

TITLE

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**MEDICAL BONE CONNECTING DEVICE AND METHOD FOR CONNECTING BONES
OR BONE PARTS**

TECHNICAL FIELD

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The present invention relates to a medical bone connecting device, such as in particular a pedicle system, an axial or parallel connector system, a cervical plate system or a vertebral body replacement. Furthermore, the present invention relates to a method for connecting two bones or bone parts by means of such a bone connecting device.

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PRIOR ART

Bone connecting devices are frequently used in medicine to bring bones or bone parts into a desired position and hold them in this position, for example after a fracture, such as a traumatic fracture, or in the event of a malposition. In particular, bone connecting devices are known in the form of spinal implant systems, which are used to connect and stabilize several vertebral bodies of the spine. These include pedicle systems in which several pedicle screws, each anchored in a vertebral body, are generally fixed to a common connecting rod and thereby connected to each other. Several connecting rods of a pedicle system or connecting rods that serve to stabilize other bones or bone parts can be connected to each other via a connector. Depending on whether the rods are connected axially one behind the other or parallel to each other, such a bone connecting device is referred to as an axial connector or a parallel connector. Bone connecting devices in the form of cervical and lumbar plate systems are also known, in which a connecting plate is fixed to several vertebrae of the cervical spine using screws in order to stabilize them. Another frequently used bone connecting device is the vertebral body replacement, which is used to replace one or more defective vertebral bodies. The vertebral body replacement, which is often used in combination with a pedicle system, is connected to the neighboring vertebral bodies, wherein an expandable vertebral body replacement is often used to adapt to the space to be filled.

Normally, bone connection devices are made of metal, for example titanium and/or a titanium alloy. Such bone connecting devices are radio-opaque and allow the exact position of the implant (e.g. the pedicle screw) to be determined when the patient is examined using an imaging procedure such as computer tomography (CT). Despite this advantage,
5 however, such metal implants obstruct the view of the bone connected to the implant and the surrounding tissue during fluoroscopy, as they are radio-opaque and also cause scattering effects during fluoroscopy, which in turn create artefacts in the area of the implant during visualization. Strong artefacts are also caused by such metal bone connection devices in magnetic resonance imaging (MRI). Due to their radiopacity, metal bone
10 connecting devices also impair radiotherapy for cancer patients, as the relatively large metal mass causes scattering phenomena that reduce the effectiveness of the radiation and therefore require a higher radiation dose, which in turn can cause side effects in the surrounding tissue.

15 In order to overcome the above-mentioned disadvantages of metal bone connecting devices, bone connecting devices made of non-metal composite materials have been developed. Although the production of three-dimensionally complex molds from composite materials is challenging, it enables the production of radiotransparent components that do not have the above-mentioned disadvantages. Bone connecting devices made of non-metal
20 composite materials based on carbon fiber-reinforced polyether ether ketone (PEEK) are preferred on the market.

Bone connecting devices and in particular the types mentioned at the beginning, such as pedicle systems, connectors, plate systems and expandable artificial vertebral bodies,
25 generally have several connecting elements that have to be attached to each other to fix the bones or bone parts. For example, in the case of a pedicle system, the screws must be fixed to the connecting rod or, in the case of a connector, the connecting rods must be fixed to a connector housing. In order to fix the at least two connecting elements of the bone connecting device to each other, screw connections are usually used in the prior art.

30 However, components made from non-metal composite materials have disadvantages when it comes to screw connections. For example, the production of precisely interlocking and therefore easily screwable and high-performance threads is considerably more difficult with composite materials than with metals. The rigidity of non-metal composite materials is
35 also usually lower than that of metals.

In contrast to the fixings usually used by screwing in a clamping element, other methods of fixing the screws to a connecting rod via a tulip head are also known in the prior art for pedicle systems. For example, US 6,251,112 B1 discloses a pedicle system in which the screws are fastened to the connecting rod by means of a clamp that can be screwed onto the tulip head, wherein a fixing screw can be screwed into the clamp in order to clamp the tulip head, which is formed in one piece with the screw, to the connecting rod. This means that a relatively large number of steps are necessary for the doctor to fix a screw to the connecting rod.

10 In the system shown in document US 2010/0114168 A1, a slotted plate is placed on the tulip head to secure a pedicle screw to the connecting rod. Clamping is achieved by means of an insert inserted into a central opening in the plate. The disadvantage of this solution is that it is only suitable for connecting rods with a certain diameter.

15 Document WO 2006/119271 A2 discloses a fixing system for a pedicle system in which a fastening element is attached to the tulip head by means of a bayonet connection in order to fix the connecting rod to a screw. Here too, the system is only designed for connecting rods with a specific diameter.

20 The document US 2004/0138660 A1 discloses a fixation system for a pedicle system with a fixation cap that is screwed onto a tulip head and presses the connecting rod against the screw head with a pressure element attached to the underside.

The document US 6,478,797 B1 shows the fixing of a connecting rod to a screw by means of a retaining element which engages over a tulip head formed in one piece with the screw and presses the connecting rod downwards via a central saddle element. The connection between the retaining element and the tulip head is made via a threaded or bayonet-like mechanism.

30 Document WO 2005/122927 A1 discloses a pedicle system in which a retaining element is latched to the tulip head via latching teeth in order to fix a pedicle screw to a connecting rod. The retaining element and tulip head are each made of a metal or a plastic. While metal has the disadvantages already mentioned, particularly with regard to radio-opacity, pure plastic generally has relatively low strength and rigidity and is therefore less suitable for
35 medical bone connections in practice.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a largely radiotransparent device which allows a simple and at the same time high-performance connection of bones or bone parts.

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To achieve this object, a medical bone connecting device is proposed as specified in Claim 1. Claim 16 specifies a method for connecting two bones or bone parts, which is preferably carried out using such a bone connecting device. Advantageous embodiments of the invention are given in the dependent claims.

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The present invention thus provides a medical bone connecting device for connecting two bones or bone parts of a human or animal patient, comprising

a first connecting element made of a fiber-reinforced plastics material, which has a first latching structure with a plurality of first latching elements, in particular latching teeth;

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and

a second connecting element made of a fiber-reinforced plastics material, which has a second latching structure with a plurality of second latching elements, in particular latching teeth.

According to the invention, the first latching elements of the first latching structure are latchable to the second latching elements of the second latching structure in order to fix the first connecting element and the second connecting element to one another and thereby connect the two bones or bone parts to one another.

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The fixation of the two connecting elements to each other by means of latching has proven to be particularly advantageous in combination with the production of the connecting elements from a fiber-reinforced plastics material. On the one hand, the fiber-reinforced plastics material enables the production of connecting elements that are not only radiolucent, but also have high strength and rigidity and therefore allow a particularly powerful connection of the bones or bone parts. The use of fibers, preferably carbon fibers, in the plastics material not only enables the respective component to be reinforced as a whole, but also allows the component to be specifically reinforced at certain points. In the case of the first and/or second connecting element, one such specifically reinforced area can be the latching structure in particular. By aligning the fibers accordingly, the reinforcement can even be direction-dependent. It has been shown that, compared to a threaded connection, a latching connection allows considerably greater tolerances and a significantly higher surface roughness in the connection areas of the respective

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components. Consequently, the provision of a latching connection is particularly suitable for connecting elements made of a fiber-reinforced plastics material. In contrast to a bayonet connection, for example, the latching connection has the further advantage that the two connecting elements can engage with each other to a greater or lesser extent as required.

5 For example, the latching structures can be continuously brought further into engagement with each other, similar to a threaded connection, in order to strengthen the fixing of the connecting elements to each other or, for example, to increase the clamping force on a component arranged between the two connecting elements.

10 The latching of the latching elements also makes it particularly easy for the user, i.e. usually the doctor, to fix the two connecting elements together. A rotational movement, which can place additional strain on the weakened spine, is not necessary for this, but the two connecting elements can generally simply be pushed together, i.e. the joining, pressing on and fixing of the connecting elements takes place in a single step, i.e. with a single,
15 continuous movement. This also allows the doctor to connect the bones or bone parts much more quickly.

The latching elements of the first latching structure can be latching teeth in particular. Similarly, the latching elements of the second latching structure can also be latching teeth
20 in particular. However, embodiments are also possible in which only the latching elements of one of the two latching structures are designed as latching teeth, while the latching elements of the other latching structure are designed as recesses or apertures, for example, in order to thereby form an engagement structure for the latching teeth. A latching tooth is generally a protruding, in particular serrated or toothed element.

25 The bone connecting device usually has at least one first component, which is designed to connect to a first bone or bone part, and a second component, which is designed to connect to a second bone or bone part. To produce the bone connection, the two components are connected to each other by means of the first and second connecting elements. The two
30 components mentioned can be the first and second connecting elements themselves. Preferably, however, the two components to be connected directly to one bone or bone part each represent separate elements with respect to the two connecting elements. Advantageously, however, the components to be connected directly to the bone or bone part can be attached to the first or second connecting part, in particular can be fixed.

