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DAMPING ELEMENT

The present invention relates to a damping element as defined in the preamble of claim 1 and to a system stabilizing adjacent vertebrae as defined in the preamble of claim 15.

The French patent document FR-A-2,799,949 discloses a spinal fixing system consisting of a number of tulip-like pedicle screws which in lieu of the conventional rigid longitudinal support are connected to each other by spiral spring elements. While the length of the spiral springs is adjustable, this design only allows a change in the spring force between two adjacent pedicle screws and hence between two adjacent vertebrae. This document allows no conclusion whether the spring elements are mounted prestressed between the pedicle screws.

Another spinal fixation system is known from the European patent document EP-A-0,516,567, said system consisting of a number of tulip-like pedicle screws which are connected to each other by single damping elements instead of the conventional rigid longitudinal support. This system entails the drawback that only compressive forces between the pedicle screws may be absorbed. The damping elements moreover being of a fixed length, the design of this document provides a substantial number of such damping elements of different lengths in order to allow affixing a damping element of appropriate length between two implanted pedicle screws. Such a design is awkward and entails storing a significant number of damping elements of different lengths.

Another spinal fixation system is known from the European patent document EP-B-0,669,109 which consists of a number of pedicle screws with pierced heads, said screws being connected to each other not by the conventional longitudinal rigid support but by an



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elastic plastic band that can be pulled through the boreholes in the pedicle screws. Hollow-cylindrical bracing elements that may absorb any compressive forces between pedicle screws are arrayed on the plastic band between the individual pedicle screws. This system incurs many drawbacks.

In the first place the plastic band and the bracing elements must be threaded into or between the boreholes of the pedicle screws which already have been implanted, entailing complexity and loss of time for the surgeon. In the second place the somewhat elastic band is not prestressed. Because the supporting body length is fixed in this system too, nominal rupture sites at the support body are proposed to allow the surgeon to cut said body to size during the surgery. This is a complex and time-consuming procedure for the surgeon and might in general result in too short a bracing element, as a result of which its damping would be effective only after a given delay -- this circumstance manifestly being undesirable.

The objective of the present invention is palliation of the above drawbacks. The invention aims to create a combined, prestressed tensile-compressive element which is affixable between two pedicle screws or pedicle hooks and which on one hand acts as a tensile spring element of a given spring rate and on the other hand as a compressive element having another spring rate.

The present invention solves this problem by a damping element exhibiting the features of claim 1 and by a system stabilizing adjacent vertebrae which exhibits the features of claim 15.

In the preferred embodiment of the damping element of the invention, one of the spring elements is mounted as a compression spring. When the damping element has been installed, the connectors configured at the ends of the spring elements touch the ends of the compression spring element, as a result of which the first spring element may be tensively loaded and be prestressed.

Essentially the advantages offered by the present invention are as follows:

- unitary tensile/compressive element of which the length is adjustable,
- the damping properties may be varied by selecting inner cylinders of different lengths,
- the prestressing force present in the aforementioned state of the damping element is clearly defined and may be selected by the surgeon to match the different patient weights and the different surgical indications,
- after traction has been applied to the vertebrae, the damping elements may be inserted in a quick and simple manner between the pedicle screws and then be affixed to them.

In one embodiment of the damping element of the invention, the spring elements are designed to exhibit a constant spring rate. As a result, the unloaded spring elements' states may be restored after the damping element has been relieved.

In another embodiment of the damping element of the invention, its cross-section orthogonal to the longitudinal axis is reniform. Such a design offers the advantages that when implanting one or several damping elements, for instance in the process of spinal column fixation, said elements may be positioned more advantageously with respect to vertebral extensions or other implant components.

Further advantageous embodiments of the present invention are characterized in the dependent claims.

The system of the invention stabilizing adjacent vertebrae essentially comprises several pedicle screws or pedicle hooks which may be linked to different affixation means. The affixation means between two pedicle screws or pedicle hooks illustratively may be bar-shaped longitudinal supports, springs or damping elements of the present invention.

At least one pedicle screw or one pedicle hook comprises receiving means allowing simultaneously receiving two parallel, longitudinal affixation means. In this manner an

element acting as a spring, for instance a damping element of the invention, may be used for affixation between at least pedicle screw or pedicle hook fitted with receiving means and a further adjacent pedicle screw or pedicle hook.

