METHOD FOR INTERBODY FUSION OF THE SPINE

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Filed: June 14, 1972

Appl. No.: 262,687

U.S. Cl. .................. 128/305, 408/30, 408/68
Int. Cl. A61b 17/32, B23b 51/08, B23b 47/00
Field of Search ........ 128/305, 310; 408/30, 68

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ABSTRACT

Three units of surgical apparatus for interbody fusion of the spine and method of use. The first unit consists of an intervertebral mortising chisel with the inner drill bit used to remove a block of tissue of specified dimension. The second unit consists of the bone plug cutter with the inner bone plug ejector used to obtain bone plug of the same chosen dimension of the intervertebral mortising chisel unit. The third unit consists of the bone plug injector and the inner bone plug injector rod used to inject bone plug removed from the graft site by the bone plug cutter and placing the bone plug into the bone plug injector where the bone plug can be injected into the space which was originally created by the first unit, the intervertebral mortising chisel.

6 Claims, 21 Drawing Figures
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METHOD FOR INTERBODY FUSION OF THE SPINE

BACKGROUND OF THE INVENTION

It has been our practice to perform posterior approach interbody fusion. The procedure involves the usual midline incision; bilateral laminectomy as well as removing the inferior half of the inferior facet of the vertebra above and the superior half of the superior facet of the vertebra below at the particular interspace to get access of space to perform interbody fusion. Once the nerve root is carefully examined and gently retracted toward midline, the intervertebral disc is incised and excised, followed by curettment with round or ring curet and removed piecemeal with pituitary ronguers of various designs. It has always been customary to use osteotomes to remove the cartilaginous surface of the superior plate of the vertebra below and the inferior plate of the vertebra above, at the interspace, followed by further curettment with round or ring curets to bleeding cancellous bone surfaces before a rectangular bone graft is impacted at the interspace, bilaterally. The general technics of interbody fusion of the intervertebral disc space are not new and the anterior or the posterior approach to perform interbody fusion has been known for many years. The apparatus and/or instruments have been osteotomes, curets of various types and sizes, vibratory tool for burring holes of various dimensions, instrument for providing a round dowel with guards for various depths have been commonly devised and used.

SUMMARY OF THE INVENTION

The present invention provides for removal of a rectangular block of intervertebral tissue of specified dimension with guarded depth for safety, as well as being able to obtain and inject a well fitted bone graft of the same dimension into the intervertebral space with safety and less time. With the apparatus of the invention, interbody fusion of the spine, both posterior and anterior approach, becomes a great deal simpler.

The present invention consists of three units, whereby the intervertebral mortising chisel can remove a rectangular block of tissue of specified dimension to suit the individual's intervertebral disc space with depth indicator for safety purposes, bilaterally. The bone plug cutter unit, of the same chosen dimension, enables one to remove a bone plug from the graft site — usually the posterior iliac crest — and ejected by the bone plug ejector of the same unit to be placed into the bone plug injector of the same chosen dimension, to be injected into the intervertebral space, a rectangular space, created by the mortising chisel to complete the perfectly tailored graft in place. Of course, the three unit apparatus will be used on the contralateral side in the same fashion so that two bone plugs, of the same chosen dimension, will be created at the desired intervertebral space. The method and apparatus can be used for anterior or posterior approach interbody fusion as well as for many other procedures whereby a specified dimension of bone block is to be removed for one reason or another when a rectangular bone graft of the same dimension is desired.

A rectangular bone graft is superior to the round dowel because it creates positive locking, less rolling action resulting in earlier fusion at the interbody space.

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BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a lateral view of a bone plug at an intervertebral space and showing the manner in which the upper and lower facets are cut.

FIG. 2 is an anterior-posterior view of the intervertebral space with two bone plugs in place upon completion of the interbody fusion.

FIG. 3 is the actual size of a bone plug, 3/8 × 1/2 × 1 inch depth.

FIG. 4a is a side elevational view of the bone plug cutter.

FIG. 4b is a side elevational view of the bone plug ejector removed from the bone plug cutter.

