ABSTRACT: An implant for correcting scoliotic, kyphotic and lordotic curves comprising a rigid member bearing at its ends on vertebrae adjacent but not included in the curve, and bridging the concave side of the curve. Threaded connecting members having hooks for engagement with vertebrae in the curve extend through apertures in the rigid bridge member and are connected to the rigid bridge member by nuts at the side of the rigid member remote from the vertebrae. Turning the nuts causes displaced vertebrae to be drawn towards the rigid member.
The invention relates to devices for correcting scoliotic curves and maintaining the correction of such curves. Devices are known for correcting and maintaining the correction of scoliotic curves which comprise a rod and a pair of oppositely directed hooks. In application of the device, the hooks are attached to vertebrae and a distriental force is applied to the portion of the spine between the hooks by increasing the spacing along the rod between the hooks, whereby the laterally displaced and rotated vertebrae are drawn into their required positions. Such devices operate by distorting a portion of the spine and large forces have to be applied to the hooks on the vertebrae engaged therewith in order to correctly reposition the displaced vertebrae. The amount of force applied has to be carefully controlled by the surgeon to avoid fracture of the bone.

It is an object of the present invention to provide an improved device for correcting and maintaining the correction of scoliotic curves. According to the present invention there is provided a device for correcting a scoliotic curve and maintaining such a correction, comprising a rigider member, end portions of said rigid member being adapted to abut and purchase on portions of vertebrae adjacent but not included in the curve, one or more connecting members each having an end portion of hook form for engagement with a vertebra in the curve, and means for connecting the connecting members to the rigid member and for adjusting the distance between the hook-form end portion of the connecting member and the rigid member and for opposing movement of the connecting member relative to the rigid member in a direction tending to increase said distance.

The means for connecting the connecting member to the rigid member may include a screw-threaded portion of the connecting member, an aperture in the rigid member for receiving the screw-threaded portion of the connecting member and a nut for threaded engagement with the screw-threaded portion of the connecting member and for abutting engagement with the rigid member to oppose movement of the connecting member relative to the rigid member in said direction tending to increase said distance, the arrangement being such that the connecting member may adapt any one of a range of orientations relative to the rigid member.

A plurality of said apertures may be provided in said rigid member.

 Said apertures may comprise a slot and discrete holes, the holes extending between the bottom of the slot and a surface of the rigid member, each of the holes having a bounding surface conforming to a sphere for cooperation with a corresponding surface of the nut.

Each of the end portions of the rigid member may include a lug adapted to engage and purchase on a portion of a vertebra adjacent but not included in the curve.

An embodiment of the present invention will now be described by way of example with reference to the accompanying drawings in which:

FIG. 1 is a side view of a rigid member of the device;
FIG. 2 is a view taken in the direction II in FIG. 1;
FIG. 3 is an enlarged cross-sectional view taken on the line III-III in FIG. 1;
FIG. 4 is a side view of a connecting member;
FIG. 5 is a cross section taken on the line V-V in FIG. 4;
FIG. 6 is an end view of the connecting member illustrated in FIG. 4, taken in the direction of the arrow VI in FIG. 4;
FIG. 7 is a view in axial section of a nut; and
FIG. 8 is a side view of a connecting member alternative to that illustrated in FIG. 4.

In FIG. 1, there is illustrated a rigid member 1 which is intended to bridge the portion of a spine including a scoliotic curve. The rigid bridge member 1 is to be located at the concave side of the curve.

End portions 2 and 3 of the member 1 have integral lugs, 4, 5 extending from the same side surface 6 of the member 1.

The ends of the lugs 4, 5 at the ends of the member are of circular arcuate form in profile as can be seen at 7 in FIG. 1. The side surfaces 8 of the lugs 4, 5 are convergent upon one another in the direction away from the plane of the side surface 6 and the surface 9 of the lugs 4, 5 connecting the convergent side surfaces 8 is of smooth arcuate form in section, as can be seen in FIG. 3.

The member 1 has formed therein a slot 10 in the portion thereof between the lugs 4, 5. The slot 10 is open at the side surface 6 of the member 1 and the bottom 10a of the slot 10 is spaced from the opposite side surface 11 of the member 1. The sides 10b of the slot 10 are inclined to planes normal to the surfaces 6 and 11 at angles of 15° and are convergent towards the bottom 10a of the slot 10. The bottom 10a conforms to a cylinder.

