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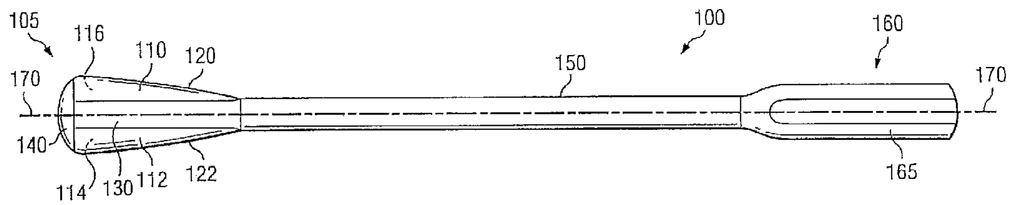

(57) Abstract: A cam spreader having a substantially rigid body with a proximal end defining a handle and a distal end defining a cam. The cam has at least a first lobe, the first lobe having an outer surface in a first quadrant of the cam as viewed in cross section along a longitudinal central axis of the body. At least a portion of the outer surface, or profile, of the curve is mathematically driven and produces a constant incremental lift.

WO 2006/007409 A1

CONSTANT LIFT CAM SPREADER

BACKGROUND

During medical procedures, including surgeries of various kinds, the need may arise to spread, or distract, bones or other anatomical parts away from one another. This may be done to allow access to an inner portion or cavity of the body, or to create proper clearance for insertion of additional instrumentation, or to create a better vantage point to observe tissues, organs, or systems. Often, the parts that are being spread or distracted are joined together by tightly bound tissue such as ligaments. This can lead to additional damage being done to the surrounding organs or tissues due to the distraction process. Additionally, further damage may be done because the surgeon may be unable to ascertain the additional stress that will be placed on the distracted body parts due to an additional degree of stress placed on the distractor being used.

One example of a surgical procedure in which distraction may be needed but where it may be difficult for the surgeon to gauge the incremental stress being placed upon adjacent distracted bones due to the additional load being placed on the distractor is intervertebral surgery. When discs within the spinal column are repaired or replaced, or during fusion techniques, the vertebrae adjacent to the damaged disc may need to be distracted to allow clearance to insert an implant or fusion device. The end plates of the vertebrae can be susceptible to breakage if too great a force is applied. Therefore what is needed is a device and method to address the above identified issues and similar issues involving the distraction of delicate tissues.

SUMMARY

The present disclosure introduces a cam spreader having a substantially rigid body with a proximal end defining a handle and a distal end defining a cam. The cam has a first lobe with an outer surface in a first quadrant of the cam as viewed in cross section along a longitudinal central axis of the body of the spreader. The first quadrant is defined by first and second orthogonal axes, with the first and second axes being orthogonal both to each other and to the central axis. The outer surface of the first lobe is defined by a first line segment intersecting the first axis at a first distance from the second axis, a second line

segment intersecting the second axis at a second distance from the first axis. A segment of a curve connecting the two line segments is defined by a mathematical equation providing for a constant incremental lift.

The foregoing has outlined features of several embodiments so that those skilled in the art may better understand the detailed description that follows. Additional features will be described below that further form the subject of the claims herein. Those skilled in the art should appreciate that they can readily use the present disclosure as a basis for designing or modifying other processes and structures for carrying out the same purposes and/or achieving the same advantages of the embodiments introduced herein. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

Aspects of the present disclosure are best understood from the following detailed description when read with the accompanying figures. It is emphasized that, in accordance with the standard practice in the industry, various features may not be drawn to scale. In fact, the dimensions of the various features may be arbitrarily increased or reduced for clarity of discussion.

Fig. 1 is a top view of a constant lift cam spreader.

Fig. 2 is a side view of a constant lift cam spreader.

Fig. 3 is a cross sectional view of a constant lift cam spreader.

Fig. 4 is a plot from which one possible cam spreader shape may be derived.

Fig. 5 is a diagram of a constant lift cam spreader between two adjacent vertebrae in a minimum lift position.

Fig. 6 is a diagram of a constant lift cam spreader between two adjacent vertebrae in a partially lifted position.

DETAILED DESCRIPTION

The present invention relates generally to the field of orthopedic surgery and more particularly to instrumentation for vertebral procedures. It is to be understood that the following disclosure provides many different embodiments, or examples, for implementing different features of various embodiments. Specific examples of components and arrangements are described below to simplify the present disclosure. These are merely examples and are not intended to be limiting. In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed. Moreover, the formation of a first feature over or on a second feature in the description that follows may include embodiments in which the first and second features are formed in direct contact, and may also include embodiments in which additional features may be formed interposing the first and second features, such that the first and second features may not be in direct contact.

Referring to Figs. 1-2 a top view and side view, respectively, of a constant lift cam spreader 100 is shown. A distal end 105 defining a series of cam lobes 110, 112, 114, 116, flat surfaces 120, 122, 130, 132 and a blunt tip 140 is shown. The distal end 105 joins to an elongated body 150 which may attach to a proximal end 160 defining a handle 165. The distal end 105, elongated body 150, and proximal end 160 may each be concentric to a single longitudinal axis 170.