35 A connection to a bone or bone part means that a corresponding component is attached to

the bone or bone part in such a way that it cannot change its position relative to the bone or bone part, even if the patient moves. The component can be anchored, in particular screwed, into the bone or bone part for this purpose. Alternatively, however, it can simply rest against the outside of the bone, in which case it is ensured, for example via other components and/or via the surrounding tissue, that the component cannot move relative to the bone. Bonding the component to the bone or bone part, e.g. using bone cement, is also conceivable.

Thermoplastics are preferably used as the plastics material, particularly so-called high-temperature thermoplastics from the polyaryletherketone, polyimide and polysulphone families. Carbon fibers are preferably used as fibers. It is particularly preferred that the fiber-reinforced plastics material of the first and/or second connecting element is carbon fiber-reinforced polyether ether ketone (PEEK). The first and second connecting elements are preferably made from the same materials.

The fiber length is preferably at least 1 mm. In order to achieve a particularly good strength of the first and/or the second connecting element, the fibers advantageously have a length which corresponds at least to the complete length of the respective connecting element along its main direction of extension. The fiber volume content is preferably in a range from 20 to 80%, more preferably in a range from 35 to 70%, particularly preferably in a range from 45 to 60%.

In principle, the connecting elements can be manufactured using a process that is conventionally known in the composite sector. These include pressing processes, winding processes, tape laying processes, pultrusion processes and long-fiber injection molding processes, such as "injection molding CMF" (composite flow molding). The pressing process described in document DE 44 45 305 C1 is preferred for manufacturing the connecting elements and preferably, if present, other components of the bone connecting device. The connecting elements can also be manufactured using so-called additive manufacturing processes, such as the 3D printing process (short, long or continuous fiber-reinforced), or a combination of the above-mentioned processes. Unidirectional prepregs, rods and fabric prepregs are the preferred starting materials for these processes. Both are geometrically flat or round-shaped starting materials. In the above-mentioned processes, the prepregs are generally preformed into preforms and welded under pressure and temperature, for example in a pressing tool, and then cooled.

The above-mentioned methods for manufacturing the connecting elements and possibly the other components are preferably near-net-shape manufacturing methods, which means that connecting elements and/or components manufactured in this way generally require only minor mechanical reworking in terms of shape and dimensions.

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The latching elements, in particular latching teeth, of a respective latching structure are preferably arranged parallel to each other and advantageously have an identical shape in cross-section. However, the latching elements of a respective latching structure can be arranged in groups, wherein the latching elements of different groups can, for example,
 10 have different orientations. For example, the latching elements of a first group can face in a first direction and the latching elements of a second group can face in an opposite direction, so that the two groups are orientated towards each other.

In order to achieve a particularly firm fixation, a respective latching structure preferably has
 15 two or four latching elements or, even more preferably, one or two pairs of latching elements. A pair of latching elements is formed in each case by two individual latching elements, which are preferably arranged at the same height of the corresponding latching structure and are advantageously arranged facing towards or away from each other, i.e. opposite each other. Preferably, the first latching structure has one or two such pairs of
 20 latching elements and the second latching structure also has one or two pairs of latching elements. It has been found that a good engagement of the two latching structures is possible and a particularly firm fixation is achieved if both the first latching structure and the second latching structure have two pairs of latching elements. The two pairs are then preferably arranged one above the other, i.e. on different levels in relation to the direction
 25 of engagement. In the case of two pairs of latching elements, two latching elements are preferably arranged parallel to each other on each side.

In other embodiments, which are also preferred depending on the application, a respective latching structure has at least three, even more preferably at least five and most preferably
 30 at least ten latching elements arranged parallel to one another, wherein these latching elements can each form part of three, at least five or at least ten pairs of latching elements arranged at the same height. In this way, the two connecting elements can be latched in several different positions.

35 In order to enable the first and second connecting elements to be latched together via the latching structures, the first and/or second connecting element has a certain elasticity in the

area of the latching structure. This elasticity can be provided in particular due to the materialization and/or the geometric design of the connecting element.

5 Preferably, the latching structure of the first connecting element is complementary to the latching structure of the second connecting element, so that a positive fit can be created between the two connecting elements when they latch together.

10 According to a preferred embodiment, the first latching elements and the second latching elements are each undercut in such a way that a release of the fixation between the first connecting element and the second connecting element is prevented when the first latching structure and the second latching structure are latched together. In this case, the latching elements that are latched together engage with each other in such a way that it is impossible to release the connection by simply pulling the two connecting elements apart. Unintentional loosening of the connection between the two connecting elements can thus be effectively
15 prevented, even when a great deal of force is applied. Preferably, the two connecting elements can only be released with the aid of a tool, in particular a special tool, once they have locked into place. This makes the bone connection particularly secure.

20 In order to make it easy for the doctor to fix the two connecting elements to each other, the first latching elements and/or the second latching elements each have a sloping surface inclined to a latching direction, which makes it easier to latch the first latching structure to the second latching structure. Preferably, the latching structures can thus be easily brought into engagement with each other, but can only be released from each other with difficulty due to the aforementioned undercut.

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Preferably, the first latching structure is an inner latching structure, the first latching elements of which face outwards in at least two opposite directions, and the second latching structure is an outer latching structure, the second latching elements of which face inwards in at least two opposite directions. In the latched state, the first latching structure is thus
30 preferably arranged inside the second latching structure. As the latching elements of a respective latching structure each face in at least two opposite directions, the latching of the latching structures can be performed accordingly from at least two directions. This enables a particularly secure and powerful fixing of the connecting elements to one another.

35 In a particularly preferred embodiment, the bone connecting device has a third connecting element, which may in particular be a connecting rod. The connecting rod may, but need

not, form part of a pedicle system. The first and second connecting elements preferably serve to clamp the third connecting element between them. In particular, the second connecting element can be a latching clip, which is preferably designed to be placed on the first connecting element and latched to it. The latching clip is preferably C-shaped as a whole, with two retaining webs that are advantageously arranged more or less parallel to each other and a connecting web that connects the retaining webs. The second latching elements are then preferably arranged on the retaining webs, with a first group of latching elements advantageously arranged on the first retaining web and a second group of latching elements arranged on the second retaining web, so that the two groups of latching elements face inwards towards each other.

Preferably, in the latched state of the first and second connecting elements, the latching connection is arranged along the latching direction at the same height as the third connecting element. By an arrangement at the same height is meant that the mutual latching engagement of the first and second latching structures along the latching direction takes place at the same height, i.e. partially or completely overlapping, with the third connecting element. In this way, the space requirement of the bone connecting device along the engaging direction can be minimized. This reduction in the overall height of the device along the direction of engagement is particularly advantageous in pediatric applications and in high thoracic and cervical applications.

The latching clip preferably has a clamping element which serves to clamp the third connecting element, wherein the clamping element is advantageously designed to bear directly against the third connecting element. In the latched state, the third connecting element is preferably arranged between the clamping element of the latching clip and the first connecting element and thus clamped in place. In principle, it is conceivable that the clamping element is arranged outside the second latching elements on the latching clip. However, in order to achieve particularly effective clamping, it is preferable for the clamping element to be arranged inside the second latching elements and advantageously in the center of the latching clip. The force can then be transmitted via the clamping element in a particularly efficient manner. Preferably, the clamping element is attached to the connecting web and protrudes from it in the direction of the third connecting element.

To further increase the clamping effect, the clamping surface of the clamping element and/or the third connecting element can have a friction-enhancing coating.

In order to adjust the flexibility of the latching clip, it can have one or more local recesses in an area between the inward-facing second latching elements. Due to the one or more local recesses, the latching clip preferably has a material taper in the corresponding area, which increases the flexibility of the latching clip. Depending on how pronounced these recesses are, latching with the first connecting element is made easier or more difficult for the doctor and, at the same time, releasing the latching connection is made easier or more difficult. Preferably, one to three such recesses are provided.

So that the first and second latching structures can be completely released from each other if necessary or the mutual engagement of the latching structures can be reduced, the first connecting element and/or the second connecting element advantageously has an intervention structure which enables the latching connection to be released, for example with the aid of a suitable tool. In particular, the intervention structure can be arranged on the outside of the first or second latching structure.

In a particularly preferred embodiment, the third connecting element is a connecting rod and the first connecting element is a tulip head, which serves to fix the connecting rod to a threaded shaft of a screw, in particular a pedicle screw. In this case, the bone connecting device is therefore a pedicle system. Depending on the embodiment, the tulip head can be formed in one piece with the screw or represent a separate component in which the screw head of the screw is held. Preferably, it is a polyaxial fixation system in which the position of the threaded shaft of the screw or screws can be adjusted relative to the connecting rod. The second connecting element, which is advantageously designed as a latching clip, is then preferably used to clamp the connecting rod to the tulip head. The first latching structure is then preferably formed on the outside of the tulip head. If the pedicle system is designed as a polyaxial fixation system, the second connecting element and/or a clamping element molded onto the latching clip, for example, can serve to clamp the screw to the tulip head by the connecting rod or the clamping element pressing the screw head against a stop surface provided on the tulip head. Depending on the situation, a so-called washer may also be provided between the connecting rod and the tulip head or between the clamping element and the tulip head. The washer can be used in particular to improve the transmission of force from the connecting rod or clamping element to the screw head. Compared to conventional clamping of the connecting rod to the tulip head by means of a clamping element provided with an external thread, clamping with a latching clip has the advantage that the space required on the side of the connecting rod opposite the screw is considerably reduced. In addition, no rotary movement is required for fixing.

