(54) Title: SYSTEM FOR OSTEOSYNTHESIS WITH AXIALLY GUIDED PRESTRESSING ELEMENTS

(57) Abstract

System for the application of axial prestressing to obtain stable and elastic osteosynthesis of fractures. The stability of the system is ensured by the collaborative action of the tendons for the application of axial prestressing, the Medullary Guide and the repositioned fracture. The elasticity and durability of the osteosynthesis is obtained by the articulated anchorage of the Prestressing Tendons. The system consists of: a) Thin Prestressing Tendons; b) Fulcrum for Bone Protection (Fig. II 6); c) Annular Distribution Washer (Fig. II 8); d) Medullary Guide of intraosseous forces and Prestressing Tendons (Fig. I, Ia, Ib). The Prestressing Tendons are thin wires or bands made of metal or other material. The one end of the Prestressing Tendons forms a sphere for the creation of a joint at their points of anchorage at the Medullary Guide and the Fulcrum for Bone Protection. Their other end is anchored into the conical cavity (female cone) of the Fulcrum for Bone Protection. The Fulcrum for Bone Protection (Fig. II 6) protects the bone from the pressure forces caused by the Prestressing Tendons. The Annular Distribution Washer (Fig. II 8) has a concave or a convex shape, depending on the bone surface on which it is adapted. The Medullary Guide (Fig. I, Ia, Ib), is a cylindrical body which can get several shapes depending on the bone. It is elastically compressible along its lateral axis, resistant along its longitudinal axis, and forms joints with the spherical ends of the Prestressing Tendons.

Application of axial prestressing
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System for osteosynthesis with axially guided prestressing elements

System for the application of axial prestressing, to obtain stable and elastic osteosynthesis of fractures. The prestressing bearers are guided by a medullary guide and the points of anchorage form articulations.

The modern notion for the neutralization of fractures demands stable and elastic osteosynthesis (1). The system described further on, is stable and elastic and restores the intraosseous forces, especially by long-bone fractures.

Fracture means that some force acted on the bone, stronger than its resistance limit, which had as a consequence the solution of its continuity.

Intraosseous forces are the total of the intrastructural forces of the bone, which counteract the body weight and the muscular contraction. The intraosseous forces are eliminated after a fracture, and we are seeking the best way for their restoration.

Prestressing means to introduce internal stresses into a material to counteract the stresses that will result from applied load. For the application of prestressing we need, a material resistant to tensile strength and a non-compressible material resistant to pressure forces.

Axial prestressing is the application of prestressing coinciding with the mechanical axis of a body. That is, the introduction of a material resistant to tensile forces under tension into a body resistant to pressure forces, which in our case is the repositioned fractured bone. Anchorage points of the prestressing are the extremities of the bone.

As prestressing bearers for long bones, we still use today, plates with screws (2). It is the so-called compressive
osteosynthesis with plates and screws, which is in fact, osteosynthesis by prestressing (3), (4).

Disadvantages are:

a) The rigid osteosynthesis resulting from the use of the plate.

b) The local osteoporosis which is provoked by the unloading of the bone by the plate.

c) The uneven distribution of pressure forces on the surface of the fracture.

d) The big difference of Modulus of Elasticity between bone and metal plate.

The first one to use a kind of prestressing with wire was Fr. Pauwels (5), (6) (Zug-Gurtung, Tension Banding). The purpose was to neutralize the tension forces by a wire bend, mostly on other kinds of fractures than those of long bones.

By the application of axial prestressing, we aim at the restoration of intraosseous forces by using stable and elastic osteosynthesis. For the application of axial prestressing the prestressing tendons must coincide with the mechanical axis of the bone, that is, they must be introduced intramedullarily.

The system consists of:

a) Thin Prestressing Tendons

b) Fulcrum for Bone Protection

c) Annular Distribution Washer

d) Medullary Guide of intraosseous forces and Prestressing Tendons

As prestressing bearers we use thin wires or bands (commonly called 'tendons') that may be made of metal or Carbon fibre plastics, or other absorbable substance (7). Materials which have a great resistance to tension. The one end of the
Prestressing Tendons forms a sphere for the creation of a joint at their points of anchorage. The Prestressing Tendons are anchored into the Fulcrum for Bone Protection (Fig. II 6). Points of anchorage are the epiphyses or the bone cortex near them. The Prestressing Tendons are also anchored into the Medullary Guide.