The distal end 105 may be integral to the body 150 or they may be a separate components coupled together. The distal end 105 may be formed from steel, iron, aluminum, or other suitable metals or alloys. The distal end 105 may also be formed from plastics, polymers, ceramics, or other materials. In one embodiment, the distal end 105 is made from surgical grade stainless steel. The depth, length, and width of the distal end 105 may vary according to the application of the spreader 100. For example, a greater maximum available spread may require a greater width in the distal end 105.

The surfaces of the distal end 105, which define the cam lobes 110, 112, 114, 116, flat surfaces 120, 122, 130, 132 and tip 140 may be created by machining, casting, forging, or some other method depending upon the application of the spreader 100 and the material composition of the distal end 105. The surfaces 120-140 may have a brushed finish, a polished finish, or some other finish. In some embodiments, a separate coating (not shown) may be utilized to provide a desired surface texture. The distal end 105 may also comprise more or fewer surfaces than shown here and may also comprise multiple pieces that are coupled together to create the desired shape.

Shoulders or cam lobes 110, 112, 114, 116 may serve to provide an incremental lifting surface. Cam lobes 110, 112 join minimum lift flat surface 130 with maximum lift surfaces 120, 122 respectively. On the reverse side of the spreader 100, cam lobes 114, 116 join minimum lift surface 132 with maximum lift surfaces 120, 122, respectively. Thus a transition or incremental lift is provided between the minimum lift and the maximum lift provided by the spreader 100. The shape of the lobes 110, 112, 114, 116 may be defined by a mathematically driven curve, as explained in greater detail below.

The flat surfaces 120, 122, 130, 132 may be substantially flat or slightly curved and may serve to provide a stable location at which maximum or minimum lift is achieved by the spreader 100. The distance or spread between surfaces 130, 132 (the depth of the spreader 100) may be seen to be relatively smaller than the distance or spread between surfaces 120, 122 (the width of the spreader 100). By selecting the distance between surfaces 120 and 122, the maximum spread or lift of the spreader 100 may be chosen according to the purpose of the spreader 100. Similarly, by selecting the distance between the surfaces 130, 132, the minimum spread or lift of the spreader 100 may also be chosen according to the purpose of the spreader. The change in lift between minimum and maximum, or vice versa, occurs on the cam lobes 110, 112, 114, 116. A degree of lift that varies continuously between minimum and maximum lift may be provided on the cam lobes 110, 112, 114, 116. Additionally, as explained in greater detail below, the varying lift of the cam lobes 110, 112, 114, 116 may be configured to provide a constant degree of incremental lift with the change in lift being based directly on the amount of rotation imparted to the tool about the longitudinal axis 170.

The tip 140 of the spreader 150 may be sloped or tapered if needed. This may allow for easier insertion of the spreader100 into an existing surgical opening or perforation. In some embodiments, the tip 140 may also be sharpened to a point. This may allow the spreader 100 to be used as a single tool that can both create an initial opening and then distract or enlarge the space or opening created. As with the other surfaces of the distal end 105, the tip 140 may be a separate component coupled to the distal end 105 or may be integral with the distal end 105.

The distal end 105 may also be integral to the body 150 of the spreader 100. In other embodiments, the distal end 105 may be detachable from the body 150. The body 150 may be formed from steel, iron, aluminum, or other suitable metals or alloys. The body 150 may also be formed from plastics, polymers, ceramics, or other materials according to need. In one embodiment, the body 150 is made from surgical grade stainless steel. The body 150 may be formed from casting, machining, or forging. The body 150 may have a surface finish corresponding to the application of the spreader 100. For example a highly polished and nonporous finish may be utilized where the spreader 100 is designed for use in a sterile surgical environment.

The dimensions of the body 150 may also be chosen according to the application of the spreader 100. For example, where the spreader 100 is needed for distraction deep within a surgical cavity, a longer body may be required than for distraction near the surface of a surgical incision. In cross section, the body 150 may be circular, but other shapes are also possible.

The body 150 may be integral with the proximal end 160, or the body 150 and proximal end 160 may be formed as separate components and coupled together. The proximal end 160 may define a handle 165. In Figs. 1 and 2, the proximal end 160 is shown as defining a flat handle 165 corresponding to the general shape of the distal end 105. Other embodiments may have handles of other shapes however. For example, a tee shaped handle may be utilized to provide additional leverage. Additionally, a textured surface or grip (not shown) may be provided in addition to, or instead of, the handle 165 depending upon the application of the spreader 100.

Fig. 3 is cross sectional view of a constant lift cam spreader 100. The view of Fig. 3 is taken along the line A-A as shown in Fig. 2. The axis 170 is orthogonal to the plane of Fig. 3 in the location shown. Axes X and Y serve to provide reference to the location of the central axis 170. Minimum spread surfaces 130, 132 are seen to be a smaller distance apart than maximum spread surfaces 120, 122. It can also be seen in this embodiment that the surfaces 130, 132 may be equidistant from the central axis 170. Similarly, surfaces 120, 122 may be equidistant from the central axis 170. Thus, lift or spread may also be defined in terms of the distance of the flat surfaces 120, 122, 130, 132 from the central axis 170. The shoulders, or cam lobes, 110, 112, 114, 116, are seen to provide a transition from minimum to maximum lift or vice versa about the central axis 170. The cam spreader may also be symmetric about the X axis and the Y axis.