In another, also preferred embodiment, the third connecting element is a connecting rod and the first connecting element is a connector, in particular an axial connector or a parallel connector, which is used to connect two connecting rods. Here too, the second connecting element is advantageously designed as a latching clip and the first latching structure is preferably arranged on the outside of the connector. However, the first latching structure can also be formed on the connecting rod, in particular on an end region of the connecting rod. In the case of an axial connector, two preferably identically designed latching clips can be provided, one for clamping the first connecting rod and the other for clamping the second connecting rod. In the case of a parallel connector, a single latching clip with two clamping elements can be provided, wherein the first clamping element is used to clamp the first connecting rod and the second clamping element is used to clamp the second connecting rod. The connector then forms a connector system together with the second connecting element(s) and, if applicable, the connecting rods.

Preferably, the connector has at least one opening for receiving a connecting rod, which widens along the direction of engagement towards the second connecting element. In this way, the connector can be used to connect connecting rods with different diameters.

In another, equally preferred embodiment, the first connecting element is a screw and the second connecting element is a bone plate. Preferably, several first connecting elements are present in the form of screws. In particular, the screw or screws and bone plate can together form a cervical plate system that serves to stabilize the cervical spine. The screw or screws preferably each have an at least partially elastically deformable screw head, on which the first latching structure is formed. The second latching structure is preferably provided on the boundary surface of openings formed in the bone plate. The screw or screws can then be fixed in the openings of the bone plate with their first latching structure provided on the screw head. Preferably, the first latching elements of the screw(s) and/or the second latching elements of the bone plate form a thread. The at least partially elastic design of the screw head with the first latching structure formed thereon makes it possible to fix the respective screw in different angular positions on the bone plate. If a thread is present, the screw can be screwed with its screw head in the desired angular position into the corresponding opening of the bone plate. If the screw is screwed in at an angle, mutual engagement is not possible in certain areas of the latching structures. However, the elasticity of the screw head still allows the screw to be screwed in in this case, as the latching structures cannot engage with each other in the areas mentioned, but can in other areas.

The screw or screws are preferably designed to be screwed directly into a bone, in particular into a vertebral body of the cervical spine.

5 In a further, also preferred embodiment, the bone connecting device is designed as a vertebral body replacement. The first connecting element can then in particular be an expansion slide and the second connecting element an expansion body. The expansion slide and expansion body are then latchable together with their respective latching structures at different positions along the longitudinal extension of the vertebral body replacement in order to adapt the longitudinal extension of the vertebral body to the patient.
10 In order to better adapt the vertebral body replacement to the anatomical conditions of the patient, the first and second latching structures can each be curved. The expansion slide and expansion body are then latched along a correspondingly curved latching direction.

15 In order to guide the first latching structure relative to the second latching structure during fixing, the first connecting element and the second connecting element preferably have interengaging guides, which in particular can form a dovetail joint together. In this way, correct fixing of the two connecting elements to each other can be guaranteed.

20 According to a development of the invention, the second connecting element has a latching clip which forms the second latching structure and is connected to the remaining second connecting element via a flexible element. Preferably, the latching clip is connected to the remaining second connecting element exclusively via the flexible element. The flexible element is preferably a web, which can in particular be formed in one piece with the latching clip and/or the remaining second connecting element. The flexibility preferably refers to the
25 remaining second connecting element, which generally has less flexibility compared to the flexible element. If, for example, the third connecting element is formed by a connecting rod and the second connecting element is used to fasten the connecting rod to a pedicle screw, the provision of the flexible element can have the advantage that there is a certain amount of movement between the connecting rod and the pedicle screw despite the fastening. In
30 particular, this can reduce a stress discontinuity between the levels of the spinal column provided with the pedicle system and the adjacent portions of the spinal column. A more gradual transition between the portion of the spine stiffened by the pedicle system and the still mobile portions can reduce the probability of proximal junctional kyphosis and at the same time protect the adjacent intervertebral discs and vertebral bodies from further
35 degeneration and unphysiological load patterns.

According to another development of the invention, the first connecting element and the second connecting element are displaceable relative to one another along the longitudinal direction of the first and second latching elements when latched together. In particular, the second connecting element may have a latching clip. Preferably, the second connecting element is also a connecting rod. The first connecting element can also be a connecting rod. Thus, in this further development of the invention, the first and second connecting elements are displaceable relative to one another over at least a certain range despite the mutual fastening by means of the latching structures. Preferably, however, the displaceability is only possible over a limited range, i.e. there is advantageously a stop on both sides, so that the range of movement is restricted and the two connecting elements cannot become detached from each other during displacement. Depending on the application and patient situation, such limited mobility can have advantages in terms of the therapy result.

The bone connection device according to the invention can be, for example, a pedicle system, a connector system, such as in particular an axial or parallel connector system, a cervical plate system, a vertebral body replacement or an intervertebral disc cage. Similar to the vertebral body replacement, the intervertebral disc cage can also be expandable.

The invention also relates to a method for connecting two bones or bone parts of a human or animal patient, in particular by means of a bone connecting device as described above, wherein a first connecting element made of a fiber-reinforced plastics material and a second connecting element made of a fiber-reinforced plastics material are fixed to one another by means of a plurality of first latching elements of a first latching structure of the first connecting element being latched with a plurality of second latching elements of a second latching structure of the second connecting element. The two connecting elements are preferably fixed to one another by means of a purely translational movement of the two connecting elements relative to one another, i.e. preferably no rotational movement is performed.

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BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention are described in the following with reference to the drawings, which are for the purpose of illustration and are not to be construed as limiting.

35 In the drawings,

- Fig. 1a shows a perspective view of a pedicle screw of a pedicle system according to the invention fixed to a connecting rod by means of a tulip head and a latching clip;
- Fig. 1b shows a perspective exploded view of the device of Fig. 1a;
- 5 Fig. 1c shows a side view of the device in Fig. 1a from a first viewing direction;
- Fig. 1d shows a side view of the device in Fig. 1a from a second viewing direction;
- Fig. 1e shows a first central cross-sectional view of the device of Fig. 1a;
- Fig. 1f shows a second central cross-sectional view of the device of Fig. 1a;
- Fig. 1g shows an enlarged detailed view of the area outlined in dashed lines in Fig. 1d;
- 10 Fig. 2 shows a perspective view of the latching clip of another pedicle system according to the invention;
- Fig. 3 shows a perspective view of the latching clip of yet another pedicle system according to the invention;
- Fig. 4a shows a perspective view of a pedicle screw of a further pedicle system according to the invention, fixed to a connecting rod by means of a tulip head and a latching clip;
- 15 Fig. 4b shows a perspective exploded view of the device of Fig. 4a;
- Fig. 5 shows a perspective view of the latching clip of a further pedicle system according to the invention;
- 20 Fig. 6a shows a perspective view of a pedicle screw of yet another pedicle system according to the invention, fixed to a connecting rod by means of a tulip head and a latching clip;
- Fig. 6b shows a perspective exploded view of the device of Fig. 6a;
- Fig. 7 shows a perspective view of the latching clip of a further pedicle system according to the invention;
- 25 Fig. 8a shows perspective view of a pedicle screw of yet another pedicle system according to the invention, fixed to a connecting rod by means of a tulip head and a latching clip;
- Fig. 8b shows a perspective exploded view of the device in Fig. 8a;
- 30 Fig. 9a shows perspective view of two connecting rods connected to each other by means of an axial connector of an axial connector system according to the invention;
- Fig. 9b shows a perspective exploded view of the device in Fig. 9a;
- Fig. 9c shows a first central cross-sectional view of the device of Fig. 9a;
- 35 Fig. 9d shows a second cross-sectional view along the plane IX-IX of the device of Fig. 9a shown in Fig. 9c;

