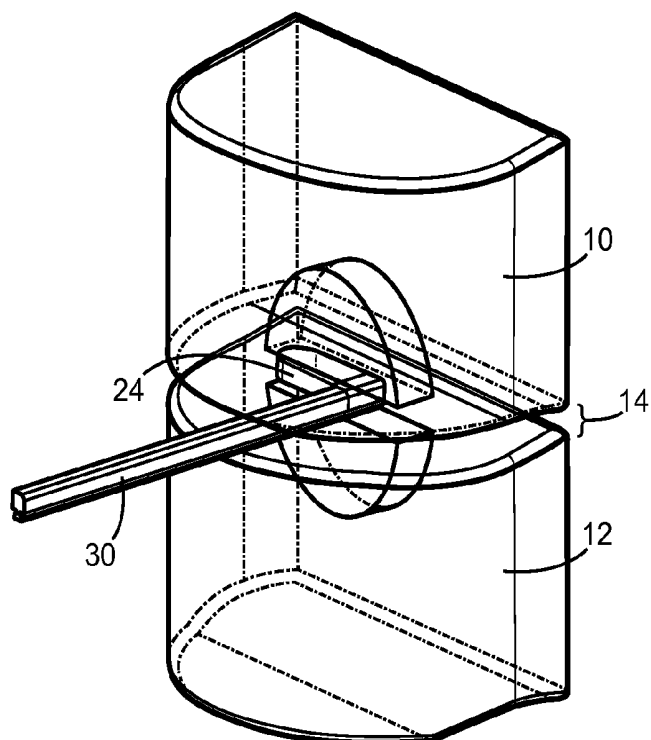


**FIG. 1**

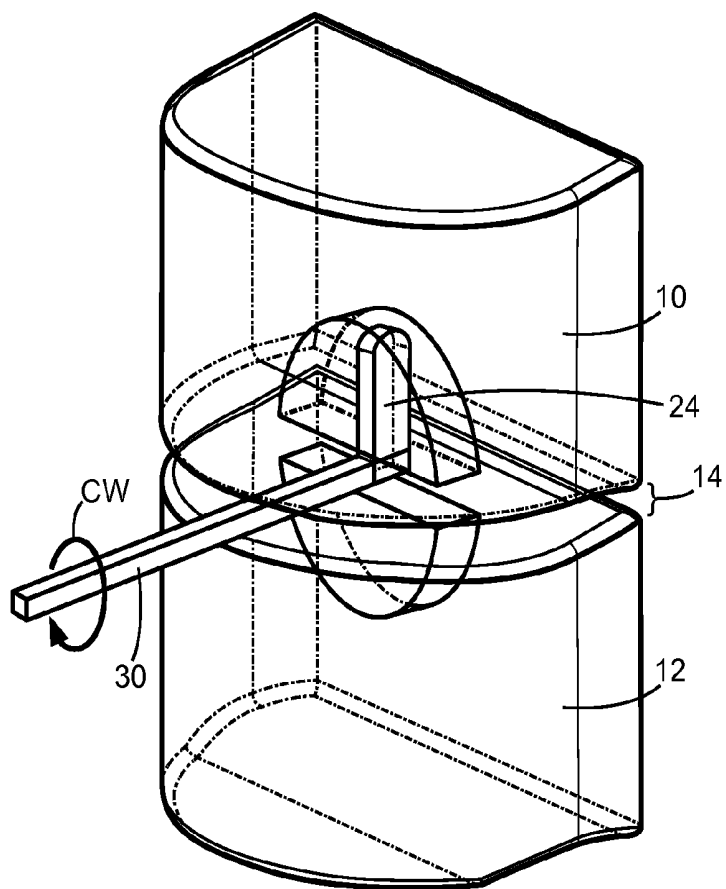


**FIG. 3**

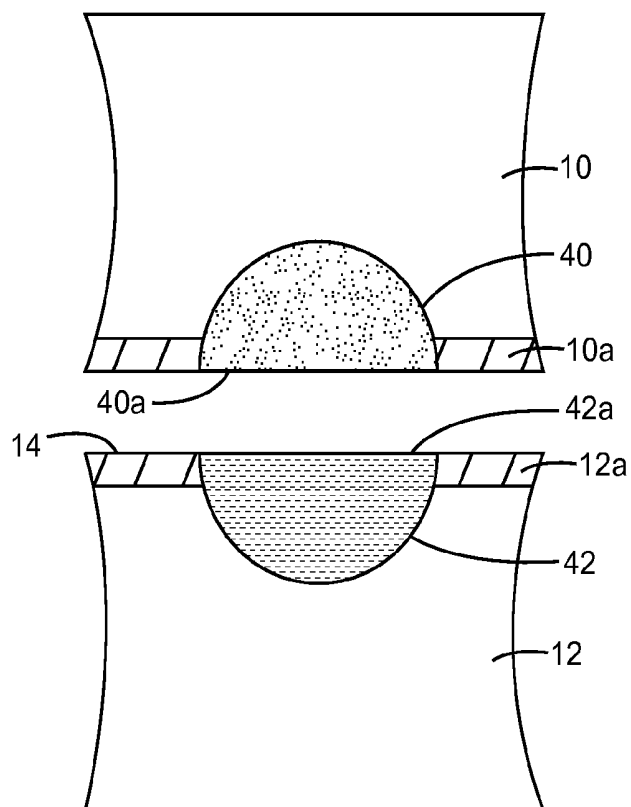




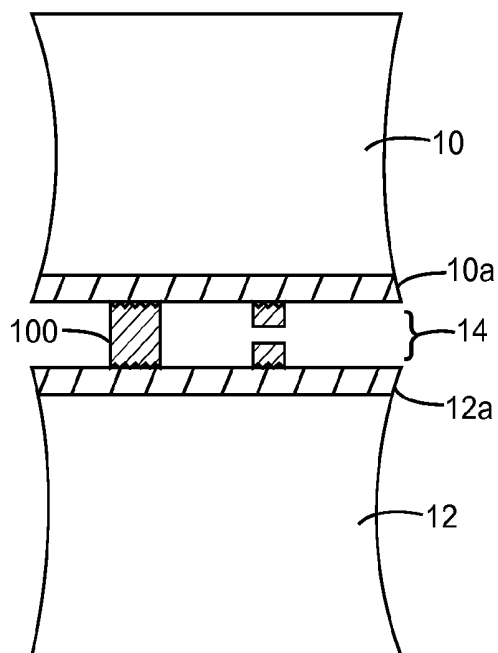
**FIG. 4**



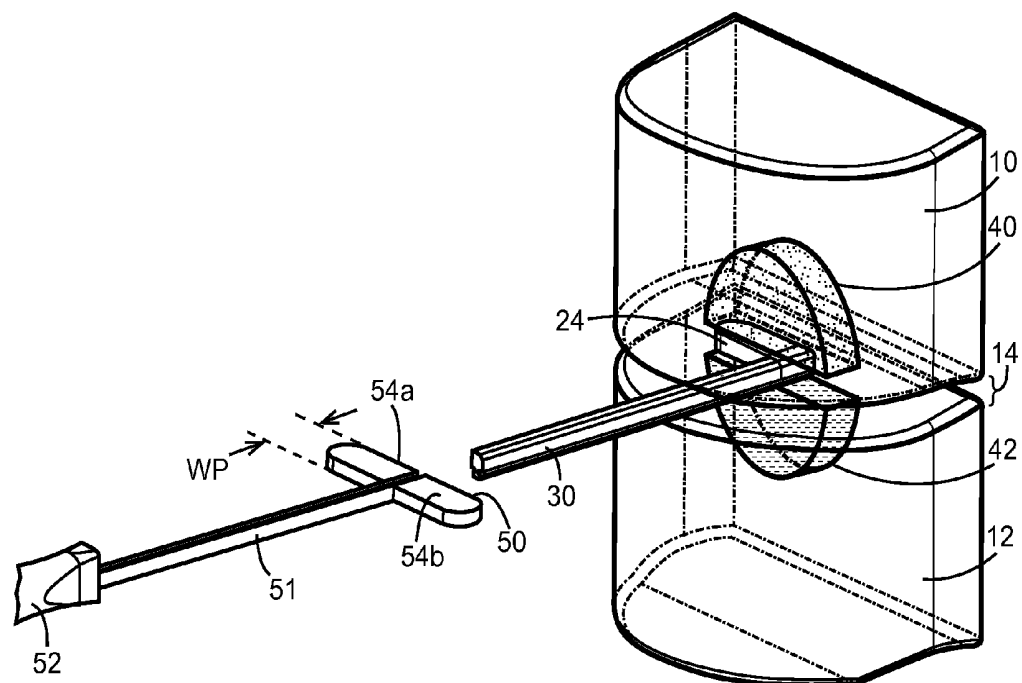
**FIG. 5**



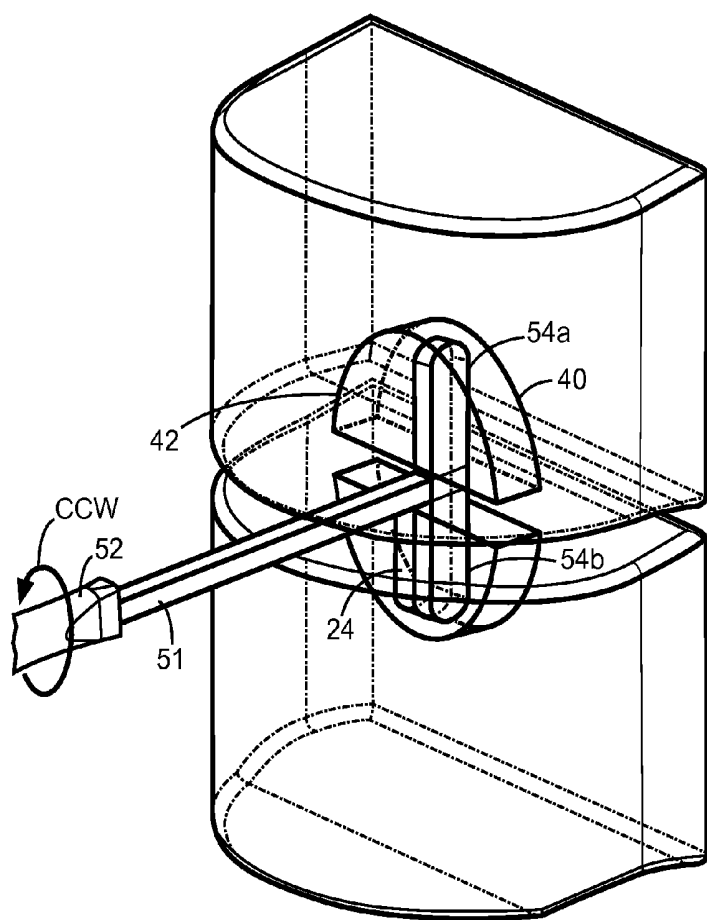
**FIG. 6**



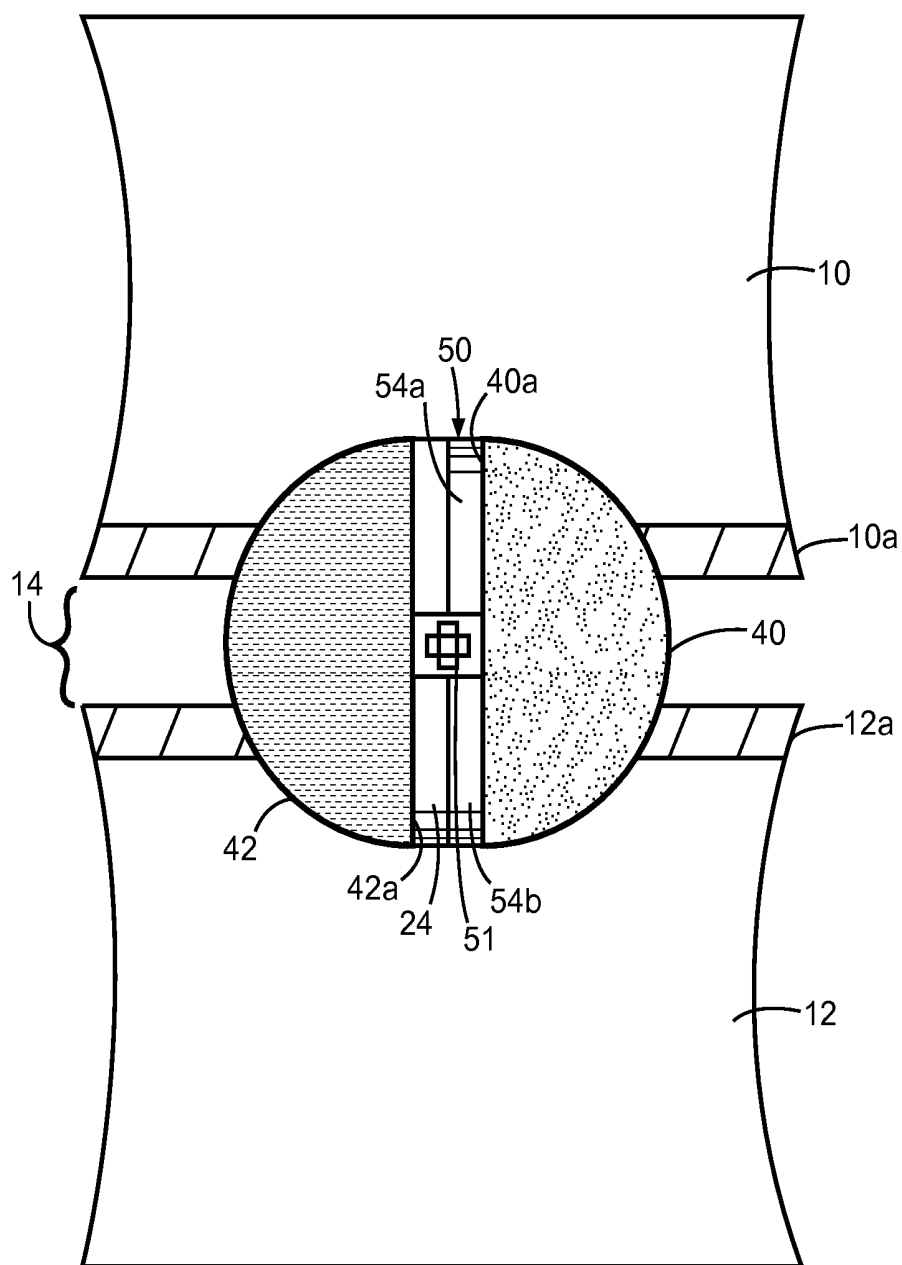
**FIG. 10**



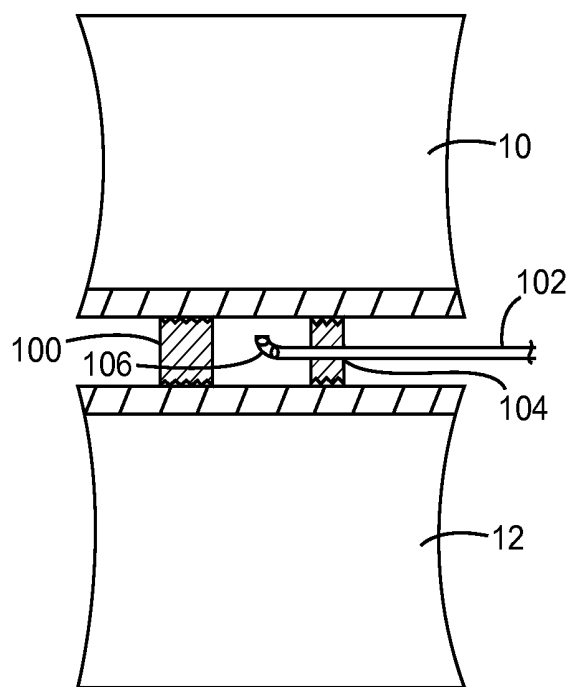
**FIG. 7**



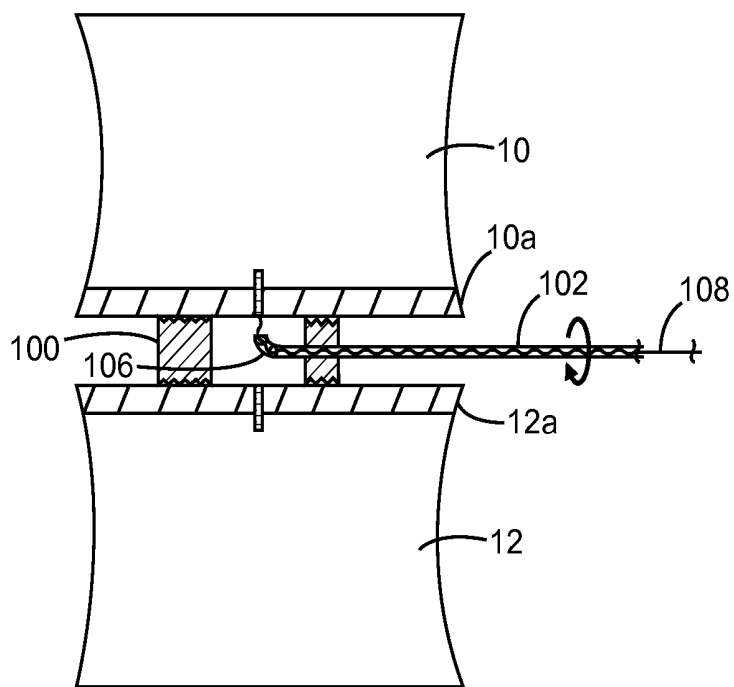
**FIG. 8**



**FIG. 9**

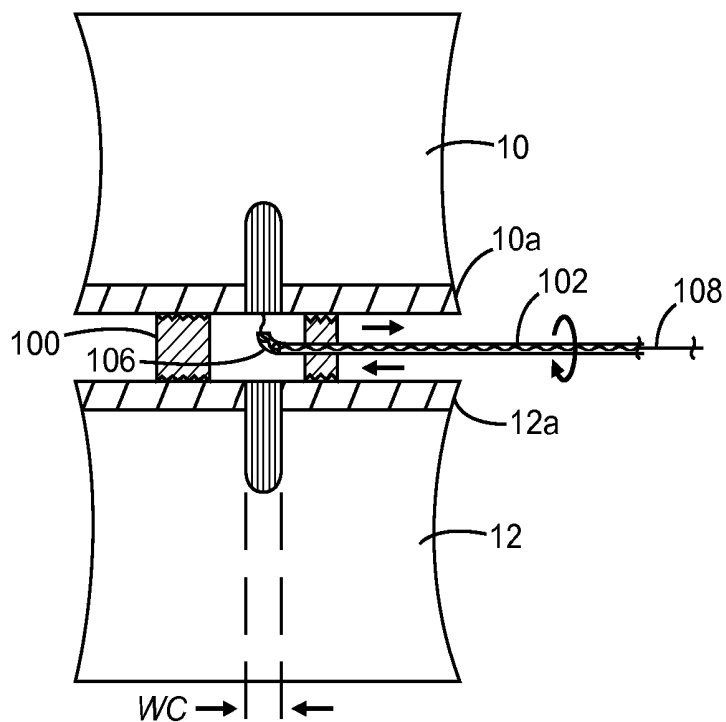


**FIG. 11**

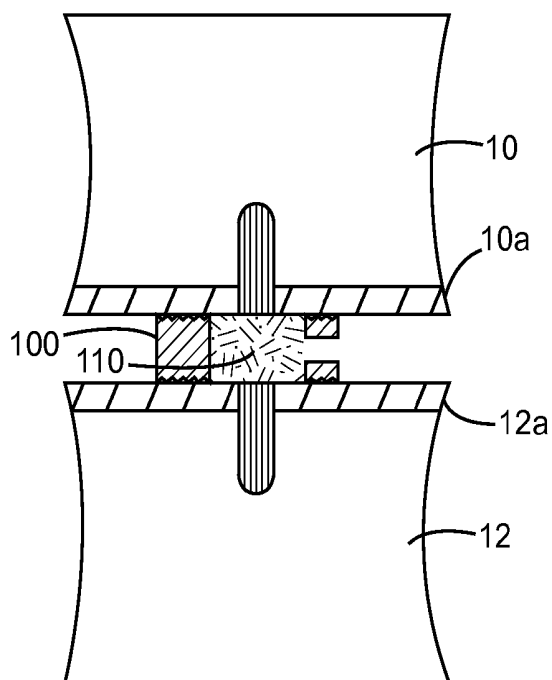


**FIG. 12**





**FIG. 13**



**FIG. 14**

# **HARVESTING BONE GRAFT MATERIAL FOR USE IN SPINAL AND OTHER BONE FUSION SURGERIES**

## **BACKGROUND OF THE INVENTION**

### **[0001] 1. Field of the Invention**

**[0002]** The present invention relates to a procedure and system for harvesting bone graft material for use in skeletal bone fusion surgery, particularly in fusions of the spinal vertebrae.

### **[0003] 2. Discussion of the Known Art**

**[0004]** An object of spinal fusion surgery is to join adjacent vertebrae at an affected level of a patient's spine by inducing growth of solid bone tissue in the intervertebral disc space. The grown bone tissue acts to fuse the vertebrae together solidly and permanently. This procedure has long been known to reduce or eliminate severe back pain suffered by a patient when he or she assumes postures that cause the vertebrae at the affected level to move relative to one another in a certain manner.

