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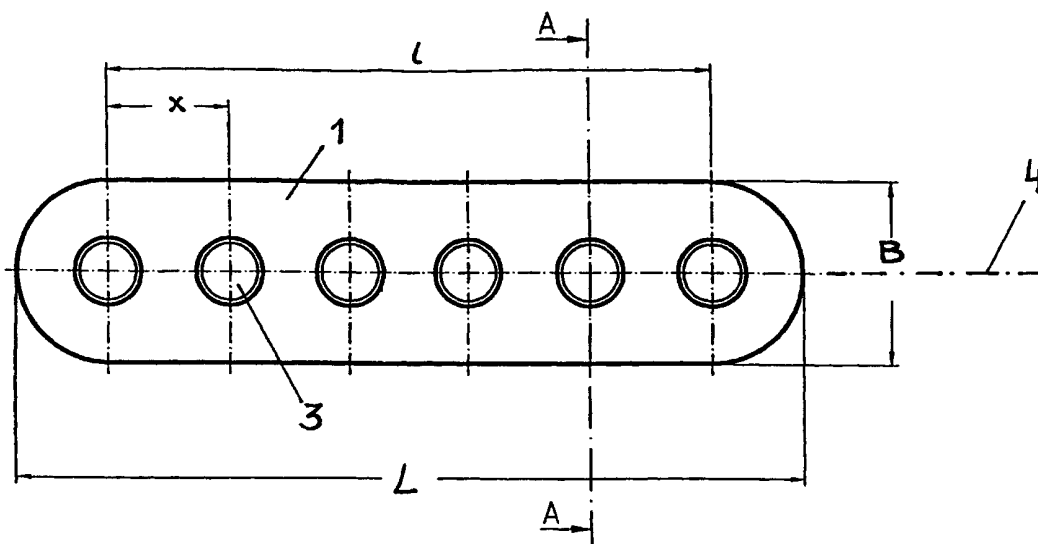
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(54) Title: RESORBABLE BONE PLATE



(57) Abstract: The bone plate of longitudinal shape has an upper surface (1), a curved lower surface (2) for contacting a bone, a plurality of conical through holes (3) connecting the upper surface (1) with the lower surface (2) for receiving bone screws, a central longitudinal axis (4) and consists of a resorbable material. The curved lower surface (2) has a radius of curvature R which is smaller than 10 mm. The ratio  $F/d$  of the total area F of the upper surface (1) including the surface area of the through holes (3) to the thickness d of the plate is in the range of 190 to 270 mm. The central part of the longitudinal plate has a generally constant width B whereas the width of the free ends of the longitudinal plate is narrowing to value  $b < 0,3 B$ . The resorbable bone plate overcomes the problems of adherence of soft-tissue. Its shape and function is optimized given the limitations of the properties of these materials.

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Resorbable bone plate

This invention concerns a bone plate in accordance with the pre-characterising portion of Claim 1.

Bone plates made of titanium have shown that this material has such a bio-compatibility that soft-tissue is adhering thereto which can be in certain situations an undesirable property for bone plates. On the other hand bone plates made of bioresorbable materials usually have insufficient mechanical properties (e.g. stiffness).

The invention as claimed aims at overcoming the problems of adherence of soft-tissue and to optimize shape and function of an resorbable plate given the limitations of the properties of these materials.

The present invention provides a bone plate as defined in Claim 1.

Resorbable materials to be used for the device according to the invention can be resorbable polymers like highly purified polyhydroxyacids, polysaccharides, polyamines, polyaminoacids, polyorthoesters, polyanhydrides, polyamidoesters, polydioxanone,

polyesteramides, copolyoxalates, polycarbonates or poly-(glutamic-co-leucine). Preferably polylactides are used or their combinations with polyhydroxybutyrates or polyhydroxyvalerates and/or resorbable glasses.

Other useful polyhydroxyacids comprise polycaprolactone, poly(L-lactide), poly(DL-lactide), polyglycolide, poly-(DL-lactide-co-glycolide), poly(DL-lactide-co-caprolactone).