The Fulcrum B.P. has a cylindrical shape, the cavity being of conical shape (female cone) and the base forming a semicircular cross-section (Fig. II 6). The Fulcrum for Bone Protection protects the bone from the pressure forces caused by the Prestressing Tendons. The Prestressing Tendons are anchored by their spherical end into the conical cavity of the Fulcrum for Bone Protection. The other end of the Prestressing Tendons is anchored into the conical cavity of the Fulcrum for Bone Protection by a cone (male cone) (Fig. II 7), a wedge or an inclined groove on the female cone and a screw. In some kinds of fractures the Prestressing Tendons may be anchored into spongy bone by the special screw, which bears the Prestressing Tendons at its base (Fig. III), and is introduced intramedullarily through the epiphyses.

The base of the Fulcrum for Bone Protection forms a joint with the Distribution Washer (Fig. II 8).

The Distribution Washer has a concave or a convex shape, depending on the bone surface on which it is adapted. The side adapted to the bone bears dents. The insides of its aperture is of semicircular cross-section for the formation or an articulation with the base of the Fulcrum for Bone Protection. By its surface, it also serves for the distribution of pressure forces caused by the Prestressing Tendons.
But because the Prestressing Tendons are not able to receive compound forces, we invented the Medullary Guide.

The Medullary Guide is a cylindrical body made of thin metal or other material, which can get several shapes, depending on the bone (Fig. 1, 1a, 1b). It is evident that we have several kinds of Medullary Guides (different diameter and length), but because of their shortness, they respect the natural curvature of the bone.

Depending on the fracture we choose the length of the Medullary Guide (for transversal fractures it must be four times its diameter, but it must necessarily be the double of its diameter far from any fragment).

The Medullary Guide serves:

a) As support for the bone (it holds in place the repositioned fractured bone, i.e. it neutralizes the torque forces, as well as the peripheral forces caused between the fracture angle and the mechanical axis of the bone).

b) It distributes the pressure forces on the fracture surface evenly.

c) It determines the direction of the Prestressing Tendons, serving as their guide, and restores the intraosseous forces.

The shape of the Medullary Guide allows:

a) An elastic compression along its lateral axis for better intramedullary adjustment.

b) Great resistance along its longitudinal axis in all directions (which hinders the angling and sliding of the fragments).

c) The neutralization of Torque forces with the opposite
directed dents with helical course (Fig. I 1).

d) The adjustment of the Prestressing Tendons with joints on its mechanical axis (Fig. I 2). The joints are formed by the hollowness made on the Medullary Guide (Fig. I 2) and the spheric end of the Prestressing Tendons. The articulating joints lend elasticity to the system and hinder the material's weariness.

e) The accurate positioning and course of the Prestressing Tendons [when having greater diameter, it bears guiding grooves and hooks (Fig. I 3)], because, depending on the medullary course of the Prestressing Tendons, we achieve not only the neutralization of tension forces, but also the unloading of the bone from pressure forces, which either exist normally and must be neutralized, or are created as a consequence of the application of prestressing.

f) The neutralization of compound forces and torques, as well as the immobilization of smaller bone fragments. For this, the Medullary Guide bears short slots, parallel to its longitudinal axis (Fig. I 4), for the immobilization of fragments with screws. The longitudinal slot also allows for the unobstructed action of the prestressing on the fracture area.