FIG. 5 is an elevational view of the bone plug cutter with the bone plug ejector inserted and illustrating the end cavity which receives the bone plug.

FIG. 6a is a side elevational view of the intervertebral mortising chisel.

FIG. 6b is a top plan view of the chisel of FIG. 6a.

FIG. 6c is a side elevational view of the drill bit which is received by the intervertebral mortising chisel.

FIG. 7 is an end elevational view of the intervertebral mortising chisel with the drill bit inserted.

FIG. 8 is a lateral view showing the mortising chisel at the intervertebral space.

FIG. 9 is an anterior-posterior view showing the opening 5 for the bone plugs as cut by the mortising chisel.

FIG. 10 is a lateral view showing the intervertebral mortising chisel inserted at a cut intervertebral space with the drill bit inserted to ream out the intervertebral disc material, as well as fabrocartilaginous material, within the mortising chisel.

FIG. 11 is a sectional view along line 11—11 of FIG. 10 showing the mortising chisel and drill bit at the interspace.

FIG. 12a is a side elevational view showing the bone plug injector which receives the bone plug injector rod.

FIG. 12b is a partial top plan view of the injector of FIG. 12a.

FIG. 12c is a side elevational view of the injector rod.

FIG. 13 is an end elevational view along line 13—13 of FIG. 12a of the bone plug injector with the bone plug injector rod inserted.

FIG. 14 is a view of the bone plug injector with the bone plug injector rod in place ready to enter the space created by the intervertebral mortising chisel.

FIG. 15 is a view with the bone plug injector holding the bone block at its end, inserted at the space created by the intervertebral mortising chisel with the bone plug injector rod in place prior to injection of the bone plug.

FIG. 16 is a view showing the bone plug injector injecting the bone graft into the space created by the intervertebral mortising chisel with the bone plug injector rod pushing the bone plug firmly in place while the bone plug injector slides upwards, outside of the bone plug injector rod; and

FIG. 17 illustrates actual end dimensions of 3/8 × 1/2 inch, 1/4 × 1/4 inch, 1/2 × 5/8 inch and 7/16 × 5/16 inch for four intervertebral mortising chisels.
DETAILED DESCRIPTION OF THE INVENTION

APPARATUS

FIG. 1 shows a portion of the lumbar region of the spinal column and shows an upper vertebra 20 and a lower vertebra 22 separated by a spinal disc 24. An inferior portion 25 of the inferior facet 26 is removed along the cutting line 27 and a superior portion 28 of the superior facet 29 is removed along the cutting line 30. This provides access to a portion of the vertebra on each side of the disc so that portions 20a and 22a on each side of the disc 24 can be removed along with a portion of the disc 24 to provide a cavity for a bone plug 32. FIG. 2 shows an anterior-posterior view of the intervertebral space with identical one plugs 32 in place at the completion of the interbody fusion and FIG. 3 shows size of bone plug 32 having dimensions of ½ x ¾ x 1 inch in length. The cross sectional size of the bone plug can vary while preferably the length of the bone plug remains about constant.

FIGS. 4a, 4b and 5 illustrate a bone plug cutter by which a bone plug is obtained for insertion into a cavity. The bone cutter 40 comprises a handle portion 41 containing a cylindrical passage 42 connected with an enlarged cylindrical passage 43 in the chisel portion 44. The cutting end 44a of the chisel portion 44 is tapered outwardly and includes an enlarged cavity 46 having the exact dimensions of a desired bone plug. For instance, the bone cutter 40, to obtain the plug of FIG. 3, would require a cavity 46 extending 1 to the step 46a and having the transverse interior dimensions of exactly ½ x ¾ inch. The bone cutter can be hammered into posterior iliac crest to obtain the required two bone blocks or plugs of identical dimensions. A bone plug ejector 48 is illustrated in FIG. 4b and after the bone plug is received in cavity 46 of the cutter 40, the ejector can be inserted through passage 42 in order to push out the bone plug from the cavity 46.