Preferably the lower surface of the bone plate has a radius of curvature  $R$  which is smaller than 9 mm. The axis of the hollow cylinder corresponding to the curved plate is running parallel to the central longitudinal axis of the plate.

The ratio  $F/d$  of the total area  $F$  of the upper surface (including the surface area of the through holes) to the thickness  $d$  of the plate is in the range of 210 to 240 mm. Preferably the ratio  $F/f$  of the total area  $F$  of the upper surface (including the surface area of the through holes) to the true surface  $f$  of the upper surface (excluding the surface area of the through holes) is in the range of 1,10 - 1,25.

The width of the free ends of the longitudinal plate is narrowing to value  $b$  being preferably smaller than 0,15  $B$ .

The upper surface of the bone plate has preferably a roughness of 0,5  $\mu\text{m}$  to 5,0  $\mu\text{m}$ , typically of 0,6  $\mu\text{m}$  to 2,5  $\mu\text{m}$ .

in order to avoid the adherence of soft tissue after implantation. In any case it is preferred that the upper surface is smoother than the lower surface.

Preferably the bone plate is provided with a torsion around its central longitudinal axis which allows application to the required bone profile. The degree of torsion of the bone plate is preferably between  $\pm 1^\circ$  to  $\pm 20^\circ$  over the total length.

The length  $l$  of the central part of the longitudinal plate corresponds preferably to 73 - 82 % of the total length  $L$  of the plate.

In order to achieve better angular stability selected or all of the conical through holes may be provided with a thread. However, it is also possible to use through holes with a smooth inner surface.

The through holes have preferably a cone angle of  $15^\circ$  to  $25^\circ$ , typically of  $18^\circ$  to  $22^\circ$ .

The bone plate is provided preferably with  $n \geq 4$  holes (more preferably with  $n \geq 6$  holes), whereby the two most centrally located holes have preferably a distance which is at least 150 %, preferably 180 % of the distance  $x$  between the other through holes. When the central part of the plate is reinforced by

omitting the most central hole (or holes) maximum rigidity of the cross section is obtained which is important for the bridging of bone defects.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming part of this disclosure. For the better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings, examples and descriptive matter in which are illustrated and described preferred embodiments of the invention.

In the drawings:

Fig. 1 is a view in elevation of the bone plate according to the invention; and

Fig. 2 is a section along line A-A of Fig. 1;

Figure 1 shows a bone plate of longitudinal shape having an upper curved surface 1, a curved lower surface 2 for contacting a long bone, e.g. a metacarpal bone, six conical through holes 3 connecting the upper surface 1 with the lower surface 2 for receiving bone screws and a central longitudinal axis 4.

The through holes 3 have a cone angle of  $20^\circ$  and a minimum diameter D of 2,8 mm located at the lower side 2.

The lower surface 2 has a radius of curvature  $R$  of 7 mm. The plate consists of polylactide copolymer with an enhanced degradation rate.

The ratio  $F/d$  of the total area  $F$  of the upper surface 1 (including the surface area of the through holes 3) to the thickness  $d$  of the plate has the value of 223 mm.

The ratio  $F/f$  of the total area  $F$  of the upper surface 1 including the surface area of the through holes 3 to the true surface  $f$  of the upper surface 1 excluding the surface area of the through holes 3 has the value of 1,17.

The central part of the longitudinal plate (over the length  $l$  in Fig. 1) has a constant width  $B$  whereas the width of the free ends of the longitudinal plate is narrowing gradually to value 0 in the form of a hemi-circle. The length  $l$  of the central part of the longitudinal plate corresponds to 77 % of the total length  $L$  of the plate.

Claims

1. Bone plate of longitudinal shape having an upper surface (1), a curved lower surface (2) for contacting a bone, a plurality of conical through holes (3) connecting the upper surface (1) with the lower surface (2) for receiving bone screws, a central longitudinal axis (4) and consisting of a resorbable material, characterized in that

A) the curved lower surface (2) has a radius of curvature  $R$  which is smaller than 10 mm;

B) the ratio  $F/d$  of the total area  $F$  of the upper surface (1) including the surface area of the through holes (3) to the thickness  $d$  of the plate is in the range of 190 to 270 mm; and

C) the central part of the longitudinal plate has a generally constant width  $B$  whereas the width of the free ends of the longitudinal plate is narrowing to value  $b < 0,3 B$ .