See, e.g., my pending U.S. patent application Ser. No. 14/180,495 filed Feb. 14, 2014, titled Determining and Placing Spinal Implants or Prostheses, published as US 2014/0163573 (Jun. 12, 2014), and incorporated fully by reference.

**[0005]** In a typical fusion procedure, the disc space is cleaned and bone, or a bone-like graft material, is deposited in the space to promote the growth of bone tissue between the vertebrae and produce a healthy fusion. Among the available graft materials, bone graft harvested directly from the patient's own bone tissue ("autograft") or from a donor, ceramics, bone morphogenic proteins, and/or stem cell based grafts are commonly used as bone growth stimulants. Of these, autograft obtained from the patient's iliac crest or pelvic area is known to work best to promote a successful fusion.

**[0006]** Using the patient's own bone tissue for graft material works well to form a confluence of the material with the vertebral bones to be fused. It is also known that (a) the more autograft material used, the greater the likelihood of achieving a successful fusion, and (b) a solid piece of autograft material works better than smaller chips to promote fusion. Basic principles of orthopaedic surgery suggest an optimum fusion will occur when a solid bone piece is inserted to span the entire intervertebral disc space, and when opposite ends of the piece enter or penetrate the end plates of the two vertebrae that face the disc space.

**[0007]** U.S. Pat. No. 7,201,775 (Apr. 10, 2007) discloses a procedure that calls for implanting a hollow cylindrical stabilizing device (see FIGS. 7 & 8 of the patent) between the end plates of two vertebrae to be fused, and rotating the device so that it gouges and shears off portions of the end plates, which portions are then forced inside of the device. The device has openings so that when oriented as in FIG. 11C of the patent, the bone portions inside the device are exposed to the vertebrae through the openings to promote a fusion, according to the patent. The procedure runs a risk of crushing the end plates and destroying the integrity of the remaining vertebral bone, however. That is, one or both vertebrae can become prone to fracture and compress into the spinal canal. Further, the device does not translocate or displace an intact piece of bone directly from one vertebra so as to enter the body of the other vertebra.

**[0008]** U.S. Pat. 8,328,870 (Dec. 11, 2012) describes an interbody fixation system including a cage having blades

mounted inside the cage. When the blades are turned not more than about 45 degrees as shown in FIGS. 2 and 6C of the patent, the blades bite into the end plates of the opposed vertebrae and fix the position of the cage on and between the end plates, according to the patent. See also, U.S. Pat. No. 7,618,423 (Nov. 17, 2009) which relates to a system for performing spinal fusion including a graft holder assembly, a locking assembly, and a pair of bone graft implants that are introduced into a disc space to effect fusion; U.S. Pat. No. 8,353,912 (Jan. 15, 2013) disclosing an ultrasonic cleaning device for leveling the surfaces of the vertebral end plates after the disc space is cleaned and before graft material is deposited in the space, and U.S. Pat. No. 8,343,178 (Jan. 1, 2013) describing an ultrasonic saw blade for cutting hard bone without damaging adjacent soft tissue. All of the foregoing U.S. patents are fully incorporated by reference.

**[0009]** Notwithstanding known meticulous procedures to obtain and use autograft material from a patient during a surgical procedure, there is no guarantee that a reliable and strong fusion will ultimately result, and that a so-called "non-union" will be avoided. A need therefore exists for a system and procedure for obtaining and depositing autograft material between two vertebrae to be fused so that the material spans the intervertebral disc space, enters the vertebral bodies, and grows rapidly to produce a healthy, strong, and permanent fusion.