The intervertebral mortising chisel 50, illustrated in FIGS. 6a and 6b, has a body 51 with an enlarged end 52 for supporting handle portions 48. The body portion 51 contains a passage 49 which connects with a cavity 53 terminating in cutting end 58b. The side 54a of the chisel contains an opening 56 and sides 54b are slightly reduced to form stops 57 and 58 on each of the sides. The chisel end 58b has a tapered cutting edge 58a leading into the cavity 53. The end stops 57, 58 are located exactly 1" from the cutting edge 58a and the stops also carry an indicator line 59 which is exactly ⅜ inches from the chisel end 58b. The chisel end is inserted into the spinal column until the stops on the two faces 54b are reached or until the line 59 is reached, depending on the judgment of the surgeon. FIG. 8 illustrates the final position of the chisel end 58a.

The outside of the chisel formed by surfaces 54a and 54b extending from chisel end 58b have the identical dimensions of the bone plug of FIG. 3 and since the cutting edge 58a tapers inwardly towards the cavity 53, the chisel will cut in the spinal column a transverse section corresponding exactly to the bone plug. After the chisel end is inserted to the desired length, the cavity 53 contains portions 20a and 22a of vertebrae 20 and 22 and a section of disc 24 which are then removed by the insertion of the drill bit 62 through the passages 49 and 53 in the chisel. The drill bit (See FIG. 6c) has a shank 63 positioned by cavity 49 in the chisel and has an end drill portion 64 which is substantially the same diameter as the narrower dimension of the cavity 53. The enlarged end 65 receives a handle 66 which is secured in place by lock screw 67. Rotation of the drill bit by gripping knob 68 of handle 66 causes the drill to remove the material in cavity 53 and this removed material can be taken from the chisel through opening 56 by means of a suitable pituitary rongeurs and forceps, etc. The end 52a of chisel 50 abuts the end 65a of drill bit 62 so that the drill 64 can only be inserted until its end is located at the cutting edge 58a.

In FIG. 10, the drill portion 64 is shown approaching its maximum insertion position and as illustrated in FIG. 11, the diameter of the drill 64 is about the same as the narrow dimension of cavity 53 while the dimension is less than the larger dimension of the cavity 53. Thus, more bone portion is located adjacent opposite side 54a than adjacent sides 54a of cavity 53. This remaining bone portion can be removed by slight twisting of the chisel or in other suitable manner in order to leave the two cavities 74 and 75 on the anterior and posterior sides of the intervertebral space as illustrated in FIG. 9.

FIGS. 12a and 12b illustrate the bone plug injector 80 which has an enlarged end 81 for supporting handle 82 and portion 83 contains a central passage 84 connecting with a passage 85 in enlarged end portion 86. Passage 85 connects with a bone plug cavity 87 at the step 88. The end 89 of cavity 87 is tapered outwardly and cavity 87 has internal dimensions identical to those of the bone plug of FIG. 3. Therefore, the internal dimensions of cavity 87 correspond with the exterior dimensions of the mortising chisel 50. A bone plug injector rod 90 comprises a rod 91 with an enlarged injector end portion 92 on one end and a screw cap on the other end, adjacent which is located a coil spring 94. With the screw cap and spring removed, the rod 91 is inserted from the end 89 of the injector through the passage 84 until the enlarged injector end 92 abuts the step 88 of cavity 85. The coil spring is then placed around the rod 91 and the cap 93 is attached so that the coil spring bears against end surface 81a of end 81 and against surface 93a of cap 93. Thereafter, the bone plug is inserted into cavity 87 and the bone plug injector 80 is ready to have its end 89 inserted into either cavity 74, 75, as illustrated in FIG. 14. The end 92a of injector rod 90 is located against the end of the bone plug 32, when in the inserted position of the injector as illustrated in FIG. 15. Since the end exterior of cavity 87 is slightly larger than cavity 75 by the very thin wall, the cavity must be slightly spread to receive the end of the bone injector 80. The end 89 of the bone injector is removed by pulling on the handle 82 with the fingers while holding the cap 93 with the palm of the hand so that the end 92a of the injector rod holds bone plug 32 in the cavity while the bone plug injector is moved outwardly until the bone plug is removed from the cavity as illustrated in FIG. 16. Thus, after insertion of a bone plug in each of the cavities 74 and 75, the interbody fusion is completed. The larger cross-section dimension of the bone plug is preferably parallel to the plane of the disc and the length dimension, generally 1 inch, is inserted into the cavity.