Six holes 12 are formed in the portion of the member 1 between the bottom 10a of the slot 10 and the surface 11. The bounding surfaces of each hole 12 include a surface 12a conforming to a truncated segment of a sphere and a cylindrical surface 12b which at one end is contiguous with the bounding surface of the slot 10. The other end of the cylindrical surface 12b includes the smaller diameter bounding circle 12c of the surface 12a. The holes 12 are disposed with uniform spacing along the slot 10.

Each hole 12 and the slot 10 constitutes an aperture for the reception of a portion of a connecting member now to be described.

The device includes one or more connecting members 14, one of which is illustrated in FIGS. 4, 5 and 6. Each connecting member 14 comprises a rodlike portion 15 threaded to a portion of its length extending from one end 16. In the embodiment illustrated the rodlike portion 15 is threaded throughout its length. The end 16 of the connecting member 14 remote from the end 15 of the portion 15 is of hook form. The inner profile of the hook is of U-shape and the outer profile of the hook is of circular arcuate form, (see FIG. 4). The outer surface 17 of the hook is of arcuate form as may be seen in FIGS. 5 and 6.

The side surfaces 18 of the nose 19 of the hook are convergent towards the free end 20 of the hook as may be seen in FIG. 6.

In use, the rodlike portion 15 of the connecting member 14 extends through the slot 10 and through one of the holes 12, the hook being located at the side of the member 1 from which the lugs 4, 5 extend. A nut 21, threadedly engaged with the rod 15, seats in the hole 12.

The nut 21 has a surface 22 which conforms to the bounding surface 12a of the hole 12 and allows the connecting member to move between and take up any one of an infinite number of orientations, relative to the member 1, within a range of orientations limited by engagement of the portion 15 with the bounding surfaces of the slot 10.

The above-described device is applied to correct, and maintain the correction of, a scoliotic curve by a surgical operation which includes forming a bore in the junction of the lamina and pedicle of a vertebra for receiving the nose 19 of the hook of a connecting member 14. Usually two connecting members are used and in this case such bores would be formed in each of two adjacent vertebrae. The junction of the lamina and pedicle in which the bore is formed is the one at the concave side of the curve.

With the noses of the hooks engaged in the bores, the rodlike bridge member 1 is brought up and the rodlike portions 15 of the connecting members 14 are inserted into two adjacent holes 12. In the case of severe curves, the rods may be inserted in nonadjacent holes 12.

Nuts 21 are threaded over the rods 15 with the surfaces 22 towards the bridge member 1, the bridge member 1 being disposed with the lugs 4, 5 directed towards the spine.

The bridge member 1 is brought up to the spine so that the lugs 4, 5 abut and purchase on the lamina of two vertebrae at the concave side of the curve. Usually there will be five vertebrae between the two vertebrae upon which the lugs 4, 5 bear and take purchase.
The nuts 21 are then rotated so that they engage the bridge member 1. Further rotation of the nuts 21 causes movement of the rodlike portions 16 through the slot 10 and holes 12 and hence reduces the distances between the bridge member 1 and the hooks and this causes the displaced vertebrae to move towards the bridge member 1.

The nuts 21 may be rotated until the displaced vertebrae in the curve are returned to their desired dispositional relationship with the remainder of the vertebrae.

Because the vertebrae in the curve are not only translationally displaced but also rotationally displaced, it has to be ensured that upon drawing the displaced vertebrae into their required positions, when rotational as well as lateral movement will occur, the displaced vertebrae are free to rotate to their required positions and that such rotational movement is not impeded by engagement of the hooks with parts, e.g. the articular process, of a vertebra adjacent to the vertebra to which the hook is connected. This may involve the removal of a part of the articular process of the adjacent vertebra.

The parts of the device are, of course, formed of a material, such as stainless steel which is appropriate for use in an implant.

As an example of the dimensions of devices in accordance with the present invention the following approximate values of four sizes may be quoted:

- Overall length of the bridge member 1: 5/4” x 6” x 7” x 8”
- Distance between end of bridge member 1 and center of nearest hole 12: 1/4” x 1/4” x 2/4” x 2/4”
- Distance between centers of holes 12’ 1/2” x 1/2” x 1/2” x 1/2”
- Portion of the bridge member intermediate the lugs is of rectangular section with sides 6 and 11 being 0.35” x 0.35” and other sides being 0.33” x 0.33”
- Length of the rod portion of the connecting members is 2”
- Outer radius of the hooks is 5/16”
- Mouth opening of the hooks is 5/6”
- Thickness of the hooks, i.e. the transverse dimension in FIG. 5, is 5/4”

The surfaces 7 and 9 of the lugs 4, 5 are of smooth arcuate form to avoid erosion of the bone on which the lugs bear and purchase and to allow small amounts of movement of the vertebrae, on which the lugs bear, relative to the rigid member upon drawing the displaced vertebrae into their required positions and upon growth.