- Fig. 10a shows a perspective view of two connecting rods connected to each other by means of an axial connector of an axial connector system according to the invention according to another embodiment;
- Fig. 10b shows a side view of the device in Fig. 10a;
- 5 Fig. 10c shows a perspective exploded view of the device in Fig. 10a;
- Fig. 11a shows a perspective view of two connecting rods connected to each other by means of a parallel connector of a parallel connector system according to the invention;
- Fig. 11b shows a perspective exploded view of the device of Fig. 11a;
- 10 Fig. 11c shows a side view of the device in Fig. 11a;
- Fig. 12a shows a perspective view of a cervical plate system according to the invention with several screws fixed in a bone plate;
- Fig. 12b shows a perspective exploded view of the device of Fig. 12a;
- Fig. 12c shows a cross-sectional view of the device of Fig. 12a in a plane centered by
15 three screws;
- Fig. 13a shows a perspective view of a vertebral body replacement according to the invention;
- Fig. 13b shows a perspective exploded view of the device of Fig. 13a; Fig. 13c
shows a central cross-sectional view of the device of Fig. 13a, in an
20 unexpanded state;
- Fig. 13d shows a central cross-sectional view of the device of Fig. 13a, in an expanded state;
- Fig. 14a shows a perspective view of another vertebral body replacement according to the invention with curved latching structures;
- 25 Fig. 14b shows a perspective exploded view of the device of Fig. 14a;
- Fig. 14c shows a central cross-sectional view of the device of Fig. 14a, in a non-expanded state;
- Fig. 14d shows a central cross-sectional view of the device of Fig. 14a, in an expanded state;
- 30 Fig. 15a shows an exploded perspective view of a pedicle screw of a pedicle system according to the invention fixed to a connecting rod by means of a tulip head and a latching clip according to a further embodiment;
- Fig. 15b shows a central cross-sectional view of the device of Fig. 15a;
- Fig. 16a shows a perspective view of a pedicle screw of a pedicle system according to
35 the invention fixed to a connecting rod by means of a tulip head and a latching clip according to yet another embodiment;

- Fig. 16b shows a perspective view of the device of Fig. 16a;
- Fig. 17a shows a side view of a bone connecting device in the form of two ends of two connecting rods slidably connected to each other via a latching connection;
- Fig. 17b shows a perspective view of the device of Fig. 17a;
- 5 Fig. 18a shows a central cross-sectional view of a fenestrated pedicle screw of a pedicle system according to the invention fixed to a connecting rod by means of a tulip head and a latching clip according to a further embodiment;
- Fig. 18b shows a perspective exploded view of the device of Fig. 18a;
- Fig. 19a shows a central cross-sectional view of a fenestrated pedicle screw of a pedicle system according to the invention fixed to a connecting rod by means of a tulip head and a latching clip according to a further embodiment; and
- 10 Fig. 19b shows a perspective exploded view of the device of Fig. 19a.

DESCRIPTION OF PREFERRED EMBODIMENTS

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Figures 1a to 19b show various embodiments of medical bone connecting devices according to the invention and parts thereof. Elements of different or identical embodiments that have the same or similar effect are each provided with the same reference sign.

20 Figures 1a to 1g show different views of a first preferred embodiment of a bone connection device according to the invention in the form of a polyaxial fixation system 1. The polyaxial fixation system 1 is designed as a pedicle system which has a plurality of screws 12, which can also be referred to as pedicle screws and can each be screwed into a vertebral body of the spinal column of a human or animal patient. Each of the screws 12 is attached to a

25 connecting rod 11 by means of a tulip head 13. The connecting rod 11 thus connects the screws 12 to each other and thereby locks or stabilizes the corresponding vertebral bodies. Preferably, the connecting rod 11 is manufactured as a whole in one piece from a fiber-reinforced plastics material.

30 The screw 12 has a largely spherical screw head 121 in which an engagement structure 122 is formed. The engagement structure 122 is, for example, hexagonal or in torx form and is used to screw the screw 12 into a vertebral body with the aid of a corresponding tool. The screw 12 has a threaded shaft 123 which extends from the screw head 12 to a screw tip 124.

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The screw 12 is preferably manufactured as a single piece from a fiber-reinforced plastics

material. In this way, the X-ray transparency of the polyaxial fixation system 1 can be guaranteed. Markers, in particular radio-opaque markers, can be provided on the screw 12 in order to nevertheless easily recognize the position and orientation of the polyaxial fixation system 1 and in particular of the screws 12 during X-ray imaging or other medical imaging, such as magnetic resonance imaging. Such a marker can, for example, be inserted in a recess provided on the screw tip 124 (recognizable in Figures 1e and 1f).

The tulip head 13, which is also made of a fiber-reinforced plastics material and is preferably manufactured in one piece as a whole, has a main body 131, from which two diametrically opposed lateral webs 132 and 132' extend upwards. The two lateral webs 132, 132' laterally delimit two receiving openings 135, 135' arranged between them and open at the top, which serve to receive the connecting rod 11. A latching structure 133 is formed on the radially outer side of the lateral webs 132 and 132', which is formed by latching elements in the form of latching teeth 134 and 134' respectively. A first group of latching teeth 134, which are arranged parallel to one another and are each of identical design, is provided on the first lateral web 134 and a second group is provided on the second lateral web 134.

Below the receiving openings 135, 135', the main body 131 of the tulip head 13 forms an interior 136 which serves to receive the screw head 121 of the screw 12. For this purpose, the screw 12 is inserted into the tulip head 13 from above with the threaded shaft 123 first until the screw head 121 abuts against a contact surface 137 delimiting the interior 136 (see Figures 1e and 1f). Due to the spherical shape of the screw head 121, the screw 12 can be arranged and fixed in different angular positions relative to the tulip head 13. The tulip head 13 thus forms a connecting element for connecting and fixing the screw 12 to the connecting rod 11.

A latching clip 15 serves to fix the screw 12 and the connecting rod 11 in a desired position on the tulip head 13. The latching clip 15, which is made of a fiber-reinforced plastics material and is preferably manufactured in one piece as a whole, has a C-shaped form as a whole with two parallel, freely projecting retaining webs 152, 152' and a connecting web 151 connecting the retaining webs 152, 152'. A latching structure 153, each with a plurality of latching elements in the form of latching teeth 154 or 154', is formed on the radial insides of the retaining webs 152, 152'. A first group of latching teeth 154, which are arranged parallel to one another and are each of identical design, is provided on the first retaining web 152 and a second group is provided on the second retaining web 152'. The latching teeth 154, 154' thus face inwards in the radial direction. Between the retaining webs 152

and 152', a clamping element 155 is fitted centrally on the connecting web 151, which projects downwards from the latter parallel to the retaining webs 152, 152' and forms a saddle-shaped, possibly coated (higher friction, locking) contact surface adapted to the outer surface of the connecting rod 11.

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To connect the screw 12 to the connecting rod 11, the connecting rod 11 is inserted into the receiving openings 135, 135' of the tulip head 13, wherein the screw head 121 is already received in the interior 136 of the tulip head 13. Subsequently, the latching clip 15 is placed onto the lateral webs 132, 132' of the tulip head 13 with its retaining webs 152, 152' leading,
 10 so that the latching structure 153 of the latching clip 15 latches with the latching structure 133 of the tulip head 13. By pressing the latching clip 15 onto the tulip head 13 along a latching direction R, the mutual engagement of the latching structures 153 and 133 can be increased and the clamping force acting on the connecting rod 11 can be increased as a result. The clamping element 155 thereby presses the connecting rod 11 onto the screw
 15 head 121 arranged underneath, which in turn is pressed against the contact surface 137 of the tulip head 13 and thereby clamped. In order to increase the clamping effect, the clamping surface of the clamping element 155 and/or the connecting rod 11 can have a friction-enhancing coating.

20 As can be seen in the enlarged detailed view of Figure 1g, the inner latching teeth 134, 134' of the tulip head 13 each have a first surface facing away from the latching clip 15, which is perpendicular to the latching direction R, and a second surface facing towards the latching clip 15, which is inclined to the latching direction R. Similarly, the complementary latching
 25 teeth 154, 154' of the latching clip 15 each have a first surface facing towards the tulip head 13, which is perpendicular to the latching direction R, and a second surface facing away from the tulip head 13, which is inclined to the latching direction R. The first and second surfaces of the latching teeth 134, 134' and 154, 154' are thus each at an acute angle to one another. The first surfaces of the latching teeth 134, 134' and 154, 154', which are perpendicular to the latching direction R, thus together form an undercut, which prevents
 30 the latching clip 15 from being removed from the tulip head 13 after mutual latching. The second surfaces of the latching teeth 134, 134' and 154, 154', on the other hand, allow easy attachment and latching of the latching clip 15 to the tulip head 13 due to their inclination to the latching direction R.

35 In order to achieve better contact pressure between the screw head 121 and the contact surface 137 of the tulip head 13, a so-called washer 14 is preferably arranged between the

connecting rod 11 and the screw head 121. As can be seen in Figure 1b, the washer 14 is ring-shaped. It can be made of a metal or a plastics material, in particular a fiber-reinforced plastics material. In order to prevent movements between the washer 14 and the screw 12 even more efficiently, one or both of the adjacent surfaces of the washer 14 and the screw head 121 can have a friction-enhancing coating and/or a surface structure. The surface structure can, for example, be formed by grooves or notches.

In order to facilitate the application and latching of the latching clip 15, which serves as a connecting element, onto the tulip head 13, the latching clip 15 and/or the tulip head 13 advantageously have a certain elasticity. Such elasticity can be achieved, for example, by providing a slot 156 or 156' running in the longitudinal or axial direction on each of the retaining webs 152, 152' of the latching clip 15, as is the case in the embodiment of Figures 1a to 1g. Alternatively or additionally, a local recess 157 can be provided on the upper side of the connecting web 151 of the latching clip 15, as shown in the latching clip 15 of the embodiment of Figure 2. The recess 157 is arranged centrally between the two retaining webs 152, 152' and extends parallel to the retaining webs 152, 152' in the longitudinal direction of the connecting rod 11. By adjusting the dimensions of the recess 157, the elasticity of the latching clip 15 can be set very precisely. Due to the recess 157, the latching clip 15 thus forms a spring element.