As previously mentioned, the bone plug cutters can be produced in standard sizes such as those illustrated in FIG. 17. In all cases, the preferred length of the bone plug is 1 inch and the cross sectional size of the bone plug 32 produced within the cavity 46 can range from
**METHOD OF OPERATION**

In the operative procedure of the posterior approach interbody fusion (as contrasted with the anterior approach), a midline incision is made long enough to expose the spinous processes, the level above and the level below the pathological interspace. The paravertebral soft tissues are then denuded off the laminae, a total of three levels, one level above and one level below the pathological interspace, followed by insertion of a self-retaining retractor. The inferior portion portion 25 of the inferior facet 26 of the upper vertebra 20, and the superior portion 28 of the superior facet 29 of the lower vertebra 22 of the pathological disc space are osteotomized and removed at lines 27 and 30, respectively, gaining adequate space to enter through the interlaminar space and proceed deeper anteriorly to perform interbody fusion procedure at the pathological disc level after the nerve root of this particular level is carefully explored and gently retracted toward midline by nerve root retractor or self-retaining nerve root retractor. Under direct vision, the vertical height of the interspace is assessed using the Penfield probe to explore the intervertebral distance between the inferior vertebral plate of the vertebra above and the superior vertebral plate of the vertebra below at this particular pathological disc space. Also, the lateral x-ray film is viewed to assess the desired dimension of an intervertebral mortising chisel 50 (see FIGS. 6a and 6b) which is to be used. As shown in FIGS. 17, four sets of instruments, with the dimensions shown, have been selected as standard sizes and a different size drill bit 62 is insertable into different size of chisel.

After the proper dimension of the intervertebral mortising chisel 50 is chosen, without the drill bit in place, the operating surgeon will examine the nerve root carefully and retract it toward midline while being held carefully and firmly by the assistant. The surgeon then will hammer the intervertebral mortising chisel through the intervertebral disc space as illustrated in FIG. 8 until the 1 inch stops 57, 58 on two faces of the chisel is reached or until the ¼ inches marking lines 59 are reached, depending on the clinical assessment of the surgeon on the actual anterior-posterior dimension of the particular patient’s vertebral body. The surgeon then inserts drill bit 62 shown in FIG. 6c through the hollow cylindrical handle of the intervertebral mortising chisel as shown in FIG. 10 using firm pressure, in rotary fashion, to ream out the intervertebral disc and fibrocartilaginous material within the confines of the rectangular space at the lower 1 or 1¼ inches portion of the intervertebral mortising chisel as shown in FIG. 11. By means of 90° angle curette, the fibrocartilaginous material at the four sides of the drill point 64 that are not reamed by the round drill point, can be removed by scraping it from the deepest portion anteriorly towards posterior direction, so that the entire chosen dimension of the intervertebral block is removed (see FIGS. 9 and 14). One can also examine under direct vision with the various angle ring curettes to make certain that all disc, as well as fibrocartilaginous materials are removed down to bleeding cancellous surfaces. The space provided is then irrigated with saline solution and packed with a sterile, moist gauze.

Exactly identical procedure is carried out with the same chosen intervertebral mortising chisel on the contralateral side of the same disc space, thus creating two rectangular block spaces at the interspace as shown in FIG. 9 (anterior-posterior view). The self-retaining retractor is then removed and the midline incision is then packed with laparotomy sponge.