Fig. 4 is a plot from which one possible cam spreader shape may be derived. With continued reference to Fig. 3, the plot of Fig. 4 may be seen to correspond to the upper left quadrant of Fig. 3, rotated 90° to simplify explanation. The plot or diagram of Fig. 4 illustrates a curve where the value of l increases in direct proportion to the angle θ. This describes the curve ACDE. Line BC is the vertical tangent to this curve and would form the side wall of a cam spreader tool or minimum lift surface 130. DF represents the flat surface on the top of the spreader, or a portion of the maximum lift surface 120. Here the maximum lift provided by the spreader 100 relative to the central axis 170 is represented by h, which is a constant. The symbol α represents the constant angle from the y axis 170 to the beginning of maximum lift surface 120. Thus GBCDF represents one quadrant of the cross section of the spreader 100. Here, the area bounded by GBCDF corresponds to the upper left quadrant of Fig. 3. Additionally, as explained in greater detail below, a is the y intercept of curve ACDE and is a variable parameter.

From Fig. 4 it may be seen that

$$\sin\alpha = h / l_{\max}$$
$$\therefore l_{\max} = h / \sin\alpha \ldots\ldots(1)$$

In the case of a cam with constant lift, the lift may be expressed in terms of a change in lift relative to a degree to rotation of the spreader 100, therefore

$$\frac{dl}{d\theta} = k \ldots\ldots(2)$$ where k is a constant lift which may be measured in mm/rad.

$$k = \frac{lift}{angle}$$
$$k = \frac{l_{\max} - a}{\alpha}$$
$$k = \frac{(\frac{h}{\sin\alpha} - a)}{\alpha} \ldots\ldots(3)$$

Returning to equation (2):

$$\frac{dl}{d\theta} = k$$

Integrating with respect to θ yields:

$$\therefore l = k\theta + C\ldots\ldots(4)$$

where C is constant of integration. To determine the constant of integration, the condition where $\theta = \alpha$, $l = l_{\max}$ as seen in Fig. 4 may be used, thus:

$$\frac{h}{\sin\alpha} = k\alpha + C$$

$$\therefore C = \frac{h}{\sin\alpha} - k\alpha\ldots\ldots(3)$$

Returning to equation (4) and replacing C with its equivalent from equation (3) yields:

$$l = k\theta + \frac{h}{\sin\alpha} - k\alpha\ldots\ldots(5)$$

Similarly, substituting the value for *k* from equation (2) into equation (5) yields:

$$l = \frac{\left(\frac{h}{\sin\alpha} - a\right)}{\alpha}\theta + \frac{h}{\sin\alpha} - \frac{\left(\frac{h}{\sin\alpha} - a\right)}{\alpha}\alpha$$

, which may be simplified to:

$$l = \frac{\left(\frac{h}{\sin\alpha} - a\right)}{\alpha}\theta + a\ldots\ldots(6)$$

Thus, as shown above, a single equation in polar form may be used to represent the curve ACDE of Fig. 4. However, as will be shown below, it may be useful to work with a parametric representation of the curve ACDE. Therefore:

$$x = l\cos\alpha$$
$$y = l\sin\alpha$$

$$\therefore x = \left[\frac{\left(\frac{h}{\sin\alpha} - a\right)}{\alpha}\theta + a\right]\cos\theta \ldots\ldots(7)$$

$$\therefore y = \left[\frac{\left(\frac{h}{\sin\alpha} - a\right)}{\alpha}\theta + a\right]\sin\theta \ldots\ldots(8)$$

In both the radial form (equation (6)) and the parametric form (equations (7) and (8)) of the equation a value for the parameter a may be determined which will result in the curve ACDE being parallel to the Y axis at a distance from the Y axis corresponding to the chosen minimum lift provided by the spreader 100. To determine the values of parameter a that will satisfy this condition, it is necessary to take the first derivative of the equations in parametric form (equations (7) and (8)) with respect to θ. Thus:

$$\frac{dx}{d\theta} = \frac{\left(\frac{h}{\sin\alpha} - a\right)}{\alpha}\cos\theta - \left[\frac{\left(\frac{h}{\sin\alpha} - a\right)}{\alpha}\theta + a\right]\sin\theta \ldots\ldots\ldots(9)$$

$$\frac{dy}{d\theta} = \frac{\left(\frac{h}{\sin\alpha} - a\right)}{\alpha}\sin\theta + \left[\frac{\left(\frac{h}{\sin\alpha} - a\right)}{\alpha}\theta + a\right]\cos\theta \ldots\ldots\ldots(10)$$

When $\frac{dx}{dy} = 0$ the slope of the curve ACDE is infinite and the curve is vertical, or parallel to the Y axis. Thus:

$$\frac{dx}{dy}=\frac{\frac{dx}{d\theta}}{\frac{dy}{d\theta}} \qquad \text{when } \frac{dx}{dy}=0 \quad \frac{dx}{d\theta}=0$$