ADVANTAGES

a) The system provides a stable and elastic osteosynthesis. Owing to the joints between the Prestressing Tendons and the anchorage and fixing points of the prestressing, we secure the longer duration of the osteosynthesis.
b) It can be used for a great variety of fractures.

c) The approach of the fracture area is made only for the insertion of the Medullary Guide and the repositioning of the fracture (Fig. IV 2), and we do not make detachments from the bone. The Prestressing Tendons are introduced intramedullarily, with the help of a guide, through small incisions of the skin near the epiphyses (Fig. IV 1).

d) The difference of Modulus of Elasticity between material and bone is negligible.

e) The removing of the material is not necessary.

f) It allows for immediate movement and loading of the member.

g) The restoration of the morphology and architecture of the bone through the reestablishment of the intraosseous forces corresponds to contemporary technology, and the applied prestressing forces cooperate with the stimulation from the natural loading. The pressure forces are osteogenetic (i.e. we do not have the osteoporosis caused by the discharge of the bone when using plates and screws).

WAY OF WORKING:

After the operative approach to the fracture area we create a socket for the Medullary Guide with the help of a rounded rasp. We drill a hole in some point of the epiphysis or near it, through which we insert a guiding tube intramedullarily (Fig. IV 1). The part of the Prestressing Tendons which forms a joint with the Medullary Guide is then inserted through the tube to the hole in the epiphysis, and by pulling it from this end, we draw the Medullary Guide to the edge of the fragment, so as to make the reposition possible (Fig. IV 1.2). The other
part of the Prestressing Tendons is inserted in the same way. After repositioning of the fracture we pull the Medullary Guide by the Prestressing Tendons until its middle coincides with the focus of the fracture (Fig. IV 3). (The nearing of the bone fragments with the help of a fracture compressor may be needed). The prestressing is then applied by dynamometers and the Prestressing Tendons are anchored at their points of anchorage (Fig. IV 5). If the anteoperational study proved that more Prestressing Tendons are needed, then these must be put into place from one epiphysis to the other, through the Medullary Guide, before the repositioning of the fracture (Fig. IV 6). It is sound and proper to apply the same tension on all Prestressing Tendons simultaneously.

For greater stability of the osteosynthesis or for immobilization of small fragments on the Medullary Guide, we may use screws, which are screwed into the longitudinal slots of the Medullary Guide described above (Fig. IV 4).
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CLAIMS

1. System for the application of axial prestressing, to obtain stable and elastic osteosynthesis of fractures. The prestressing bearers are guided by a medullary guide and the points of anchorage form articulations. The system consists of:
   a) Thin Prestressing Tendons
   b) Fulcrum for Bone Protection
   c) Annular Distribution Washer
   d) Medullary Guide of intraosseous forces and Prestressing Tendons.

2. The prestressing bearers, according to claim 1, are thin wires or bands (commonly called 'tendons'), made of various materials. The one end of the Prestressing Tendons forms a sphere for the creation of a joint with the Medullary Guide and the Fulcrum for Bone Protection. They are anchored at the bone cortex near the epiphyses into the Fulcrum for Bone Protection and at the Medullary Guide. In some kinds of fractures the Prestressing Tendons may be anchored into the spongy bone of one of the epiphyses, by the special screw which bears the Prestressing Tendons at its base.

3. The Fulcrum for Bone Protection, according to claim 1, has a cylindrical shape, the base forming a semicircular cross-section, and the cavity being of conical shape (female cone), into which are anchored either the spherical end of the Prestressing Tendons or their other end, by a cone (male cone), a wedge or an inclined groove on the female cone and a screw. The base of the Fulcrum
for Bone Protection forms a joint with the inner-side of the Distribution Washer. The Fulcrum for Bone Protection protects the bone from the pressure forces exercised by the Prestressing Tendons.

4. The Distribution Washer, according to claim 1, has a concave or a convex shape, depending on the bone surface on which it is adapted. The side adapted on the bone bears dents. This same side also serves for the distribution of pressure forces caused by the Prestressing Tendons. The inner side of its aperture is of semicircular cross-section for the formation of a joint with the base of the Fulcrum for Bone Protection.