By subcutaneous undermining incision through one side of the midline incision, toward the chosen posterior iliac crest where bone graft is to be taken, after the soft tissues are denuded, approximately one-half inch to 1 inch lateral to the sacroiliac joint is chosen as the donor site. Using the bone plug cutter 40, as shown in FIG. 4a, without bone plug ejector 48 (FIG. 4b) in place, the bone plug cutter is then hammered through in the direction of the posterior iliac crest to obtain two bone blocks of identical dimensions as that of the chosen intervertebral mortising chisel for grafting purpose. Thereafter, the bone plug ejector is inserted through the bone plug cutter 40 to expel the bone block out of the bone plug cutter. The soft tissue over the posterior iliac crest (the donor site) is then reapproximated with 2-0 chromic gut. A typical bone block is illustrated in FIG. 3 after being expelled by ejector 48.

Returning to the midline incision, the self-retaining retractor is then reinserted to expose the pathological disc space once again. One of the bone plugs removed is then placed inside the lower portion of a bone plug injector 80, of the same dimension as the cutter. Holding the bone plug in place, it is inserted into the intervertebral space previously created by the intervertebral mortising chisel, as illustrated in FIG. 15. By hand pressure over the top nut 93, of the bone plug injector rod as shown in FIG. 12c and squeezing the cross-bar handle 82 of the bone plug injector, as shown in FIGS. 12a, 13 and 14, the bone plug is thus injected into the interspace as illustrated in FIG. 16. Exact identical procedure is then carried out on the contralateral side until both bone blocks are inserted at the interspace, bilaterally. Using curved bayonet forceps, the nerve roots on both sides are examined carefully, as well as counter-sinking both bone blocks individually by a special im-pactor to drive both bone blocks making sure that both are placed deep enough, at least one-eighth inch or one-fourth inch beyond the posterior boundary of the vertebral bodies of the pathological disc space. With the operative table deflexed, under direct vision, both bone blocks usually are being impacted at the interspace and locked into position requiring no internal fixation. Two polyethylene tubing are inserted and exit through the posterior gluteal region to join up with the Hemovac for draining purpose. The midline wound is then closed in the usual manner.

The Hemovac is usually removed about 48 hours postoperatively and the patient is instructed to avoid flexion of his hips or spine and to keep his back in extended attitude at all times. The patient is also instructed to turn, back fully extended left or right; otherwise, no special instructions, as compared with usual laminectomy and/or fusion managements. While the invention has been described in connection with a posterior interbody fusion, the apparatus and method can be used in any operation in which a bone block is to be placed in a prepared cavity. As previously stated, the
The method of performing interbody fusion of the spine between an upper and lower vertebra and across a section of the disc comprising the steps of:

1. Employing a thin walled hollow chisel of rectangular cross section having exterior dimensions corresponding to the desired rectangular cross section of the cavity and the hollow also being of rectangular cross section;

2. Cutting the sides of the cavity thereby cutting the sides of the cavity;

3. Inserting a cylindrical drill bit within the hollow of said chisel and drilling out the greater portion of the tissue defined by the hollow of said chisel and then subsequently removing the remainder of said tissue; and

4. Removing the drill bit from said hollow;

5. Inserting into said cavity a bone plug having dimensions equal to the dimensions of said cavity.

6. The method of claim 1 wherein during the drilling out step:

7. Removing the drilled out loose material from the cavity by conducting the material through an opening in the side of the chisel.

8. The method of claim 1 wherein after the removing step and prior to the inserting step:

9. Enlarging slightly the cross sectional dimensions of the cavity by forcing a tool within the cavity having exterior dimensions slightly greater than the dimensions of the cavity with the tool having an interior hollow substantially equal to the normal cross sectional dimensions of the cavity;

10. The inserting of the bone plug into the cavity is accomplished by having the bone plug be located within the tool and then removing the tool from the cavity while maintaining the bone plug within the cavity which causes the bone tissue surrounding the cavity to retract to its initial position and in tight contact with the bone plug.

11. A method as defined in claim 1, including producing a second interbody cavity in a second location of said disc, and inserting into said second cavity a second bone plug of the same size and shape as said second cavity.

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