## **SUMMARY OF THE INVENTION**

**[0010]** According to one aspect of the invention, a procedure for harvesting bone graft material for use in a skeletal bone fusion surgery, includes inserting a cutting blade to a certain position inside a space between first and second bones to be fused, and rotating the blade so that it cuts into both of the bones and forms solid bone segments within each of the first and the second bones. Each bone segment is displaced to a position at which a first end portion of the segment is located in the first bone, an intermediate portion of the segment spans the space between the two bones, and a second end portion of the segment is located in the second bone. The bone segment thus forms a strut graft that acts as a pathway for bone growth to fuse the first and the second bones with one another.

**[0011]** According to another aspect of the invention, a procedure for harvesting bone graft material for use in a skeletal bone fusion surgery, includes inserting a cutting blade to a certain position inside a space between first and second bones to be fused, and rotating the blade so that it cuts multiple grooves into the bones, and produces a slurry of morselized cortical and cancellous bone that oozes from the two bones. The slurry is confined in the region of the bones so that upon healing, the slurry becomes solid bone that fuses the first and the second bones with one another.

**[0012]** For a better understanding of the invention, reference is made to the following description taken in conjunction with the accompanying drawing and the appended claims.

## **BRIEF DESCRIPTION OF THE DRAWING FIGURES**

**[0013]** In the drawing:

**[0014]** FIG. 1 is a diagram of two adjacent spinal vertebrae to be fused with one another according to a first embodiment of the invention;

**[0015]** FIG. 2 shows a tool shaft with an associated cutting blade at a distal end of the shaft, according to the invention;

[0016] FIG. 3 is a diagram of the tool shaft in FIG. 2 inserted inside a disc space between the vertebrae in FIG. 1, and a cage to which the shaft is pivoted for rotation with the cutting blade;

[0017] FIG. 4 is an enlarged, isometric view of the tool shaft and cutting blade inserted in the disc space as in FIG. 3;

[0018] FIG. 5 is a view similar to FIG. 4, showing the cutting blade turned 90 degrees from the position in FIG. 4 by the tool shaft;

[0019] FIG. 6 illustrates two semicircular bone segments formed inside the vertebrae after the cutting blade is rotated over 360 degrees by the tool shaft;

[0020] FIG. 7 is an isometric view of a pusher or paddle fixed at a distal end of a cannulated shaft that slides over the tool shaft;

[0021] FIG. 8 is a view similar to FIG. 7, showing paddle inserted in the disc space and turned 90 degrees from the angular position of the paddle in FIG. 7 by the cannulated shaft;

[0022] FIG. 9 illustrates the bone segments in FIG. 6 forming two strut grafts between the vertebrae when the paddle is in the position shown in FIG. 8, according to the invention;

[0023] FIG. 10 shows the vertebrae in FIG. 1 to be fused with one another according to a second embodiment of the invention, including a cage placed in the disk space;

[0024] FIG. 11 shows a distal end of a cannula inserted in the disc space through an opening in a side wall of the cage in FIG. 10;

[0025] FIG. 12 shows a cutting tip of a flexible wire inserted through the cannula and into the disk space, with the tip angled toward one of the vertebrae;

[0026] FIG. 13 shows the tip of the wire cutting multiple grooves in the vertebrae when the tip is rotated and displaced laterally in the disc space by the cannula; and

[0027] FIG. 14 shows a bony slurry produced by the cut vertebrae and confined by the cage so as to fuse the vertebrae with one another, according to the invention.

#### DETAILED DESCRIPTION OF THE INVENTION

[0028] The present invention resides in harvesting bone graft material directly from bones to be fused in a surgical procedure on a patient, in situ. In the illustrated embodiment, the procedure is a spinal fusion wherein the bones to be fused are spinal vertebrae, and the harvested material spans the disc space between the vertebrae and enters the vertebral bodies. As a result, the graft material grows quickly to obtain a healthy, solid, and permanent fusion. While the invention is illustrated and described below as applied to a spinal fusion, persons skilled in the art will recognize that the invention can be applied in other bone fusion surgeries, for example, fusions of the ankle.

[0029] FIG. 1 is a diagram showing two adjacent vertebrae 10, 12 in a patient's spine. The spine has an axis S, and the two vertebrae 10, 12 are separated by a disc space 14. The vertebrae have end plates 10a, 12a that face one another across the disc space 14.

[0030] In one embodiment of the invention, shown in FIGS. 2 to 9, a bone cutter 20 has a base 22 and a generally U-shaped, two-dimensional ultrasonic cutting blade 24. The blade 24 has a cutting edge 24a formed along legs 24b, 24c, and a closed end 24d of the "U" shaped blade 24. As shown in FIG. 2, the blade legs 24b, 24c are spaced apart by width WC, and the closed end 24d of the blade is at a length L from the bone cutter base 22. The base 22 is fixed at 26 to a distal end

28 of a tool shaft 30 having an axis A, and the tool shaft 30 has an axial pivot 31 extending from the distal end 28. As seen in FIG. 3, the pivot 31 at the distal end 28 of the shaft 30 is received in a corresponding pivot opening 32 formed in a spacer or cage 33 after the cage is placed in the disc space 14 between the vertebrae 10, 12.

[0031] The cage 33 can be formed of a surgical metal, polymer, ceramic, or composites thereof. In addition to providing a common axial pivot or anchor point for the tool shaft 30 and other instrumentation to be aligned between the end plates 10a, 12a of the vertebrae, the cage 33 supports the vertebral bones 10, 12 above and below the disc space 14 to prevent subsidence of graft bone segments obtained as described below. The cage 33 also enhances the stability of the entire construct to ensure a successful fusion.

[0032] If surgery is performed using a posterior approach, the cage 33 enters the disc space 14 from the posterior side, and should be urged anteriorly as far as possible to lodge against the disc annulus while the vertebral bones 10, 12 compress against the cage. To provide an effective anchor point for the pivot 31 on the tool shaft, the cage 33 should be relatively large and have a curvilinear shape to conform with the anterior disc space occupied by the cage 33. Cages usually have an aperture to allow bone graft material to be deposited inside them, and for the material to contact vertebrae above and below the cage so that a solid bond between the vertebrae will grow through the cage itself.