In the embodiment described above, there are six holes 12. It is to be understood that not all the apertures will be associated with a connecting member when the device is implanted. The purpose of providing a greater number of holes than will actually be used in any one implant is so that the one device could be used with any one of a number of scoliotic curves of different characteristics. Whilst six holes are provided in the embodiment illustrated it will be understood that any number of holes may be provided but usually there will not be less than two or more than six.

Whilst one particular shape of hook of the connecting member has been described, it is to be understood that other shapes of hook may be employed which are appropriate for use with other parts of vertebrae than those described above.

An example of another shape of hook which may be employed is illustrated in FIG. 8. The connecting member illustrated in FIG. 8 comprises a threaded rod portion 25 and a hook 26 which is more nearly of C-shape rather than the U-shape of the hook illustrated in FIG. 4. The axis of the rod portion 25 passes through the point about which the arcuate member and inner profiles of the hook are struck. As can be seen in FIG. 8, the hook tapers towards its nose 27.

It will be realized that the junction of the lamina and pedicle is a comparatively strong region in which to make the mechanical connection between the vertebra and the device.

A consideration of the forces likely to be involved in correcting a scoliotic curve by applying a force to a displaced vertebra in a direction approximating to a radius of the curve will show that such forces are likely to be less than if the correction is performed by applying distracting forces. Since bone fracture must be avoided, advantages are achieved when the applied forces on the bone can be reduced and the forces are applied to the bone at a stronger region of the bone.

A further advantage believed to be present in a device according to the present invention is that the correction is maintained even when growth occurs because the mechanical arrangement of the device is such that growth and hence movement of the vertebrae relative to the device does not result in reduction of the correcting force applied by the device.

It is to be understood that the terms scoliosis and scoliotic are to be understood not only in their narrow meanings but also in their broader meanings as including kyphosis and kyphotic, and lordosis and lordotic. Devices in accordance with the invention are suitable for correcting and maintaining the correction of curves which are strictly termed kyphotic and lordotic.

In the embodiment described above, the rodlike portion of each connecting member extends through an aperture in the rigid bridge member, which aperture comprises the slot and one of the holes. It will be understood that the slot common to all the holes, is not essential and that entirely discrete apertures may be provided in which case each discrete aperture may comprise a portion having a bounding surface conforming to a truncated segment of a sphere and a portion having a bounding surface conforming to a frustum of a cone with the smaller bounding circles of the conical and spherical bounding surfaces coincident.

We claim:

1. A surgical implant device for correcting a scoliotic curve and maintaining such correction, comprising:
   a. a rigid bridge member of a material compatible with living animal tissue having a length dimension at least 10 times its width dimension to provide opposite ends to engage spaced vertebrae adjacent the curve with the intermediate portion of the bridge member spanning the curve;
   b. tension means including at least two elongated members each configured to be hooked about a vertebra and extending from the same side of the bridge member to hook about a vertebra in the curve;
   c. adjustable securing means on the tension means engaging the bridge member and serving to hold the tension means which are hooked about the vertebrae in the curve drawn toward the bridge member.

2. A surgical implant device according to claim 1 wherein the adjustable securing means on the tension means includes a threaded shank portion which extends through an aperture in the bridge member and is engaged therein.

3. A surgical implant device according to claim 2 wherein a plurality of said apertures are provided in said bridge.

4. A surgical implant device according to claim 3 wherein said apertures define a slot and discrete holes, the holes extending between the bottom of said slot and a surface of said bridge, each of said holes having a bounding surface conforming to a portion of a sphere for cooperation with a corresponding surface of a nut.

5. A surgical implant device according to claim 1 wherein each of said end portions of said bridge includes a lug for bearing against a portion of a vertebra adjacent to but not included in the curve.

6. A surgical implant device for correcting a scoliotic curve and maintaining such correction, comprising:
   a. a rigid elongate bridge member of a material compatible with living animal tissue for placement against the concave side of the curve so as to span the curve and have opposite ends thereof bear against spaced vertebrae;
   b. said bridge including a plurality of apertures;
   c. at least two threaded rod members for extending independently from said apertures to vertebrae within the curve, each of said tension members having a screw-threaded portion and a hook portion for engagement with a vertebra, the hook members all extending in the same direction; and
   nuts for screw-threaded engagement with said screw-threaded portion of said tension members and with said bridge.