Therefore, from equation (9) the curve is vertical when

$$\frac{\left(\frac{h}{\sin\alpha}-a\right)}{\alpha}\cos\theta-\left[\frac{\left(\frac{h}{\sin\alpha}-a\right)}{\alpha}\theta+a\right]\sin\theta=0.........(11)$$

The width of the curve ACDE may be given by the x coordinate from the parametric equation (7) at angle θ. Therefore the desired minimum lift of the spreader relative to the central axis 170 can be substituted for x, giving:

$$\left[\frac{\left(\frac{h}{\sin\alpha}-a\right)}{\alpha}\cdot\theta+a\right]\cos\theta=\text{minimum lift from axis 170 }.........(12)$$

Equations 11 and 12 thus form a system of non linear simultaneous equations with 2 variables (θ and a). The value of h may be chosen to correspond to the desired maximum lift of the spreader 100 from the central axis 170. A desired width of the flat surfaces corresponding to maximum lift (e.g., surfaces 120, 122) may also be chosen. The angle α corresponds to the angle from the central axis to an edge of the flat surface of maximum lift as may be seen in Fig. 4. Thus values for h, α, and minimum lift are known constants. Therefore equations 11 and 12 can be solved by numerical means for θ and a. Equations (11) and (12) may be solved numerically by the fixed point iteration method or the Newton-Raphson method, for example. The cam curve ACDE may then be plotted using either the polar form (equation (6)) or the parametric form (equations (7) and (8)). Once the curve ACDE has been plotted along with the other components of the graph of Fig. 4, the area bounded by BCDFG may be used as a cross sectional pattern which defines a single quadrant of the distal end 105 of the spreader 100. To create a full cross section of the distal end 105, the area BCDFG may be reflected about the Y axis and the resulting graph reflected about the X axis. The resulting cross section may appear similar to Fig. 3 but with all dimensions known. Using the full cross section as a pattern, the distal end 105 of the spreader 100 may be constructed according to known techniques and materials. In one embodiment, the resulting spreader will result in a maximum force or lift when rotated approximately 60 degrees from the position of minimum lift.

Fig. 5 is a diagram of a constant lift cam spreader 100 in a minimum lift position between two adjacent vertebrae 501, 505. Fig. 5 provides an example of one environment 500 in which one embodiment of the constant lift cam spreader 100 may operate. The surgical site 500 may be cleaned and an incision made that allows the spreader 100 access to the vertebrae 501, 505. In a fusion or disc replacement procedure, the disc (not shown) interposing the vertebrae 501, 505 may be perforated or removed to allow insertion of the spreader 100. As previously described, the spreader 100 may also be driven directly into tissue such as the spinal disc such that the initial perforation is made by the sharpened tip 140.

The distal end 105 of the spreader 100 may be inserted between the vertebra 501, 505 in a position of minimum lift. Thus minimum lift surfaces 130, 132 may be in substantially solid contact with the endcaps 502, 507 of vertebrae 501, 505, respectively. To effect distracting, or spreading, of the vertebrae 501, 505, the spreader 100 may be rotated about the central axis 170. The spreader 100 may be designed such that rotation in either direction results in the same distraction. Here the spreader is rotated counter clockwise in the direction of arrow B.

Fig. 6 is a diagram of a constant lift cam spreader 100 between two adjacent vertebrae 501, 505 in a partially lifted position. As the spreader 100 is rotated about axis 170 in the direction of arrow B, the minimum lift surfaces 130, 132 are replaced as the primary contact surface to the endcaps 502, 507 by cam lobes 110, 114, respectively. Thus the distance between the vertebrae 501, 505 begins to increase as a result of the increasing lift provided by the spreader 100. Here, the vertebrae 501, 505 may displace from one another in the general direction of arrows C and D, respectively. The displacement of the vertebrae may be more easily controlled and stress to the end plates 502, 507 minimized due to the constant rate of incremental lift relative to the amount of rotation of the tool 100.

If so desired, the spreader 100 may provide increasing lift or displacement commensurate with the degree of rotation about the axis 170 until the endcaps contact 502, 507 come into contact with maximum lift surfaces 120, 122, respectively. When the desired amount of lift has been achieved, the remaining steps of the surgical procedure may be carried out. For example, a spacer device, such as is described in U.S. Patent Ser. No. 10/404,262, the disclosure of which is hereby incorporated by reference, can be inserted into the distracted disc space. The spreader 100 may also be rotated in an opposite direction (e.g., clockwise) to provide a proportionate decrease in lift relative to the amount of opposite rotation. The spreader 100 may be rotated completely back to the minimum lift position in preparation for retraction from between the vertebrae 501, 505.

The foregoing has outlined features of several embodiments according to aspects of the present disclosure. Those skilled in the art should appreciate that they may readily use the present disclosure as a basis for designing or modifying other processes and structures for carrying out the same purposes and/or achieving the same advantages of the embodiments introduced herein. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the present disclosure, and that they may make various changes, substitutions and alterations herein without departing from the spirit and scope of the present disclosure.

WHAT IS CLAIMED IS:

1. A cam spreader comprising:
a substantially rigid body with a proximal end defining a handle and a distal end defining a cam with a first lobe having an outer surface in a first quadrant of the cam as viewed in cross section along a longitudinal central axis of the body;
wherein the first quadrant is defined by first and second orthogonal axes, the first and second axes being orthogonal to each other and to the central axis;
wherein the outer surface of the first lobe is defined by a first line segment intersecting the first axis at a first distance from the second axis, a second line segment intersecting the second axis at a second distance from the first axis, and a segment of a curve connecting the two line segments and defined by a mathematical equation.