Pedicle screws or pedicle hooks that are fitted with receiving means allowing concurrent connection between two parallel, longitudinal affixation elements and the pedicle screw or pedicle hook are known for instance from US patent 4,653,481 (Howland). Similarly to the longitudinal supports cited in said patent, the damping elements of the present invention may be affixed by means of bars mounted on the connectors parallel to the longitudinal axis for instance in parallel ducts to the screw heads. Very easily and without further manipulation, the damping element displaceability in the ducts parallel to the longitudinal axis allows inserting a damping element of the present invention – which was prestressed to a desired spring force before implantation – into the receiving means at the pedicle screws. The compensation in length at different spacings between the pedicle screws or pedicle hooks is implemented by the axial displaceability of the bar-shaped connectors which are configured end-wise parallel to the longitudinal axis and which are situated at the damping elements of the invention in the ducts that are also parallel to the longitudinal axis.

Illustratively prestressing the damping element allows taking into account a number of instabilities, indications or patient weight. In the case of extension of the pertinent spinal segments, the damping element is compressed, whereas in the case of flexion of the pertinent spinal segment it is tensioned. The selections of the spring material, for instance a polymer, preferably a polycarbonate urethane (PCU) for the compressively loaded spring, and of metal for the tensively loaded spring element, of the geometric dimensions as well as the prestressing of the tensively loaded spring element allow optimally matching the system of the present invention to a patient's biomechanical particulars.

Essentially the advantages of the system of the present invention are as follows:

-- harmonic transition in rigidity from the stabilized spinal segment to the healthy spinal segments,

-- the damping elements may be combined selectively in segments with rigid bars.

The invention and further design modes of it are elucidated below in relation to several illustrative modes of implementation shown in partly schematic manner.

Fig. 1 is a longitudinal section of one embodiment mode of the damping element of the invention,

Fig. 2 is a view of an embodiment mode of the system of invention stabilizing adjacent vertebrae,

Fig. 3 is an exploded view of an embodiment mode of the damping element of the invention,

Fig. 4 is an elevation of an embodiment mode of the damping element of the invention,

Fig. 5 is a perspective of an embodiment mode of the damping of the invention,

Fig. 6 is a topview of an embodiment mode of the damping element of the invention,

Fig. 1 shows an embodiment mode of the damping element 1 of the invention having two spring elements 2, 4 concentrically mounted with the longitudinal axis 3. The first spring element 2 is designed as a helical spring with a central cavity 15, whereas the second spring element 4 is bar-shaped and configured in said cavity 15. The end-side connectors 5, 6 also are mounted coaxially with the longitudinal axis 3 and each is fitted with a threaded segment 16, 17 with an outer thread 18, said segments being coaxial with the longitudinal axis 3 and pointing toward the spring elements 2, 4. The first spring element 2 is fitted at its axial ends 21 with inner threads 24 in the cavity 15 which match the outer threads 18, as a result of which the threaded segments of the connectors 5, 6 can be screwed into the first spring element 2. Moreover each connector 5, 6 comprises an open recess 23 configured

coaxially with the longitudinal axis 3 at the inner end 19 of said connector, as a result of which the bar-shaped second spring element 4 can be received at its axial ends 22 in said recesses 23. The connectors 5, 6 also are coaxially bar-shaped at their outer end 20. When the damping element 1 is assembled, the ends 22 of the second spring 4 rest against the end faces 25 of the recesses 23 orthogonal to the longitudinal axis 3, and as a result the connectors 5, 6 are a distance L between these end faces 25. This distance L as well as the length of the undeformed first spring element 2 are selected in such a way that when the threaded segments 16, 17 are screwed into the inner threads 24, the first spring element 2 is stretched by a desired length and as a result prestressing is imparted to the damping element 1.