In another embodiment, shown in Figure 3, the spring effect of the latching clip 15 is achieved by two recesses 157 arranged laterally on the connecting web 151. Here too, the recesses 157 each run parallel to the retaining webs 152, 152' in the longitudinal direction of the connecting rod 11. Depending on the embodiment, the central recess 157 of Figure 2 can also be combined with the two lateral recesses 157 of Figure 3.

In the embodiment shown in Figure 3, no slot 156 or 156' is provided on each of the retaining webs 152, 152'. Instead, an outwardly projecting, bow-shaped intervention structure 159 is provided on the radially outer side of each of the retaining webs 152, 152' in the region of their free ends. The intervention structures 159 serve to release the mutual engagement of the latching structures 133 and 153 if necessary, in order to release the fastening of the connecting rod 11 to the tulip head 13. For this purpose, the intervention structures 159 can be gripped behind with a suitable tool in order to move the retaining webs 152, 152' outwards in a radial direction.

In the embodiment shown in Figures 4a and 4b, the latching clip 15 has neither a slot 156,

156' nor a local recess 157. The elasticity in the area of the latching structure 153 can be achieved here, for example, by selecting the appropriate material when manufacturing the latching clip 15.

- 5 Figure 5 shows an embodiment of a latching clip 15, which has a slot 156 running in the axial direction on each of the retaining webs 152, 152', similar to the latching clip 15 of Figure 1b. Two bow-shaped intervention structures 159 are attached to the side of the slot 156 on the retaining web 152 or 152'. Two parallel recesses 157 are formed on the connecting web 151 in order to give the latching clip 15 a certain flexibility with regard to
10 latching.

While the lateral webs 132, 132' of the tulip head 13 in the embodiments of Figures 1a to 4b each have rounded outer surfaces with correspondingly rounded latching teeth 134, 134' along their longitudinal extent, the outer surfaces of the lateral webs 132, 132' in the
15 embodiment of Figures 6a and 6b are each flat. Accordingly, the latching teeth 134, 134' here also run in a straight line along their longitudinal extension. The same applies analogously to the inner surfaces of the retaining webs 152, 152' and the latching teeth 154, 154' formed thereon.

- 20 Figure 7 shows a further embodiment of a latching clip 15 which, similar to that of Figures 3 and 5, has two parallel recesses 157 on the upper side of the connecting web 151 to effect the latching clip elasticity. The latching clip 15 is otherwise formed largely like that of Figures 6a and 6b, although it also has an intervention structure 159 on the outer sides of the retaining webs 152 in order to be able to release the latching clip 15 from the tulip head 13
25 if necessary using a suitable tool. The provision of intervention structures 159, which serve to release the mutual engagement of the latching structures, but which can also be designed differently than in the present embodiment and the embodiments described above, is of course also conceivable for each of the latching clips 15 of the embodiments of Figures 1a to 2 and 4a, 4b and 6a, 6b. The latching clips 15, 24 and 34 of the embodiments of Figures
30 8a to 11c described further below can also have such intervention structures 159 for releasing the mutual engagement of the latching structures.

The embodiment of Figures 8a and 8b differs from that of Figures 6a and 6b in that guides are provided on the latching clip 15 and on the tulip head 13 in order to guide the latching
35 of the latching clip 15 onto the tulip head 13 laterally and thereby ensure correct attachment of the latching clip 15. A dovetail inner guide 158, 158' in the form of a downwardly projecting

projection is provided on each of the retaining webs 152 for lateral guidance. On the outside of the tulip head 13, two complementary dovetail outer guides 138, 138' are provided, each in the form of a short guide groove extending parallel to the latching direction R. Furthermore, in the embodiment of Figures 8a and 8b, in contrast to that of Figures 6a and 6b, a central recess 157 is formed on the upper side of the connecting web 151 of the latching clip 15.

Figures 9a to 9d, 10a to 10c and 11a to 11c show further embodiments of bone connecting devices according to the invention, which are designed here as connectors for connecting and fixing two connecting rods 21 and 22 or 31 and 32 in each case. The connecting rods 21 and 22 or 31 and 32 are connected to one or more bones or bone parts via further components not shown in the figures, such as screws in particular. While the embodiment of Figures 9a to 9d and 10a to 10c each relates to an axial connector system 2, the embodiment of Figures 11a to 11c relates to a parallel connector system 3.

The axial connector system 2 of Figures 9a to 9d has an axial connector 23, which forms a housing designed to receive a first connecting rod 21 and a second connecting rod 22 from opposite sides. For this purpose, the connecting rods 21 and 22 are each inserted into a receiving opening 232 and 232' respectively, which are formed by a main body 231 of the axial connector 23. The connecting rods 21, 22 each project with their free ends into an interior space 235 or 235' (see Figures 9c and 9d), where they can be clamped by means of a respective latching clip 24.

The two almost identically designed latching clips 24 have a similar design to the latching clip of the embodiment of Figures 6a and 6b. They have an overall C-shaped configuration with two parallel retaining webs 242, 242' and a connecting web 241 connecting them. Between the retaining webs 242, 242', a clamping element 245 is provided on the underside of the connecting web 241 with an underside shaped complementarily to the connecting rod 21 or 22. While the clamping element 245 of the first latching clip 24 resting against the first, thicker connecting rod 21 is somewhat wider, that of the second latching clip 24 resting against the second, thinner connecting rod 22 is correspondingly narrower. This ensures that the respective latching clip 24 fits snugly against both connecting rods 21, 22.

The main body 231 and the latching clips 24 thus each form a connecting element. They are preferably each made in one piece as a whole from a fiber-reinforced plastics material.

To clamp the connecting rods 21 and 22 to the axial connector 23, the latching clips 24 are thus attached to the main body 231. Corresponding latching structures 233 and 233' with a plurality of latching teeth 234 and 234' are provided on the outside of the main body 231 for this purpose. A correspondingly complementary latching structure 243 with latching teeth

5 244 and 244' is formed on the inside of each of the two latching clips 24. When the latching clips 24 are applied to the axial connector 23, the latching structures 233 and 243 or 233' and 243 engage with one another, whereby the respective latching clip 24 is fixed to the main body 231. By further pressing the respective latching clip 24 against the main body 231, the clamping of the connecting rod 21 or 22 can be reinforced.

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In order to be able to use the same main body 231 for connecting rods 21 or 22 of different thicknesses, the receiving openings 232, 232' are each surrounded by a contact surface 236 or 236', which widens along the engaging direction R towards the latching clip 24, as can be seen in particular in Figure 9d.

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Once the two connecting rods 21, 22 have been connected and fixed by means of the axial connector 23, the connecting rods are arranged one behind the other along their longitudinal extension. As can be seen in Figure 9c, the axial connector 23 can cause a certain inclination of the connecting rods 21, 22 relative to each other, i.e. the first connecting rod

20 21 extends at a certain angle along its longitudinal extent relative to the second connecting rod 22.

Figures 10a to 10c show another embodiment of an axial connector system 2, which has two latching clips 24, which are connected to each other by means of a connecting portion

25 247 and are thus preferably formed together in one piece. The connecting portion 247 can connect the two latching clips 24 to each other at a certain angle, as is the case here, so that a corresponding inclination of the interconnected connecting rods 21, 22 relative to each other is achieved (see Fig. 10b). The two identically designed latching clips 24 each have a connecting web 241 with a clamping element 245 attached thereto and two retaining webs 242, 242' extending parallel from the connecting web 241 with latching teeth 244 and

30 244' attached thereto. The latching teeth 244, 244' each form a latching structure 243, which is designed to engage in a latching structure 212 or 222 provided on the connecting rod 21 or 22. For this purpose, the respective free ends of the connecting rods 21, 22 are each formed by a cuboid latching block 211 or 221, on which the latching structure 212 or 222 is

35 formed with corresponding latching teeth 213, 213' or 223, 223'. The latching block 211 or 221 is advantageously formed in one piece with the remaining connecting rod 21 or 22. In

this case, the connecting rods 21 and 22 thus each form a connecting element of the axial connector system 1. Compared to the embodiment of Figures 9a to 9d, the embodiment of Figures 10a to 10c thus has fewer components, but requires a specific configuration of the connecting rods 21, 22 in their respective end regions.