2. The spreader according to claim 1 wherein the first distance from the second axis corresponds to a maximum lift provided by the first cam lobe and the second distance from the first axis corresponds to a minimum lift provided by the first cam lobe.

3. The spreader according to claim 2 wherein a mathematical equation describes a constant incremental lift between the minimum and maximum lift.

4. The spreader according to claim 2 wherein the curved segment is a portion of a plot of the curve given by the mathematical equation,

$$l = \frac{\left(\frac{h}{\sin\alpha} - a\right)}{\alpha}\theta + a,$$

wherein l is the distance from an intersection of the axes to the curve and θ is the independent variable and represents the angle between the second axis and the line from the intersection of the first and second axis and the curve,
h is the maximum lift of the cam,
α is the angle between a line extending from the curve to the intersection of the axes where the distance from the curve to the second axis equals h, and

a is a variable parameter denoting the distance from the intersection of the axes to the intersection of the curve and the second axis.

5. The spreader according to claim 4 wherein possible values for the parameter a may be determined by solving the simultaneous equations:

$$\frac{\left(\frac{h}{\sin\alpha}-a\right)}{\alpha}\cos\theta-\left[\frac{\left(\frac{h}{\sin\alpha}-a\right)}{\alpha}\theta+a\right]\sin\theta=0 \quad \text{, and}$$

$$\left[\frac{\left(\frac{h}{\sin\alpha}-a\right)}{\alpha}\cdot\theta+a\right]\cos\theta=w,$$

w representing a minimum lift of the spreader.

6. The spreader according to claim 4 wherein first line segment is perpendicular to the first axis and the second line segment is perpendicular to the second axis.

7. The spreader according to claim 6 wherein the curved segment joins the first line segment
where the distance from the curve to the second axis equals h.

8. The spreader according to claim 7 wherein the curved segment joins the second line segment where the curve is parallel to the first axis.

9. The spreader of claim 8 further comprising a second lobe having an outer surface in a second quadrant as viewed in cross section along the longitudinal central axis of the body, the second lobe configured as a rotation about the first axis of the first lobe.

10. The spreader of claim 9 further comprising a third lobe having an outer surface in a third quadrant as viewed in cross section along the longitudinal central axis of the body, the third lobe configured as a rotation about the second axis of the first lobe.

11. The spreader of claim 10 further comprising a fourth lobe having an outer surface in a fourth quadrant as viewed in cross section along the longitudinal central axis of the body, the fourth lobe configured as a rotation about the second axis of the second lobe.

12. A spreader comprising:

an elongated body with distal and proximal ends along a central axis; and a plurality of cam lobes coupled to the distal end and having first and second substantially flat surfaces corresponding to a minimum and maximum displacement from the central axis, respectively, and a curved surface between the first and second flat surfaces; wherein the curved surface of at least one of the cam lobes has a profile defined by a mathematical relationship between an amount of constant incremental displacement provided by the cam and an angle of rotation of the body.

13. The spreader of claim 12 wherein the incremental lift provided by the at least one cam is given by the equation,

$$l = \frac{\left(\frac{h}{\sin\alpha} - a\right)}{\alpha}\theta + a;$$

wherein l is the incremental displacement relative to the central axis,

θ is an angle of rotation of the body away from a position of minimum displacement towards a position of maximum displacement,

h is the maximum displacement of the cam,

α is a angle of rotation of the body where maximum displacement is first achieved, and

a is a variable parameter corresponding to a distance a long a line from the central axis to the first flat surface and orthogonal to each to where a curve produced by the equation intersects such line.

14. The spreader of claim 13 wherein a value for the parameter a may be established by solving the simultaneous equations:

$$\frac{\left(\frac{h}{\sin\alpha}-a\right)}{\alpha}\cos\theta-\left[\frac{\left(\frac{h}{\sin\alpha}-a\right)}{\alpha}\theta+a\right]\sin\theta=0 \quad \text{, and}$$

$$\left[\frac{\left(\frac{h}{\sin\alpha}-a\right)}{\alpha}\cdot\theta+a\right]\cos\theta=w,$$

w representing a minimum displacement of the spreader.

15. The spreader of claim 14 wherein the simultaneous equations are solved numerically.

16. The spreader of claim 12 wherein at least one cam lobe is removably attached to the body.

17. The spreader of claim 12 wherein the cam lobes are formed integrally with the body.

18. The spreader of claim 12 further comprising a handle coupled to the proximal end of the body.

19 The spreader of claim 18 wherein the handle is removably coupled to the body.

20. The spreader of claim 12 wherein the body and cam lobes are constructed of surgical grade stainless steel.

21. The spreader of claim 20 wherein the body and cams are cast.

22. The spreader of claim 20 wherein the body and cams are forged.

23. The spreader of claim 20 wherein the body and cams are machined.

24. A constant lift cam spreader comprising:
an elongated body with proximal and distal ends and a central longitudinal axis, the body defining a spreader on the distal end;
wherein the spreader has an upper and lower flat wall, each oppositely equidistant from the central axis and defining a maximum spread;
wherein the spreader has left and right side walls, each oppositely equidistant from the central axis and defining a minimum spread;
wherein the spreader has four rounded shoulders, each between a pair of flat walls;
wherein the rounded shoulders provide for an increase in spread from minimum to maximum that is in direct proportion to an angle of rotation of the body away from a position providing the minimum spread.

