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[54] **EXPANDING BONE CONNECTOR**

[75] Inventors: **Artur Fischer**, Altheimerstrasse 219, D-7241, Germany; **Jean-Nicolas Müller**, Strasbourg, France

[73] Assignee: **said Fischer, by said Müeller**

[*] Notice: The portion of the term of this patent subsequent to July 25, 1989, has been disclaimed.

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** ..... **128/92 BB**

[51] **Int. Cl.** **A61f 5/04**

[58] **Field of Search** ..... 128/92 BB, 92 CA, 92 R, 128/92 D, 92 BC, 92 B

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Primary Examiner—William E. Kamm
Assistant Examiner—J. Yasko
Attorney, Agent, or Firm—Michael S. Striker

[57] **ABSTRACT**

A connector for fractured bones has a sleeve which can be inserted into a fractured bone so as to bridge the fracture thereof with an expansible leading end portion being located in one bone fragment, an open trailing end portion being located in the other bone fragment, and an intermediate portion extending between the end portions. An expander screw expands the leading end portion, and the intermediate portion is provided over most or all of its length with one or several ribs projecting beyond its circumference so as to prevent it from rotating in the bone.

6 Claims, 3 Drawing Figures

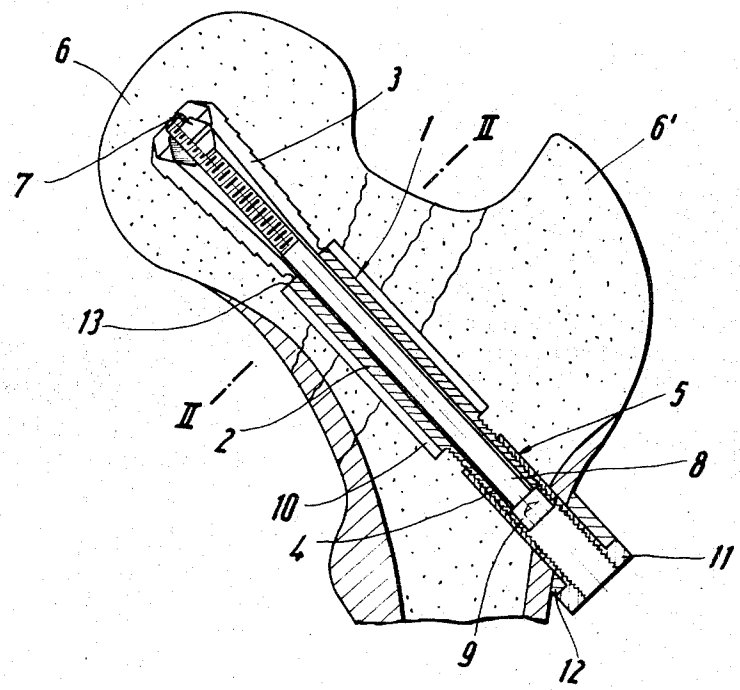
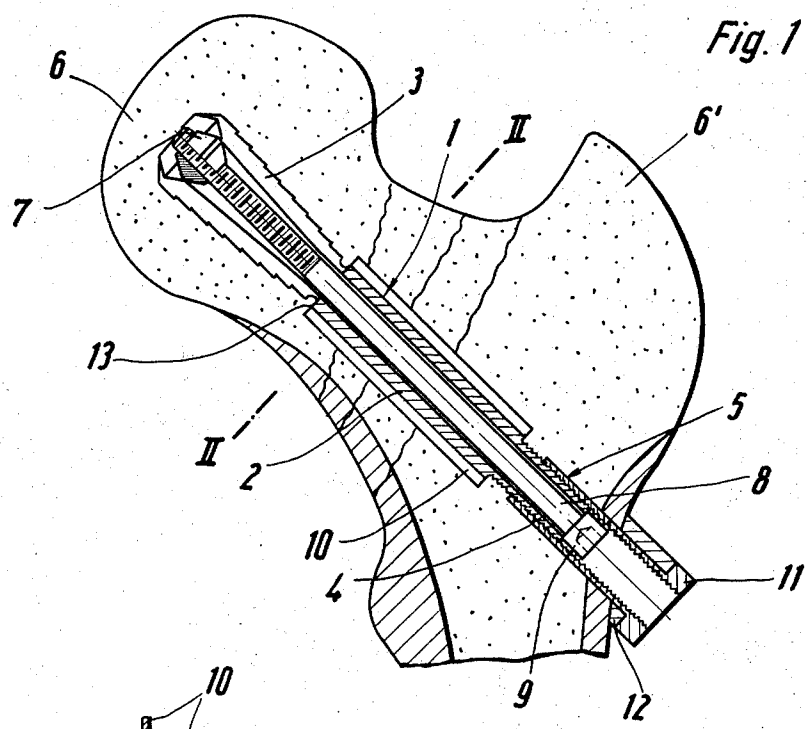