Fig. 2 shows an embodiment mode of the system of the invention illustratively as a system stabilizing adjacent vertebrae (omitted). Several pedicle screws or hooks 12 are affixed to the pedicles of vertebrae to be connected so that their central axes 28 are configured transversely to the spinal column's longitudinal axis. The receiving means 13 at the pedicle screws or hooks 12 are mounted perpendicularly to the central axes 28 and are designed as ducts 26. The bar-shaped outer ends 20 of the connectors 5, 6 (Fig. 1) may be inserted into said ducts 26 and consequently the damping elements 1 are axially displaceable in the ducts 26 before being locked in place by screws 27 relative to the pedicle screws or hooks 12. The receiving means 13 at the pedicle screws or hooks 12 each comprise two parallel ducts 26 and allow locking for instance a bar-shaped affixation means 7 at a pedicle screw or hook 12 next to a damping element 1.

Fig. 3 shows an embodiment mode of the damping element 1 of the invention which comprises a first spring element 2 in the form of a helical spring, a bar-shaped second spring element 4 and two connectors 5, 6 configured coaxially with the longitudinal axis 3.

Figs. 4 and 5 shown an embodiment mode of the damping element 1 of the invention comprising a first spring element 2 in the form of a helical spring and two connectors 5, 6

which are connected to the first spring element 2 and which are coaxial with the longitudinal axis 3.

Fig. 6 is an embodiment mode of the damping element 1 of the invention which exhibits a circular cross-section orthogonally to the longitudinal axis 3. Other cross-sectional shapes, for instance oval or elliptical cross-sections, that might be advantageous in implanting the damping element 1 also are conceivable.

CLAIMS

1. A damping element (1)
characterized by
 - (a) two spring elements (2, 4) coaxial with or parallel to a longitudinal axis (3), and two axially end-side connectors (5, 6) which can be linked to the spring elements (2, 4) in a manner that at least one of the spring elements (2, 4) is connected to the connectors (6, 7), whereby
 - (b) the first spring element (2) exhibits a spring rate F ,
 - (c) the second spring rate (4) exhibits a spring rate f , and
 - (d) the spring rates F and f are different from each other.
2. Damping element (1) as claimed in claim 1, characterized in that the spring elements (2, 4) are configured concentrically with the longitudinal axis (3).
3. Damping element (1) as claimed in either of claims 1 and 2, characterized in that at least one spring element (2, 4) is prestressed.
4. Damping element (1) as claimed in one of claims 1 through 3, characterized in that the spring elements (2, 4) exhibit constant spring rates F , f .
5. Damping element (1) as claimed in one of claims 1 through 4, characterized in that its cross-section orthogonal to the longitudinal axis (3) is reniform.
6. Damping element (1) as claimed in one of claims 1 through 5, characterized in that one spring element (4) is a compression spring.

7. Damping element (1) as claimed in one of claims 1 through 6, characterized in that one spring element (2, 4) is fitted with a multiple spring coil.

8. Damping element (1) as claimed in either of claims 6 and 7, characterized in that the spring element (4) in the form of a compression spring is made of a polymer, preferably a polycarbonate urethane (PCU).

9. Damping element (1) as claimed in one of claims 1 through 8, characterized in that the second spring element (4) is integral with one of the connectors (5, 6).

10. Damping element (1) as claimed in one of claims 1 through 9, characterized in that the second spring element (4) is configured inside the first spring element (2).

11. Damping element (1) as claimed in one of claims 1 through 10, characterized in that the two spring constants F , f differ at least by the factor 2, preferably at least by the factor 5.

12. Damping element (1) as claimed in claim 11, characterized in that the two spring constants differ F , f by a factor between 10 and 100.

13. Damping element (1) as claimed in one of claims 1 through 12, characterized in that the spring rate F of the second spring element (4) is between 100 N/mm and 5,000 N/mm.

14. Damping element (1) as claimed in claim 13, characterized in that the spring rate f of the second spring element (4) is between 200 N/mm and 2,000 N/mm.

15. A system stabilizing adjacent vertebrae, comprising

(a) N pedicle screws or pedicle hooks (12), where $N \geq 3$, and

(b) at least one pedicle screw or one pedicle hook (12) comprises receiving means (13) simultaneously allowing receiving two parallel longitudinal affixation means (7) characterized in that

an element (14) acting as a spring is used for affixation between the at least one pedicle screw or pedicle hook (12) fitted with receiving means (13) and a further adjacent pedicle screw or pedicle hook (12).

16. System as claimed in claim 15, characterized in that the element (14) acting as a spring is a damping element as claimed in one of claims 1 through 14.