25. The spreader of claim 24 wherein a curve providing a partial profile of each of the rounded shoulders, when viewed in cross section along the central axis, may be plotted in the first quadrant of a two-dimensional graph with an x axis extending towards the side walls and a y axis extending towards the upper and lower walls, by parametric equations,

$$x = \left[\frac{\left(\frac{h}{\sin\alpha} - a \right)}{\alpha} \theta + a \right] \cos\theta$$

and

$$y = \left[\frac{\left(\frac{h}{\sin\alpha} - a \right)}{\alpha} \theta + a \right] \sin\theta$$

wherein h is the distance along the y axis from the x axis to the wall,
wherein l is the incremental lift relative to the central axis,

θ is an angle of rotation of the body away from a position of minimum lift towards a position of maximum lift,

α is a angle of rotation of the body where maximum lift is first achieved, and

a is a variable parameter representing the distance along the x axis to a point where the curve intersects the x axis.

26. The spreader of claim 25 wherein a value for the parameter a may be established by solving the simultaneous equations:

$$\frac{\left(\frac{h}{\sin\alpha}-a\right)}{\alpha}\cos\theta-\left[\frac{\left(\frac{h}{\sin\alpha}-a\right)}{\alpha}\theta+a\right]\sin\theta=0 \quad \text{, and}$$

$$\left[\frac{\left(\frac{h}{\sin\alpha}-a\right)}{\alpha}\cdot\theta+a\right]\cos\theta=w,$$

where w is the distance from the right wall to the central axis.

27. A method of manufacturing a constant lift cam spreader comprising:

determining a minimum displacement of the spreader;

determining a maximum displacement of the spreader;

determining a width of a surface of the spreader at the maximum displacement;

plotting the minimum displacement, the maximum displacement, and the width at maximum displacement on a two dimensional graph with x and y axes;

numerically solving the simultaneous equations:

$$\frac{\left(\frac{h}{\sin\alpha}-a\right)}{\alpha}\cos\theta-\left[\frac{\left(\frac{h}{\sin\alpha}-a\right)}{\alpha}\theta+a\right]\sin\theta=0 \quad \text{, and}$$

$$\left[\frac{\left(\dfrac{h}{\sin\alpha}-a\right)}{\alpha}\cdot\theta+a\right]\cos\theta=w,$$

for θ in [0,π/2] with a as a variable parameter;

wherein h is half of the desired height, w is half of a desired total width of the spreader, and α is an angle from the intersection of the x and y axes to an end of the plotted desired width at maximum displacement;

plotting a curve of the equation:

$$l=\frac{\left(\dfrac{h}{\sin\alpha}-a\right)}{\alpha}\theta+a$$

within the first quadrant of the graph;

plotting a reflection of the first quadrant rotated about the x axis in the second quadrant;

plotting a reflection of the first and second quadrants rotated about the y axis; and

using a bounded area of the graph as a profile for constructing at least one cam lobe.

28. The method of claim 27 wherein the at least one cam lobe is formed by casting.

29. The method of claim 27 wherein the at least one cam lobe is formed by machining.

30. The method of claim 27 wherein the at least one cam lobe is formed by forging.

31. The method of claim 27 wherein the wherein the at least one cam lobe is formed from stainless steel.

32. The method of claim 27 further comprising coupling the at least one cam lobe to a distal end of an elongated stainless steel body.

33. The method of claim 32 further comprising coupling a handle to a proximal end of the stainless steel body.

34. A method of using a constant lift cam spreader in a medical procedure comprising:
accessing at least two adjacent bone structures;
inserting a cam spreader in a first position between the bone segments, the cam spreader having an outer surface configured to provide a minimum lift in the first position, a maximum lift in a second position, and a constant incremental lift between the first and second position based upon a degree of rotation between the first and second positions; and
rotating the cam spreader towards the second position.

35. The method according to claim 34 further comprising performing a surgical procedure.

36. The method according to claim 34 wherein rotating further comprises:
rotating the cam spreader a first degree towards the second position provide a first amount of incremental lift; and
rotating the cam spreader a second degree towards the second position to provide a second amount of incremental lift.

37. The method according to claim 34 further comprising:
rotating the cam spreader back to the first position; and
withdrawing the cam spreader from between the bone segments.