5. The Medullary Guide of intraosseous forces and Prestressing Tendons, according to claim 1, is a cylindrical body, made of thin metal or other material, which can get several shapes (depending on the bone). The length of the Medullary Guide must be four times its diameter for transversal fractures, or it must be the double of its diameter far from any fragment. The Medullary Guide:

a) Is elastically compressible along its lateral axis.
b) Is of great resistance along its longitudinal axis.
c) At its center as well as at the ends of its longitudinal axis it bears cavities for the articulated anchorage with the Prestressing Tendons.
d) At its perimeter it bears guiding grooves and hooks, which determine the accurate course of more Prestressing Tendons.
e) It bears small longitudinal slots for the immobili-
zation of fragments.

f) Its surface bears opposite directed dents, with helical course, for the neutralization of torque forces.
SUMMARY

System for the application of axial prestressing to obtain stable and elastic osteosynthesis of fractures. The stability of the system is ensured by the collaborative action of the tendons for the application of axial prestressing, the Medullary Guide and the repositioned fracture. The elasticity and durability of the osteosynthesis is obtained by the articulated anchorage of the Prestressing Tendons.

The system consists of:

a) Thin Prestressing Tendons
b) Fulcrum for Bone Protection (Fig. II 6)
c) Annular Distribution Washer (Fig. II 8)
d) Medullary Guide of intrarosseous forces and Prestressing Tendons (Fig. I, Ia, Ib)

The Prestressing Tendons are thin wires or bands made of metal or other material. The one end of the Prestressing Tendons forms a sphere for the creation of a joint at their points of anchorage at the Medullary Guide and the Fulcrum for Bone Protection. Their other end is anchored into the conical cavity (female cone) of the Fulcrum for Bone Protection by a cone (male cone), a wedge, e.t.c., at the bone cortex near the epiphyses (Fig. II 6) and (Fig. IV 1,2,3). The Prestressing Tendons can also be anchored by both their ends at the bone cortex near the epiphyses into the Fulcrum for Bone Protection.

The Fulcrum for Bone Protection (Fig. II 6) protects the bone from the pressure forces caused by the Prestressing Tendons. The Prestressing Tendons are anchored into its conical cavity (female cone) either by their spherical end, or by their other end and a cone (male cone) (Fig. II 7). The base of the
Fulcrum for Bone Protection forms a joint with the Distribution Washer.

The Annular Distribution Washer (Fig. II 8) has a concave or a convex shape, depending on the bone surface on which it is adapted. The side adapted to the bone bears dents. The inserside of its aperture forms a joint with the base of the Fulcrum for Bone Protection. The Distribution Washer distributes the pressure forces caused by the Prestressing Tendons.

The Medullary Guide (Fig. I, Ia, Ib), is a cylindrical body which can get several shapes depending on the bone. It is elastically compressible along its lateral axis, resistant along its longitudinal axis, and forms joints with the spherical ends of the Prestressing Tendons by the hollownesses made at its center as well as at its ends, where the Prestressing Tendons are anchored. The Medullary Guide serves as a guide of intraosseous forces and of the Prestressing Tendons.

The application is simple and the approach of the fracture area is made only for the reposition of the fracture and the insertion of the Medullary Guide. The system is stable and elastic and restores the architecture and the intraosseous forces of long bone fractures (Fig. IV, V). The removal of the material is not necessary after the bone consolidation.
1. Odontoid protrusions
2. Articulating joint of prestressing bearer
3. Guides for prestressing bearer
4. Longitudinal opening for screws
1. Odontoid protrusions
2. Articulating joint of prestressing bearer
3. Guides for prestressing bearer
4. Longitudinal opening for screws
6. Lever for bone protection
7. Anchorage cone
8. Washer
Anchorage screw

Tap
Application of axial prestressing
INTERNATIONAL SEARCH REPORT

International Application No

PCT/GR 91/00009

I. CLASSIFICATION OF SUBJECT MATTER
(If several classification symbols apply, indicate all)*

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5
A61B17/58

II. FIELDS SEARCHED

Minimum Documentation Searche7

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IV. CERTIFICATION

Date of the Actual Completion of the International Search
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Date of Mailing of this International Search Report
19 SEP 1991

International Searching Authority
EUROPEAN PATENT OFFICE

Signature of Authorized Officer
MOERS R.
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