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The parallel connector 33 of the parallel connector system 3 shown in Figures 11a to 11c also serves to connect two connecting rods 31 and 33 to each other and to fix them together. In contrast to the embodiments of Figures 9a to 10c, however, the connecting rods 31, 33 are arranged and fixed here with their free ends parallel to one another in the main body 331 of the connector. Instead of two latching clips 24, however, the clamping is achieved here with a single common latching clip 34. However, the latching clip 34 has two clamping elements 345, 345', which are each designed to clamp one of the connecting rods 31, 33 and the shape of which is adapted to the diameter of the respective connecting rod 31, 33. The receiving openings 332, 332' for inserting the connecting rods 31 and 33 are also here each delimited by a contact surface 336 or 336' which widens along the latching direction R towards the latching clip 34, whereby the fixing of connecting rods 31, 33 each with different diameters is made possible. For latching the latching clip 34 to the main body 331, the latching clip 34 has a latching structure 343 with oppositely arranged latching teeth 344 and 344' on its retaining webs 342 and 342', which are connected to one another via the connecting web 341. As a complementary counterpart to the latching structure 343, a further latching structure 333 with outwardly projecting latching teeth 334 and 334' is formed on the outside of the main body 331. When the latching clip 34 is latched onto the main body 331, the free ends of the connecting rods 31 and 32 projecting into the inner spaces 335 and 335' are thus clamped.

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Another embodiment of a bone connecting device, which is also in accordance with the invention, is shown in Figures 12a to 12c. This is a cervical plate system 4 with a bone plate 41, which has a main body 411 with several openings 412, into each of which a screw 42 can be inserted to connect bones or bone parts. The screws 42 each have a screw head 421 and a threaded shaft 426 extending from the screw head along a longitudinal center axis 428 to a screw tip 427. The screws 42 are designed for anchoring in a bone or bone part, in particular in a vertebral body of the cervical spine. For screwing in the screws 42, an engagement structure 425, for example hexagonal or in torx form, is provided in each case, which is accessible with a corresponding tool through the respective screw head 421, which is formed in a semi-cavity shape. Both the bone plate 41 and each of the screws 42 thus form a connecting element of the bone connecting device and are preferably each

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manufactured as a whole in one piece and from a fiber-reinforced plastics material.

To fix the screws 42 in the openings 412 of the bone plate 41, the screw heads 421 each have a latching structure 423 with a plurality of outwardly projecting latching teeth 424 on their outer side. A correspondingly complementary latching structure 413 with a plurality of inwardly projecting latching teeth 414 is formed on the surfaces of the bone plate 41 surrounding the openings 412. Preferably, the latching teeth 424 of the screws 42 and/or the circumferentially extending latching teeth 414 of the bone plate form a thread.

10 The screw head 421 of the screws 42 each has a certain elasticity, which is achieved by means of slots 422, on the basis of which the screw head 421 is divided into a plurality of segments which can be elastically pressed inwards. When a screw 42 is screwed into an opening 412 in such a way that its longitudinal center axis 428 extends exactly along that longitudinal center axis 415 which is defined by the latching structure 413 provided in the opening 412, the latching teeth 424 of all segments of the screw head 421 engage in the latching structure 413. This is the case with the screw 42 shown on the far right in Figure 12c. If, on the other hand, the screw 42 is screwed into an opening 412 at an angle, as shown on the far left in Figure 12c, the longitudinal center axis 428 of the screw 42 deviates from the longitudinal center axis 415 defined by the latching structure 413. Due to the angular deviations, the latching teeth 424 of certain segments of the screw head 421 can then no longer latch into the latching structure 413 of the bone plate 41, but are instead pressed slightly inwards radially, which is, however, made possible due to the elasticity of the screw head 421 caused by the slots 422. While these inwardly pressed segments cannot contribute to fixing the screw 42 to the bone plate 41, engagement of the latching teeth 424 of other segments of the screw head 421 in the latching structure 413 of the bone plate is still possible even in the inclined position of the screw 42. Thus, even in the inclined position of the screw 42 relative to the bone plate 41, as shown on the far left in Figure 12c, a fixation of the screw 42 to the bone plate 41 can be achieved via the latching structures 413 and 423. The screws 42 can thus be fixed to the bone plate 41 in different polyaxial positions.

Figures 13a to 13d show an exemplary embodiment of a bone connecting device according to the invention in the form of a vertebral body replacement 5. The vertebral body replacement 5 has an expansion slide 51, a cover plate 52, an expansion body 53 and a base plate 54, which are each made of a fiber-reinforced plastics material and are preferably formed as a single piece.

The expansion slide 51 has an overall cube-like shape with a main body 511, which forms the centrally arranged component of the vertebral body replacement 5. A connecting structure 512 is formed on the upper side of the main body 511, which enables the cover plate 52 to be attached and fastened to the expansion slide 51 via a bayonet connection, for example. The expansion slide 51 has a latching structure 513, which is formed by a plurality of latching teeth 514 and 514', which are arranged on two opposite sides of the main body 511. The latching teeth 514 and 514' thus face outwards in opposite directions and form an internal latching structure.

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The cover plate 52 is formed by a substantially flat main body 521, on the underside of which a connecting structure 522 is formed, which serves to attach and fasten the cover plate 52 to the connecting structure 512 of the expansion slide 51. Expansion slide 51 and cover plate 52 could in principle also be formed in one piece with each other. An upper bone contact surface 523 is formed on the upper side of the main body 521, which is designed for contact with a bone, in particular with an upper vertebral body of the patient, and has a corresponding surface structure which favors a close connection and, in particular, growth of the bone. The main body 521 has a notch 524 on each of two opposite side walls, which serves to attach an instrument with which the doctor can expand the vertebral body replacement 5.

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The expansion body 53 has a substantially cube-shaped main body 531, which is hollow on the inside and open at the top, thereby allowing the expansion slide 51 to be accommodated. A connecting structure 532 is formed on the underside of the main body 531, which enables the base plate 54 to be attached and fastened via a bayonet connection, for example. A latching structure 533 with a plurality of latching teeth 534 or 534' is formed on two opposite inner sides of the main body 531. The latching structure 533, which thus forms an outer latching structure, is complementary to the latching structure 513 of the expansion slide 51 and thus enables a mutual latching connection between the expansion slide 51 and the expansion body 53. Depending on the position at which the latching structures 513 and 533 are latched together, the expansion slide 51 can protrude from the expansion body 53 to different extents. In order to maintain a certain elasticity of the outer latching structure 533 relative to the inner latching structure 513, slots 535 are provided at the sides of the latching structure 533.

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The base plate 54 has a main body 541, which has a connecting structure 542 on its upper

side for attaching the base plate 54 to the connecting structure 532 of the expansion body 53. In principle, the expansion body 53 and the base plate 54 could also be formed in one piece. On its underside, a lower bone contact surface 543 is formed on the main body 541, which is designed for contact with a bone, in particular with a lower vertebral body of the patient, and has a corresponding surface structure that favors a close connection and, in particular, growth of the bone. The main body 541 has a notch 544 on each of two opposite side walls, which serves to attach an instrument with which the doctor can expand the vertebral body replacement 5.

10 The vertebral body replacement 5 is inserted into the free space between two vertebral bodies of a patient in a non-expanded state, as shown in Figure 13c, and then expanded by the physician in order to fill the space between the two vertebral bodies and to fit closely to the vertebral bodies with the bone contact surfaces 523 and 543. The expanded state is shown in Figure 13d. The physician performs the expansion with a tool or instrument not shown in the figures, which engages in the notches 524 and 544. Due to the surfaces of the latching teeth 514, 514' and 534, 534' being inclined to the latching direction R in combination with the elasticity provided by the slots 535, the expansion slide 51 can be easily moved out of the expansion body along the direction of engagement R. In the opposite direction, however, the latching teeth 514, 514' and 534, 534' each have a surface perpendicular to the latching direction R and thus together form an undercut which effectively prevents subsequent compression of the vertebral body replacement 5.

Figures 14a to 14d show another embodiment of a vertebral body replacement 5, also according to the invention, which differs from that of Figures 13a to 13d in particular in that the latching structures 513 and 533 of the expansion slide 51 and the expansion body 53 are slightly curved here in order to enable latching along a correspondingly curved latching direction R (see in particular Figures 14c and 14d). The vertebral body replacement 5 is thus better adapted to the anatomical conditions of a patient. Furthermore, the expansion body 53 of this embodiment has a bow-shaped, outwardly projecting intervention structure 536, which makes it possible to pull the latching teeth 534 away from the latching teeth 514 by means of a suitable tool, thereby cancelling the mutual engagement of the latching structures 533 and 513 if necessary. The vertebral body replacement 5 can thus be shortened along the latching direction R, for example in order to remove the vertebral body 5 from the spinal column.