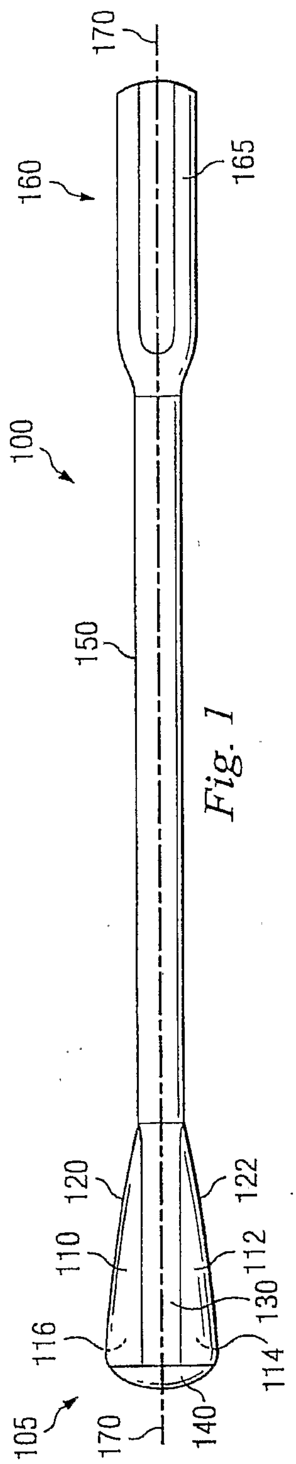
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Fig. 1

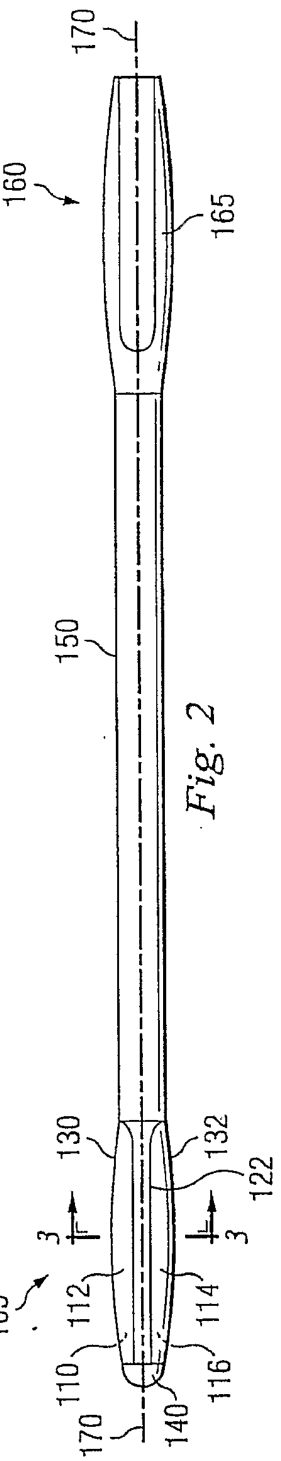
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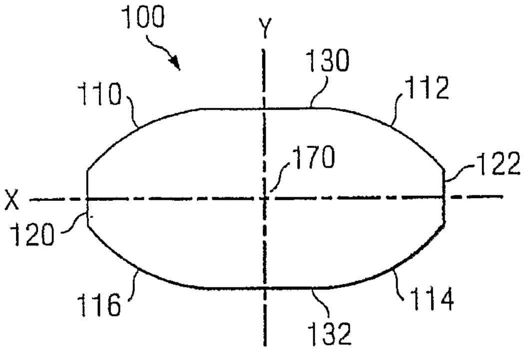
Fig. 2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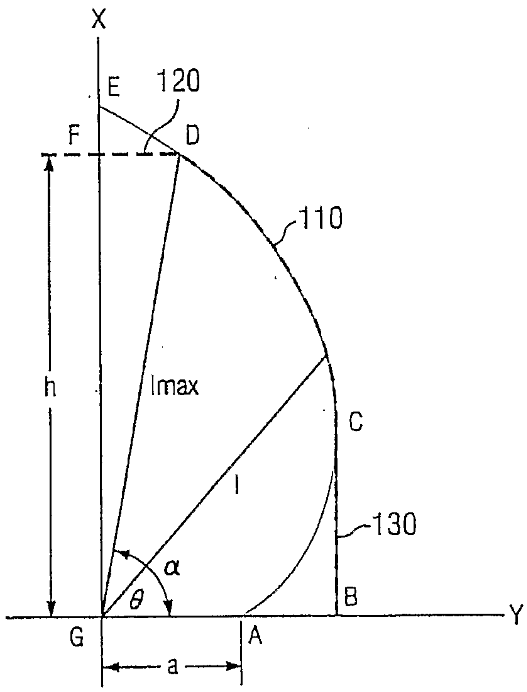
132