2. Bone plate according to claim 1, characterized in that the radius of curvature  $R$  is smaller than 9 mm.

3. Bone plate according to claim 1 or 2, characterized in that the ratio  $F/d$  is in the range of 210 to 240 mm.

4. Bone plate according to one of the claims 1 to 3, characterized in that the ratio  $F/f$  of the total area  $F$  of the upper surface (1) including the surface area of the through holes

(3) to the true surface  $f$  of the upper surface (1) excluding the surface area of the through holes (3) is in the range of 1,10 - 1,25.

5. Bone plate according to one of the claims 1 to 4, characterized in that the width of the free ends of the longitudinal plate is narrowing to value  $b < 0,15 B$ .

6. Bone plate according to one of the claims 1 to 5, characterized in that the upper surface (1) has a roughness of 0,5  $\mu\text{m}$  to 5,0, preferably of 0,6  $\mu\text{m}$  to 2,5  $\mu\text{m}$ .

7. Bone plate according to one of the claims 1 to 6, characterized in that the upper surface (1) is smoother than the lower surface (2).

8. Bone plate according to one of the claims 1 to 6, characterized in that plate is provided with a torsion around its central longitudinal axis (4).

9. Bone plate according to one of the claims 1 to 8, characterized in that the length  $l$  of the central part of the longitudinal plate corresponds to 73 - 82 % of the total length  $L$  of the plate.

10. Bone plate according to one of the claims 1 to 9, characterized in that conical through holes (3) are provided with a thread.

11. Bone plate according to one of the claims 1 to 9, characterized in that conical through holes (3) have a smooth inner surface.

12. Bone plate according to one of the claims 1 to 11, characterized in that it is provided with  $n \geq 4$  holes (3), preferably  $n \geq 6$  holes (3), and that the two most centrally located holes (3) have a distance which is at least 102 %, preferably of 150% to 180% of the distance  $x$  between the other holes (3).

13. Bone plate according to one of the claims 1 to 12, characterized in that the through holes (3) have a cone angle of  $15^\circ$  to  $25^\circ$ , preferably of  $18^\circ$  to  $22^\circ$ .