[0033] Because, as explained below, the inventive procedure obtains bone graft material directly from the vertebrae to be fused rather than an outside source, it is therefore not critical for the cage 33 to act primarily as a fusion device. The cage 33 can work mainly as a fixation device that connects to the vertebral bones 10, 12 above and below the cage. An example of a suitable cage that also acts as a fixation device is available from Biomet, Inc., as the C-THRU™ Anterior Spinal System. The Biomet cage has with a large chamber that opens at the superior and inferior (top and bottom) ends of the cage for in which graft material can be packed. Although the cage 33 as shown in FIG. 3 is not centered directly beneath the portions of the vertebrae 10, 12 to be cut, it may be desirable to use a cage such as the Biomet with a chamber that opens at both ends, and to form an opening in a side of the cage to allow the cutting blade 24 at the distal end of the tool shaft 30 to pass into the chamber. The cage 33 can then be centered directly beneath the facing surfaces on the bones 10, 12 to be cut. (See FIG. 11, cage 100).

[0034] As seen in FIG. 2, the "U" shape cutting blade 24 extends radially outward from its base 22 at the distal end 28 of the tool shaft 30. The legs 24b, 24c and the closed end 24d of the blade 24 extend in a plane that coincides with the shaft axis A. The bone cutter 20 including the cutting blade 24 is dimensioned and configured to be inserted with the tool shaft 30 to a desired position in the disc space 14, with the plane of the cutting blade 24 held generally parallel to the end plates 10a, 12a of the vertebrae to be fused, as shown in FIG. 4. The cutting edge 24a of the blade 24 is activated, for example, by a conventional ultrasonic driver coupled to the tool shaft 30 in a known manner. Ultrasonically energized bone cutting blades are known generally, and persons skilled in the art can construct and use the blade 24 as described herein. See, e.g., the website at [www.misonix.com](http://www.misonix.com).

[0035] In the inventive procedure, the tool shaft 30 is rotated about the shaft axis A by, e.g., a removable or cannulated handle (not shown in the drawing) having an axial thru

passage that is keyed to a cross sectional profile of the shaft, or by a flexible motor drive, so that the cutting edge **24a** of the blade **24** is urged over a circular path that cuts into the vertebral end plates and adjacent regions inside the vertebrae **10**, **12**. See FIG. 5. As a result, as depicted in FIG. 6, the cutting blade **24** forms two solid, semicircular bone segments **40**, **42** in the vertebral bodies **10**, **12** wherein the radius of each segment **40**, **42** corresponds to the length **L** of the blade **24** from the shaft axis **A**, and the thickness of each segment corresponds to the spacing **WC** between the blade legs **24b**, **24c**.

[0036] The bone segments **40**, **42** are comprised of autologous graft material that is then used to form strut grafts between the same vertebrae **10**, **12** from which the grafts are formed. Note that in FIG. 6 that flat surfaces **40a**, **42a** of the segments are exposed to face one another across the intervertebral disc space **14**. While the tool shaft **30** may be withdrawn with the cutting blade **24** from the disc space **14** at this time, it is preferred that the shaft and the blade remain in place as noted below.

[0037] After removing a handle or other drive from the tool shaft **30**, and as shown in FIGS. 7 to 9, an elongated pusher or paddle **50** is inserted into the disc space **14** until the paddle overlies the cutting blade **24** and extends substantially entirely over the exposed flat surfaces of the vertebral bone segments **40**, **42**. In the disclosed embodiment, the paddle **50** is formed at a distal end of a cannulated shaft **51** whose axial passage is keyed to the cross section of the tool shaft **30**. The cannulated shaft **51** is slid over the tool shaft **30**, a handle **52** is provided at the proximal end of the shaft **51**, and the paddle **50** is inserted inside the disc space **14**. Using the handle **52**, the paddle **50** is rotated (together with the blade **24** if left in place) through the same circular path initially cut by the blade **24** through the vertebrae **10**, **12**.

[0038] If the cage **33** is of such size that it encompasses areas of the vertebral end plates **10a**, **12a** that will be cut by the blade **24**, the blade **24** and the paddle **50** must then be able to be inserted and operate within the perimeter of the cage. In such a case, the cage may be formed with a through passage between its anterior and posterior facing side walls. The dimensions of the passage must be such as to allow of the tool shaft **30** with the bone cutting blade **24**, the cannulated shaft **51** with the paddle **50**, and any other needed instrumentation to pass and operate inside the cage **70** when performing the inventive fusion procedure.

[0039] In the illustrated embodiment, the paddle **50** has two "U" shaped arms **54a**, **54b** that extend outward and 180 degrees apart from one another as shown in FIGS. 7 to 9. Each paddle arm **54a**, **54b** has a width **WP** that does not exceed the width **WC** of the bone cutter blade **24**. Likewise, the length of each paddle arm **50a**, **50b** does not exceed about one-half the length of either of the exposed surfaces **40a** or **42a** of the bone segments **40**, **42** facing the disc space **14**. The entire paddle **50** may also be formed from one or more balloons which, when inflated, take the form of a rigid pusher or paddle device.

[0040] When the paddle **50** is inserted in the disk space **14**, the paddle arms **54a**, **54b** are generally parallel to and overlie the exposed surfaces **40a**, **40b** of the bone segments **40**, **42** formed by the blade **24**. The cannulated shaft **51** is turned about its axis **A** until each paddle arm **54a**, **54b** abuts the exposed surface of one of the bone segments, and the shaft **51** is turned about 90 degrees farther so that the paddle arms **54a**, **54b** urge the bone segments **40**, **42** to rotate in unison within their associated vertebra until, as shown in FIG. 9, (i) a lead-

ing portion of each segment **40**, **42** enters the vertebra opposite the vertebra in which the segment was formed, (ii) a central portion of each segment spans the disc space **14** entirely, and (iii) a trailing portion of each segment remains inside the vertebra in which it was formed.

[0041] When displaced as described above and shown in FIG. 9, each one of the bone segments **40**, **42** forms a vertical bridge strut graft that completely spans the disc space **14** and also enters the vertebrae **10**, **12** above and below the space. Each strut graft acts as a pathway for bone growth and promotes a healthy fusion of the vertebrae. The tool shaft **30** is then withdrawn from the cage **33** inside the disc space **14**, and the paddle **50** and the blade **24** can remain in a vertical orientation between the displaced bone segments **40**, **42** without affecting the quality of the ensuing fusion.