Fig. 3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α
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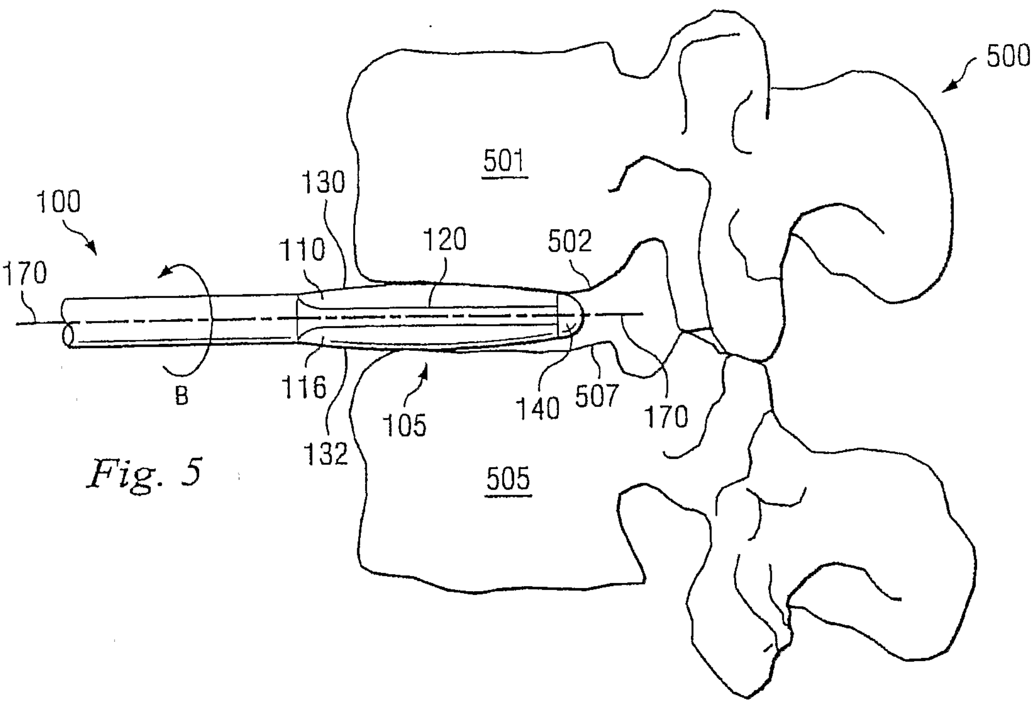
a

Fig. 4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507
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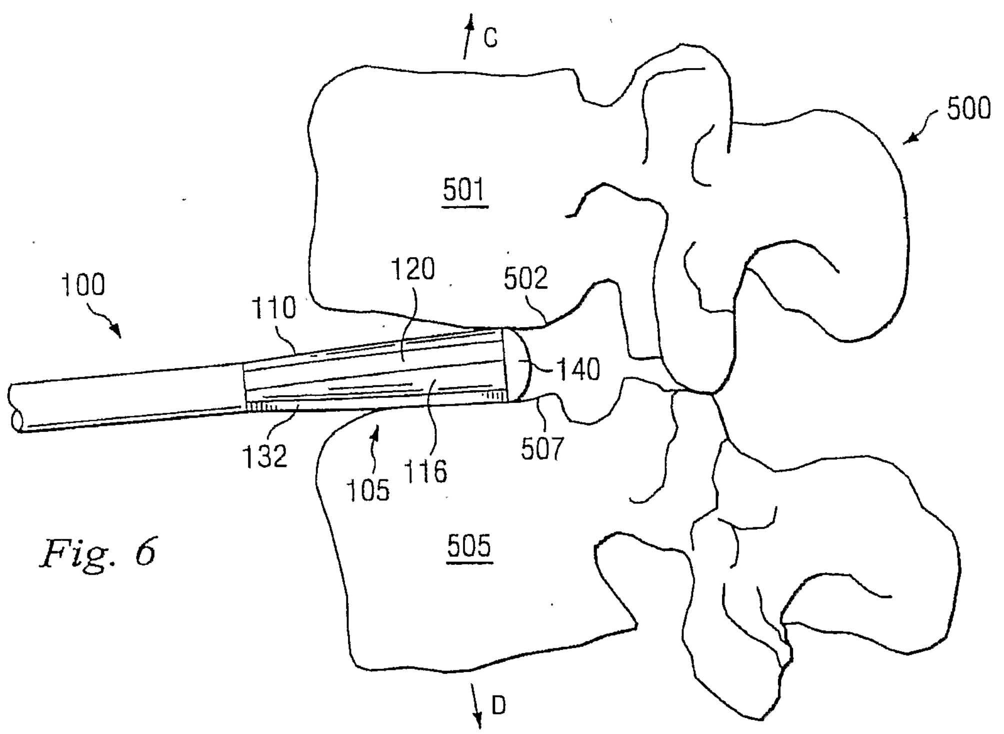
132
505

Fig. 5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105
116
507
505
D

Fig. 6

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2005/021352

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61B17/02 A61F2/46

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61B A61F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/078079 A1 (FOLEY KEVIN T) 22 April 2004 (2004-04-22)	1-3,12, 16-18, 21,24
A	paragraph ‘0068! - paragraph ‘0094!; figures 11A-29B	27-33

X	US 6 368 325 B1 (MCKINLEY JAMES T ET AL) 9 April 2002 (2002-04-09)	12,17,21
A	column 6, line 14 - column 7, line 10; figures 6-10	1,24,27

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 November 2005	15/11/2005

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Filali, S

International application No.
PCT/US2005/021352

INTERNATIONAL SEARCH REPORT

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.: 34-37
because they relate to subject matter not required to be searched by this Authority, namely:
Rule 39.1(iv) PCT - Method for treatment of the human or animal body by surgery

2. [ ] Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US2005/021352

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2004078079 A1	22-04-2004	AU 2003279927 A1	13-05-2004
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		EP 1558183 A1	03-08-2005
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US 6368325 B1	09-04-2002	US 2002055745 A1	09-05-2002