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Figures 15a and 15b show an embodiment of a bone connection device according to the

invention in the form of a polyaxial fixation system 1, which substantially corresponds to that of Figures 1a to 1f, with the difference that the latching structures 133 and 153 here each have only two pairs of latching teeth 134, 134' and 154, 154' respectively. A pair of latching teeth 134, 134' of the latching structure 133 formed on the tulip head 13 is formed in each case by the two latching teeth 134 and 134', which are arranged at the same height of the lateral webs 132 and 132'. Similarly, a pair of latching teeth 154, 154' of the latching structure 153 formed on the latching clip 15 is formed in each case by the two latching teeth 154 and 154', which are arranged opposite one another at the same height of the retaining webs 152 and 152'. The embodiment with only two pairs of latching teeth 134, 134' or 154, 154' has proved to be particularly advantageous in terms of the strength of the connection when the latching clip 15 is latched onto the tulip head 13. This can be explained by the fact that the mutual undercuts formed by the latching teeth 134, 134' or 154, 154' are larger due to the smaller number of latching teeth. Nevertheless, it is still possible to snap the latching clip 13 onto the tulip head 15. By the term "snap", it should be understood that this also includes the process or step of ratcheting the latching clip 13 onto the tulip head 15 and that, in some embodiments, engagement of the latching elements or latching teeth can be achieved by ratcheting one set of latching elements or teeth over or around another set of latching elements or teeth in a stepwise manner such that at least one latching tooth of the latching clip 13 and tulip head 15 are engaged, and more preferably, a plurality of latching teeth of the latching clip 13 and tulip head 15 are engaged.

In principle, it is possible to reduce or increase the number of latching teeth per latching structure in all the embodiments shown in Figures 1a to 17b. A number of only one or two latching teeth or one or two pairs of latching teeth has proven to be particularly advantageous in terms of the strength of the connection. A number of at least three, at least five or even at least ten latching teeth or pairs of latching teeth, on the other hand, has the advantage that the first connecting element and the second connecting element can be latched together in several different positions.

Figures 16a and 16b show an exemplary embodiment of a polyaxial fixation system 1, i.e. a pedicle system, in which a connecting rod 11 is attached to a pedicle screw 12 by means of a latching clip 15. However, the connecting rod 11 is not, as in the embodiment example of Figures 1a to 1f, clamped between the latching clip 15 and the tulip head 13, but is held by a connecting clip 16, which is preferably connected in one piece to the remaining latching clip 15 via a web 161. The connecting clip 16 itself forms a latching clip. To clamp the washer 14 and the screw head 121, the latching clip 15 has an enlarged clamping element 155. The connecting clip 16 has an internal latching structure 163, which is arranged on two

retaining webs 162, 162' of the connecting clip 16 extending parallel to one another and has latching teeth 164, 164' arranged opposite one another. The latching teeth 164, 164' are designed to engage in latching teeth 113, which are formed by a latching structure 112 of the connecting rod 11. The latching structure 112 is in turn formed by a latching block 111, which is arranged at a free end of the connecting rod 11 and is integrally molded on the latter. The connection between the connecting rod 11 and the pedicle screw 12 is thus made in particular via the web 161, which has a certain flexibility due to its shape and thus allows certain movements between the connecting rod 11 and the screw 12. In this way, a gradual transition can be achieved between the portion of the spinal column stiffened by the pedicle system and the adjacent, still movable portions.

Figures 17a and 17b show a bone connecting device according to the invention, designed as an axial connector system, according to yet another embodiment. The latching structures 212 and 163 are here each integrally connected to or molded onto the first connecting rod 21 and the second connecting rod 22, respectively. The first connecting rod 21 forms a latching block 211 at one of its free ends, which, similar to the first connecting rod 21 shown in Figure 10c, forms a latching structure 212 with latching teeth 213, 213' on the outside. However, the latching structure 212 here extends further along the longitudinal direction of the connecting rod 21. A connecting clip 16 is molded onto the free end of the second connecting rod 22, which forms a latching clip and is connected to the remaining connecting rod 22 exclusively via a web 161. The connecting clip 16 has a latching structure 163 with latching teeth 164 and 164' on the inside, which are designed to latch into the latching teeth 213, 213' of the latching structure 211 formed on the first connecting rod 21. Since the latching structure 211 extends further along the longitudinal direction of the connecting rods 21 and 22 than the latching structure 163, the connecting rods 21 and 22 can be displaced relative to one another over a limited range in the longitudinal direction when latched together. Such mutual displaceability of the interconnected connecting rods 21, 22, which is limited by corresponding stops, can bring advantages depending on the application and have a positive effect on the therapy. The connecting rods 21 and 22 of this embodiment, but also of other embodiments, can be straight or bent with any desired curvatures.

Figures 18a and 18b and Figures 19a and 19b show further embodiments of bone connection devices according to the invention in the form of a pedicle system. In contrast to the pedicle screws in Figures 1a to 8b and 15a to 16b, the pedicle screws 12 are fenestrated here. As a result, bone cement, for example, can be fed through the screw 12 in order to strengthen the bone in the corresponding area and/or to improve the anchoring

of the screw 12 in the vertebra. The screw 12 therefore has several openings in the region of the screw tip 124, which are in communication with and open outwards from an internal channel extending along the longitudinal axis of the screw. In the embodiments of Figures 18a, 18b and 19a, 19b, the latching elements of the latching structure 133 formed on the tulip head 13 are not formed as latching teeth, as in the embodiments described above, but as apertures 139, 139'. The apertures 139, 139' serve to engage the latching teeth 154, 154' of the latching clip 15, as shown in Figures 18a and 19a. For example, the apertures 139, 139' may be in the form of slots while the latching teeth 154, 154' of the latching clip may be configured to engage with the slots.

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In the embodiment of Figures 18a and 18b, the latching clip 15 has a latching structure 153 with only two latching teeth 154, 154', which are arranged as a pair at the same height in each case and are directed outwards away from each other. In one embodiment, the latching teeth 154, 154' may each be provided on one of a pair of flexible prongs or fingers of the clip 15. Similarly, the latching structure 133 of the tulip head 13 also has a latching structure 133 which has only two latching elements formed as apertures 139, 139'. The apertures 139, 139' may be configured as slots, in one embodiment, to receive the latching teeth 154, 154'. As shown, it is understood that the clip 15 may be forced onto the tulip head 13 such that the flexible prongs containing the latching teeth 154, 154' are slightly deformed to allow the latching teeth 154, 154' to slide along the shaped internal channels of the tulip head 13 until they engage with the apertures 139, 139'.

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In the embodiment shown in Figures 19a and 19b, the latching clip 15 has a latching structure 153 with a total of four latching teeth 154, 154', which are provided in the form of two pairs. In one embodiment, a pair of latching teeth 154, 154' may be provided on each a pair of flexible prongs or fingers of the clip 15. The latching teeth 154 and 154' of each pair are arranged at the same height and face outwards away from each other. Accordingly, the latching structure 133 of the tulip head 13 also has a latching structure 133 which has a total of four latching elements formed as apertures 139, 139'. Analogue to the latching teeth 154, 154', the apertures 139, 139' are also provided in the form of two pairs. Similar to the apertures 139, 139' of Figures 18a and 18b, the apertures 139, 139' may be configured as slots to receive the pair of latching teeth 154, 154'. Similar to Figures 18a and 18b, the clip 15 may be forced onto the tulip head 13 such that the flexible prongs containing the pairs of latching teeth 154, 154' are slightly deformed to allow the pairs of latching teeth 154, 154' to slide along the shaped internal channels of the tulip head 13 until they engage with the pairs of apertures 139, 139'.

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The invention is not limited to the embodiments described above, but a variety of modifications are possible. For example, in the polyaxial fixation system 1, the screw 12 could also be formed integrally with the tulip head 13. The latching clips 24 of the axial connector 23 could also be formed in one piece and the latching clip 34 of the parallel connector 33 could just as well be formed in two parts, i.e. with one for each connecting rod 31, 32. The bone plate 41 could have any other number of openings 412 for insertion of a screw 42 in each case and/or be shaped in any other way. Different and/or additional elements of different embodiments can also be easily transferred or exchanged. For example, just like the latching clips 15 shown in Figures 3, 5, 7 8a and 8b, the latching clips 24 and 34 can have one or more local recesses 157 for adjusting the flexibility and/or have an internal guide co-operating with an external guide provided on the main body 231 or 331. It would of course also be conceivable in principle that the external guide is provided on the latching clip 15, 24, 34 and the internal guide is provided on the tulip head 13 or on the main body 231 or 331. The mutual displaceability of the first connecting element and the second connecting element along the longitudinal direction of the latching teeth in accordance with the embodiment shown in Figures 17a and 17b is in principle conceivable in all embodiments. In particular, the latching structure 112 of the embodiment shown in Figures 16a and 16b could also be longer in order to enable a corresponding, preferably limited longitudinal displacement. A large number of further modifications are conceivable.