[0042] After the cutting blade **24** cuts through the vertebrae **10**, **12**, and especially after the bone segments **40**, **42** are rotated, there will likely be a massive release of blood since the bone is very vascular. Accordingly, in addition to inserting and using a cage such as the mentioned Biomet device for the cage **33** in the disk space **14**, a system should be in place to extinguish such hemorrhaging. One approach is to use a coagulating agent such as, for example, the Surgiflo® Hemostatic Matrix available from Ethicon US, LLC, and injecting the agent through an applicator tube into a port formed on the cage **33**. Also, with much bleeding, there may be a need to seal the disc space **14** so that the coagulating agent stays within the disc space. That is, the disc space **14** may need to be capped or sealed closed to confine the blood, the coagulating agent, and the graft bone segments within the disc space. With the coagulating agent injected into the closed disc space which provides a pressurized environment, bleeding will stop.

[0043] Further, the cage may also have ports so situated that the coagulating agent makes a seal between the upper and the lower surfaces of the cage, and the adjacent vertebral bone. This would prevent bloody fluid from escaping above and below the cage through small gaps.

[0044] When the paddle **50** is rotated, it is urged against the exposed surfaces **40a**, **42a** of the bone graft segments **40**, **42** after the segments were cut and formed by the blade **24**. The paddle **50** does not occupy any space in which new bone graft is being deposited. That is, the paddle **50** is not embedded in any new bone growth, but remains in a final vertical position with the bone segments **40**, **42** at each side, and with the vertebral bones **10**, **12** above and below the paddle.

[0045] As the bones **10**, **12** heal and the graft bone segments **40**, **42** grow, the paddle **50** becomes firmly anchored inside the vertebrae **10**, **12** and thereby adds stability to the overall construct by pinning the vertebrae together. To that end, the paddle **50** may be constructed, for example, with extensible pins to engage the exposed surfaces **40a**, **42a** of the bone segments and/or the vertebrae **10**, **12** above and below the paddle **50**. Such engagement would stabilize the entire construct and ensure that the paddle **50** and the graft bone segments **40**, **42** do not migrate. Together with the cage **33**, the paddle **50** also prevents subsidence with collapse of the disc height.

[0046] It is also possible for the paddle **50** to be constructed of balloons so that, if desired after inflation and use, the paddle can be deflated and easily removed after it is rotated to a vertical position with the bone segments **40**, **42** at either side. In such an embodiment, however, any additional fixation that would otherwise result from using a more solid form of

the paddle **50** will not be realized unless the balloons are later filled with a material such as, e.g., methyl methacrylate that hardens in place.

[0047] The paddle **50** may also be constructed in a known manner so that the two arms **54a**, **54b** of the paddle overlie one another at one side of the cannulated shaft as the paddle is being inserted inside the disc space **14**. When between the vertebrae **10**, **12**, one of the arms may then be displaced to the opposite side of the shaft so that the paddle extends fully across the exposed surfaces **40a**, **42a** of the bone segments above and below the paddle.

[0048] It is preferable that the solid bone cutting blade **24** remain in situ, and no attempt made to withdraw the blade from between the bone segments **40**, **42** after the blade forms the segments and the paddle **50** is inserted into the disk space **14**. This ensures the paddle **50** will displace the bone segments **40**, **42** over the identical path cut by the blade **24** through the vertebrae **10**, **12**, since a variance of even one millimeter to either side of the path can cause the paddle **50** to lock against solid uncut vertebral bone and prevent the paddle from displacing the segments **40**, **42** fully to the positions in FIG. 9. If the cage **33** provides enough precision with respect to the position of the blade **24** and the paddle **50** during use, however, it may be possible to remove the cutting blade **24** prior to inserting and using the paddle **50**.

[0049] The above procedure has the following features:

[0050] 1. The bone cutting blade **24** can be activated ultrasonically to make the vertebral cuts safely and precisely;

[0051] 2. The cutting blade **24** and the paddle **50** can be made small enough to be inserted into the intervertebral disc space **14** during a minimally invasive surgical procedure; and

[0052] 3. In addition to adding stability to the construct, the cage **70** provides a common pivot point for the rotation of the bone cutting blade **24** and the paddle **50**, to ensure the bone segments **40**, **42** are displaced smoothly and accurately by the paddle after being formed by the blade.

[0053] Another embodiment of the inventive system and procedure is illustrated in FIGS. **10** to **14**. Instead of cutting and forming the solid autograft segments **40**, **42** and displacing them as described above, a bone cutting instrument having a straight rather than a two-dimensional or "U" shaped cutting edge like the blade **24** is inserted into the disc space **14** instead. The instrument is operated to strike the vertebral bones **10**, **12** and groove them in such a way that a slurry of morselized cortical and cancellous bone rich in osteogenic cells and blood oozes from the vertebrae. By confining the slurry within the disc space **14**, the slurry also remains present in the vertebrae **10**, **12**, and thus forms a solid bony fusion of the two vertebrae.

[0054] A cage **100** is set in the disc space between the vertebrae **10**, **12**. See FIG. **10**. The cage **100** may be similar to the earlier mentioned Biomet C-THRU Anterior Spinal System device, or equivalent. In addition, the cage **100** should have sufficient size and volume to contain and confine the slurry to be produced from the vertebrae as detailed below, and be constructed so its edges seal any gaps between the cage and either bone **10**, **12**. As described above with respect to the embodiment of FIGS. **1** to **9**, such sealing prevents liquid graft material from migrating outside the internal chamber of the cage **100** and the intervertebral disc space. For example, a seal can be formed by constructing the cage **100** with internal and/or external channels that guide a sealing agent around the circumference of the superior and inferior edges of the cage **100**, and the agent can be injected into the cage during the

procedure. The mentioned Surgiflo® Hemostatic Matrix is an example of such a sealing agent.

[0055] As seen in FIGS. **11** to **13**, a cannula **102** is inserted through an opening **104** in the wall of the cage **100**, and the cannula **102** has a distal tip **106** that is angled toward the vertebrae above and below the perimeter of the cage. A flexible, sharp tipped wire **108** is inserted through the cannula **102**, past the distal tip **106** of the cannula, and against the end plate **10a** or **12a** of a confronting vertebra. A motor or other drive mechanism coupled to a proximal end of the cannula **102** spins the cannula so that the sharp tip of the wire **108** cuts into the end plates **10a**, **12a** of both vertebrae **10**, **12**.