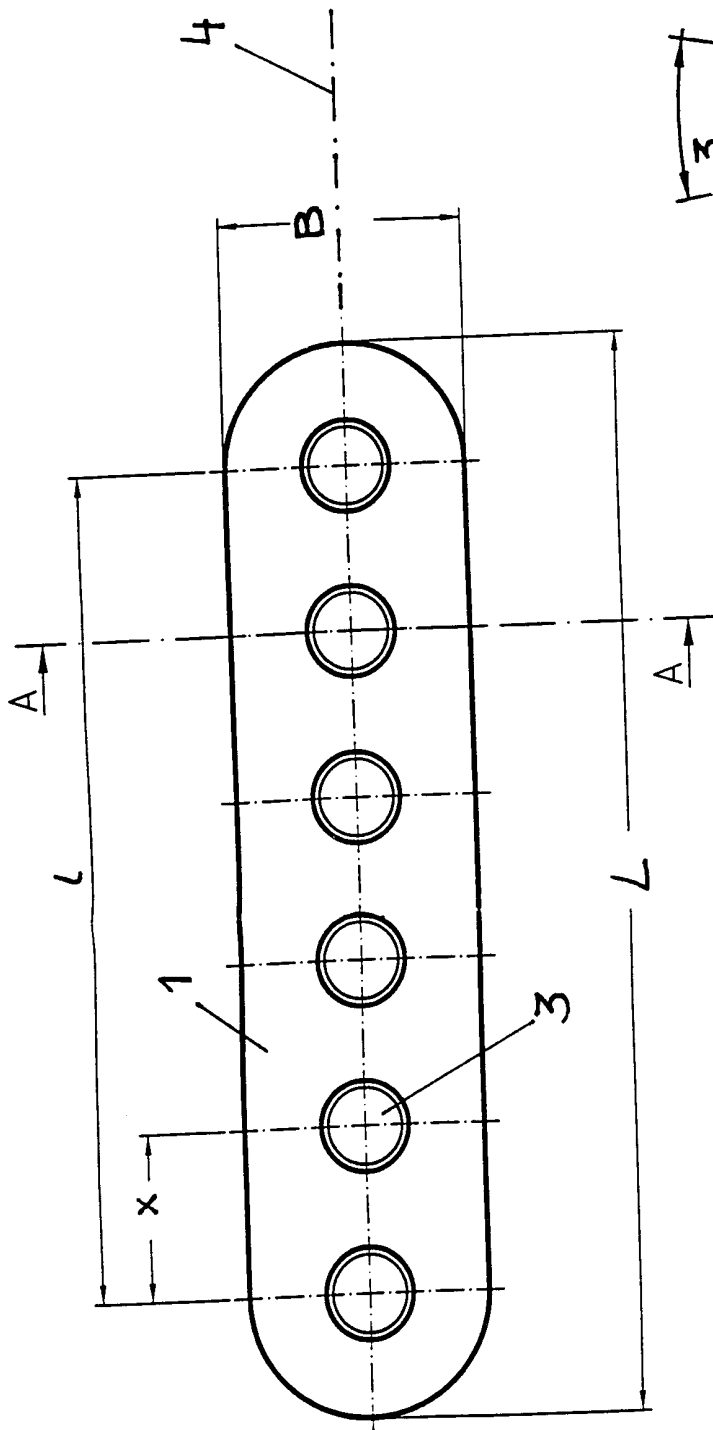


Fig. 1

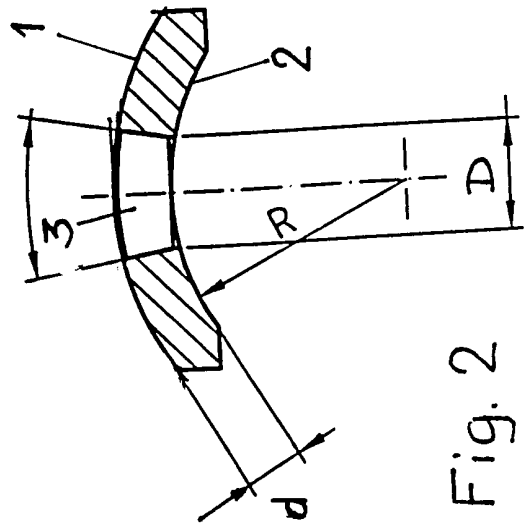


Fig. 2

A - A

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/CH 99/00582

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 A61B17/80

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

**B. FIELDS SEARCHED**

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

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

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

EPO-Internal, PAJ, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0 530 585 A (SYNTHESE) 10 March 1993 (1993-03-10) figures 4A,5A ---	1-7,9, 12,13
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Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

Inte. onal Application No

PCT/CH 99/00582

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>WO 99 38448 A (DEPUY INTERNATIONAL)                      5 August 1999 (1999-08-05)                      page 1, line 1 - line 3                      page 5, line 9 - line 10                      page 8, line 1 - line 10                      page 8, line 20 - line 21                      figures 1,3</p> <p style="text-align: center;">---</p>	1-4, 11
A	<p>WO 99 44259 A (BIONX IMPLANTS)                      2 September 1999 (1999-09-02)                      page 19, line 1 - line 16                      figures 2,5</p> <p style="text-align: center;">---</p>	1,5, 11
A	<p>WO 97 09000 A (SYNTHESE)                      13 March 1997 (1997-03-13)                      page 4, line 1 - line 8                      page 4, line 23                      figures 1,3</p> <p style="text-align: center;">---</p>	10, 11
A	<p>US 5 772 662 A (M.W.CHAPMAN ET AL.)                      30 June 1998 (1998-06-30)                      claim 2                      claims 9,10</p> <p style="text-align: center;">-----</p>	1,5

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