LIST OF REFERENCE SIGNS

1	polyaxial fixation system	159	intervention structure
11	connecting rod		
111	latching block	16	connecting clip
112	latching structure	161	web
113	latching teeth	162, 162'	retaining web
		163	latching structure
12	screw	164, 164'	latching teeth
121	screw head		
122	engagement structure	2	axial connector system
123	threaded shaft		
124	screw tip	21	first connecting rod
		211	latching block
13	tulip head	212	latching structure
131	main body	213, 213'	latching teeth
132, 132'	lateral web	22	second connecting rod
133	latching structure	221	latching block
134, 134'	latching teeth	222	latching structure
135, 135'	receiving opening	223, 223'	latching teeth
136	interior		
137	contact surface	23	axial connector
138, 138'	dovetail outer guide	231	main body
139, 139'	apertures	232, 232'	receiving opening
		233, 233'	latching structure
14	washer	234, 234'	latching teeth
		235, 235'	interior
15	latching clip	236, 236'	contact surface
151	connecting web		
152, 152'	retaining web	24	latching clip
153	latching structure	241	connecting web
154, 154'	latching teeth	242, 242'	retaining web
155	clamping element	243	latching structure
156, 156'	slot	244, 244'	latching teeth
157	recess	245	clamping element
158, 158'	dovetail inner guide	246	recess

247	connecting portion	424	latching teeth
		425	engagement structure
3	parallel connector system	426	threaded shaft
		427	screw tip
31	first connecting rod	428	longitudinal center axis
32	second connecting rod		
		5	vertebral body replacement
33	parallel connector		
331	main body	51	expansion slide
332, 332'	receiving opening	511	main body
333	latching structure	512	connecting structure
334, 334'	latching teeth	513	latching structure
335, 335'	interior	514, 514'	cogs
336, 336'	contact surface		
		52	cover plate
34	latching clip	521	main body
341	connecting web	522	connecting structure
342, 342'	retaining web	523	upper bone contact surface
343	latching structure	524	notch
344, 344'	latching teeth		
345, 345'	clamping element	53	expansion body
		531	main body
4	cervical plate system	532	connecting structure
		533	latching structure
41	bone plate	534, 534'	latching teeth
411	main body	535	slot
412	opening	536	intervention structure
413	latching structure		
414	latching teeth	54	base plate
415	longitudinal center axis	541	main body
		542	connecting structure
42	screw	543	lower bone contact surface
421	screw head	544	notch
422	slot		
423	latching structure	R	latching direction

CLAIMS

1. Medical bone connecting device (1; 2; 3; 4; 5) for connecting two bones or bone parts of a human or animal patient, comprising

a first connecting element (13; 21, 22; 23; 33; 42; 51) made of a fiber-reinforced plastics material, which has a first latching structure (133; 212, 222; 233, 233'; 333; 423; 513) with a plurality of first latching elements (134, 134'; 139, 139'; 213, 213', 223, 223'; 234, 234', 334, 334'; 424; 514, 514'); and

a second connecting element (15; 24; 34; 41; 53) made of a fiber-reinforced plastics material, which has a second latching structure (153; 243; 343; 413; 533) with a plurality of second latching elements (154, 154'; 244, 244'; 344, 344'; 414; 534, 534');

wherein the first latching elements (134, 134'; 139, 139'; 213, 213', 223, 223'; 234, 234', 334, 334'; 424; 514, 514') of the first latching structure (133; 212, 222; 233, 233'; 333; 423; 513) are latchable with the second latching elements (154, 154'; 244, 244'; 344, 344'; 414; 534, 534') of the second latching structure (153; 243; 343; 413; 533) in order to fix the first connecting element (13; 21, 22; 23; 33; 42; 51) and the second connecting element (15; 24; 34; 41; 53) to one another and thereby connect the two bones or bone parts to one another.

2. Bone connecting device (1; 2; 3; 4; 5) according to Claim 1, wherein the first latching elements (134, 134'; 139, 139'; 213, 213', 223, 223'; 234, 234', 334, 334'; 424; 514, 514') and the second latching elements (154, 154'; 244, 244'; 344, 344'; 414; 534, 534') are each undercut in such a way that a release of the fixation between the first connecting element (13; 21, 22; 23; 33; 42; 51) and the second connecting element (15; 24; 34; 41; 53) is prevented when the first latching structure (133; 213, 213', 223, 223'; 233, 233'; 333; 423; 513) and the second latching structure (154, 154'; 244, 244'; 344, 344'; 414; 534, 534') are latched together.

3. Bone connecting device (1; 2; 3; 4; 5) according to Claim 1 or 2, wherein the first latching elements (134, 134'; 139, 139'; 213, 213', 223, 223'; 234, 234', 334, 334'; 424; 514, 514') and/or the second latching elements (154, 154'; 244, 244'; 344, 344'; 414; 534, 534') each have a sloping surface inclined to a latching direction (R) in order to facilitate latching of the first latching structure (133; 212, 222; 233, 233'; 333; 423; 513) with the second latching structure (154, 154'; 244, 244'; 344, 344'; 414; 534, 534').

4. Bone connecting device (1; 2; 3; 4; 5) according to one of the preceding claims, wherein the first latching structure (133; 212, 222, 233, 233'; 333; 423; 513) is an inner latching structure of which the first latching elements (134, 134'; 139, 139'; 213, 213', 223, 223'; 234, 234', 334, 334'; 424; 514, 514') face outwards in at least two opposite directions, and wherein the second latching structure (154, 154'; 244, 244'; 344, 344'; 414; 534, 534') is an outer latching structure of which the second latching elements (154, 154'; 244, 244'; 344, 344'; 414; 534, 534') face inwards in at least two opposite directions.

5. Bone connecting device (1; 2; 3; 4; 5) according to Claim 4, wherein the bone connecting device (1; 2; 3; 4; 5) comprises a third connecting element (11; 21, 22; 31, 32), and wherein the second connecting element is a latching clip (15; 24; 34) which serves to clamp the third connecting element (11; 21, 22; 31, 32) between the first connecting element (13; 23; 33) and the second connecting element (15; 24; 34).

6. Bone connecting device (1; 2; 3; 4; 5) according to Claim 5, wherein the latching clip (15; 24; 34) comprises a clamping teeth (155; 245; 345, 345') which is arranged within the second latching elements (154, 154'; 244, 244'; 344, 344').

7. Bone connecting device (1; 2; 3; 4; 5) according to Claim 5 or 6, wherein the latching clip (15; 24; 34), for adjusting its flexibility, has a local recess (157) in a region between the inwardly facing second latching elements (154, 154'; 244, 244'; 344, 344').

8. Bone connecting device (1; 2; 3; 4; 5) according to one of Claims 5 to 7, wherein the third connecting element is a connecting rod (11) and the first connecting element is a tulip head (13) which serves to fix the connecting rod (11) to a threaded shaft (123) of a screw (12), in particular a pedicle screw.

9. Bone connecting device (1; 2; 3; 4; 5) according to one of Claims 5 to 7, wherein the third connecting element is a connecting rod (21, 22; 31, 32) and the first connecting element is a connector, in particular an axial connector (23) or a parallel connector (33), for connecting two connecting rods (21, 22; 31, 32).

10. Bone connecting device (1; 2; 3; 4; 5) according to Claim 9, wherein the connector (23; 33) has at least one opening (232, 232'; 332, 332') for receiving the connecting rod (21, 22; 31, 32), which at least one opening (232, 232'; 332, 332') widens along a latching direction (R) towards the second connecting element.

11. Bone connecting device (1; 2; 3; 4; 5) according to Claim 4, wherein the first connecting element is a screw (42) and the second connecting element is a bone plate (41), and wherein the screw (42) has an at least partially elastically deformable screw head (421), on which the first latching structure (423) is formed, and the first latching elements (424) and/or the second latching elements (414) preferably form a thread.

12. Bone connecting device (1; 2; 3; 4; 5) according to one of Claims 1 to 4, which is designed as a vertebral body replacement (5), wherein the first connecting element is an expansion slide (51) and the second connecting element is an expansion body (53).

13. Bone connecting device according to one of the preceding claims, wherein the first connecting element (13) and the second connecting element (15) comprise interengaging guides (138, 138', 158, 158'), which preferably together form a dovetail joint to guide the first latching structure (133) relative to the second latching structure (153) during fixation.

14. Bone connecting device according to any one of the preceding claims, wherein the second connecting element comprises a latching clip forming the second latching structure, and wherein the latching clip is connected to the remaining second connecting element via a flexible element.

15. Bone connecting device according to one of the preceding claims, wherein the second connecting element comprises a latching clip, and wherein the first connecting element and the second connecting element are displaceable relative to each other along the longitudinal direction of the first and second latching elements over preferably a limited range when latched together.

16. Method for connecting two bones or bone parts of a human or animal patient, in particular by means of a bone connecting device (1; 2; 3; 4; 5) according to one of the preceding claims, wherein a first connecting element (13; 21, 22; 23; 33; 42; 51) made of a fiber-reinforced plastics material and a second connecting element (15; 24; 34; 41; 53) made of a fiber-reinforced plastics material are fixed to one another by means of a plurality of first latching elements (134, 134'; 139, 139'; 213, 213', 223, 223'; 234, 234', 334, 334'; 424; 514, 514') of a first latching structure (133; 212, 222; 233, 233'; 333; 423; 513) of the first connecting element (13; 21, 22; 23; 33; 513); 21, 22; 23; 33; 42; 51) being latched with

a plurality of second latching elements (154, 154'; 244, 244'; 344, 344'; 414; 534, 534') of a second latching structure (153; 243; 343; 413; 533) of the second connecting element (15; 24; 34; 41; 53).