[0056] The wire **108** is pushed farther into the cannula **102** so that the wire tip cuts a groove completely through the end plates and adjacent regions of the vertebrae **10**, **12**, as seen in FIG. **12**. The position of the wire **108** at the tip **106** of the cannula is adjusted and the cannula **102** is moved axially in anterior and posterior directions so that the combined width WC of all the vertebral cuts is increased as desired. See FIG. **13**. The cannula **102** and wire **108** are then withdrawn from inside the cage **100** and the disc space.

[0057] As a result and as shown in FIG. **14**, all of the bony slurry **110** obtained from the cut vertebrae will either be contained inside the cage **100** in the disc space, or within the vertebrae **10**, **12** in the region of the grooved cuts. Upon healing, the slurry forms a solid bony fusion of the vertebrae. If needed, a second cage or other device can be provided to cap or otherwise seal the cage **100** and the disc space to ensure the slurry stays so confined before healing.

[0058] While the foregoing represents preferred embodiments of the invention, it will be understood by those skilled in the art that various modifications, adaptations, and additions may be made without departing from the spirit and scope of the invention. For example, while the invention is described herein as applied to a spinal fusion, the invention may be adapted for other bone fusion procedures as well, for example, ankle bone fusions. Accordingly, invention includes all such modifications, adaptations, and additions that are within the scope of the following claims.

I claim:

1. A procedure for harvesting bone graft material for use in a skeletal bone fusion surgery, comprising:

inserting a cutting blade to a certain position inside of a space between first and second bones to be fused;

rotating the cutting blade so that it cuts into the first and the second bones and forms solid bone segments within each of the first and the second bones;

urging each bone segment out of an associated bone so that a first end portion of the segment enters the opposite bone, an intermediate portion of the segment spans the space between the two bones, and a second end portion of the segment remains in its associated bone; and

each bone segment forming a strut graft that acts as a pathway for bone growth, thereby fusing the first and the second bones with one another.

2. The bone harvesting procedure of claim 1, wherein the first and the second bones are first and second vertebrae to be fused in a patient's spine, and the cutting blade is inserted to a position inside of a disc space between the first and the second vertebrae.

3. The bone harvesting procedure of claim 1, including arranging an ultrasonic driver for energizing the cutting blade.

4. The bone harvesting procedure of claim 1, wherein after the cutting blade rotating step, flat surfaces of the bone segments are exposed to face one another across the space between the first and the second bones.

5. The bone harvesting procedure of claim 4, including placing a pusher or paddle into the space between the first and the second bones for performing the urging step.

6. The bone harvesting procedure of claim 1, including inserting a cage to a position inside the space between the first and the second bones, so that the cage is compressed between the two bones.

7. The bone harvesting procedure of claim 6, including constructing the cage to provide a pivot point for a distal end of a first tool shaft, and the cutting blade is mounted at the distal end of the first tool shaft when performing the cutting blade inserting and rotating steps.

8. The bone harvesting procedure of claim 7, including mounting the paddle at a distal end of a cannulated tool shaft, and sliding the cannulated tool shaft over the first tool shaft to perform the bone segment urging step.

9. A procedure for harvesting bone graft material for use in a skeletal bone fusion surgery, comprising:

placing a cage to a certain position inside a space between first and second bones to be fused, whereby portions of the bones are exposed to an inside region of the cage;

inserting a cutting blade or wire into the inside region of the cage to a position at which a cutting tip of the blade or wire faces the exposed portions of the first and the second bones;

rotating the cutting blade or wire and cutting multiple grooves into the bones, thereby producing a slurry of morselized cortical and cancellous bone that oozes from the bones;

confining the slurry within the inside region of the cage; and

upon healing, the slurry becoming solid bone that fuses the first and the second bones with one another.

10. The bone harvesting procedure of claim 9, wherein the first and the second bones are first and second vertebrae to be fused in a patient's spine, and the cutting blade or wire is inserted to a position inside of a disc space between the first and the second vertebrae.

11. The bone harvesting procedure of claim 9, including sealing the cage for preventing the confined slurry from escaping.

12. The bone harvesting procedure of claim 9, including arranging a cannula for entering the cage from outside so that a distal end of the cannula is within the inside region of the cage, and inserting the cutting blade or wire through the cannula and into the inside region of the cage at the distal end of the cannula.

13. The bone harvesting procedure of claim 12, including performing the rotating step by rotating the cannula about its axis after the cutting blade or wire is inserted through the cannula into the inside region of the cage.

14. The bone harvesting procedure of claim 13, including adjusting the position of the cutting blade or wire at the distal end of the cannula and moving the cannula axially in anterior and posterior directions, thereby increasing a combined width of the multiple grooves cut into the first and the second bones as desired.

\* \* \* \* \*

专利名称(译)	收获用于脊柱和其他骨融合手术的骨移植材料		
公开(公告)号	<a href="#">US20160113779A1</a>	公开(公告)日	2016-04-28
申请号	US14/524044	申请日	2014-10-27
[标]申请(专利权)人(译)	NEUBARDT SETH 大号		
[标]发明人	NEUBARDT SETH L		
发明人	NEUBARDT, SETH L		
IPC分类号	A61F2/44 A61B17/16		
CPC分类号	A61B17/1671 A61F2/4455 A61B17/1635 A61B2017/320077 A61F2/4601 A61F2/4611 A61F2002/4649		
其他公开文献	US9833332		
外部链接	<a href="#">Espacenet</a> <a href="#">USPTO</a>		

#### 摘要(译)

一种用于收集用于脊柱和其他融合手术的骨移植材料的技术。在所公开的实施例中，骨切割刀片放置在两个待融合的椎骨之间的椎间盘空间中。刀片切入椎骨并在每个椎骨内形成自体骨的固体段。每个骨段被推出其相关的椎骨，直到该段的第一部分进入相对的椎骨，中间部分跨越椎间盘空间，第二部分保留在相关的椎骨中。因此，每个节段形成支柱移植体以促进健康和永久的融合。在另一个实施例中，将线放置在椎间盘空间中并旋转以切割椎骨中的凹槽，使得颗粒状皮质骨和松质骨的浆液渗入放置在椎间盘空间中的笼中。浆液愈合以牢固和永久地融合椎骨。