Fig. 1



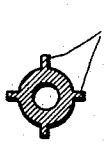
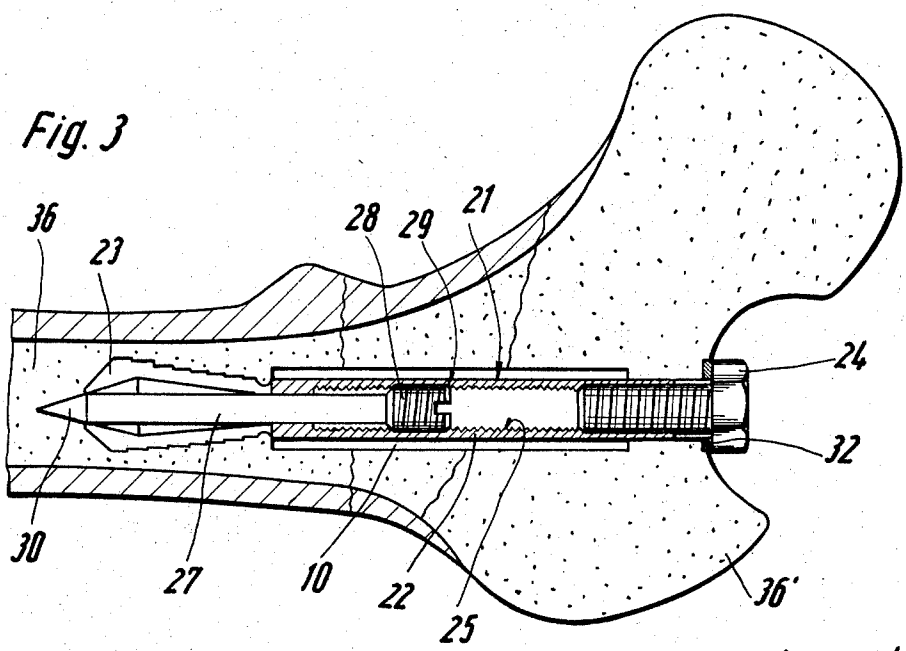


Fig. 2

Fig. 3



Inventor:
ARTUR FISCHER
JEAN-NICOLAS MÜLLER
By: Arthur F. Stahl
Attorney

EXPANDING BONE CONNECTOR

CROSS-REFERENCE TO RELATED APPLICATION

A related application, of which the present is a continuation-in-part, was filed on Oct. 1, 1970 in the name of Artur Fischer, under the title "CONNECTOR FOR FRACTURED BONES"; it is copending under Ser. No. 77,267.

BACKGROUND OF THE INVENTION

The present invention relates generally to a medical appliance, and more particularly to a connector for fractured bones.

Connectors for fractured bones are already known, and one such connector is described in the aforementioned copending application. In the use of such a connector, which is based on the expansion principle, the fractured bone is provided with a bore which extends into both of the bone fragments and which must have a diameter so selected that the connector portion of largest cross-section can still be accommodated in it. The connector is then inserted into the bore and the expanding member provided for the purpose is driven or drawn into the expansion sleeve of the connector in order to thereby expand the sleeve and anchor the connector in one of the bone fragments. Subsequently a cap nut or similar member is connected with the sleeve at the end located in the other bone fragment and the two bone fragments are then drawn together by the aid of this cap nut or analogous means until the two bone fragments are tightly drawn into abutment along the fracture and assume their previous relative positions.

There are, however, certain difficulties still inherent in the prior-art connectors of this type, difficulties which have prevented the use in practice of such connectors. On the one hand, the bore must have a diameter which corresponds to the largest diameter of the connector, as mentioned before, and such largest diameter is the outer diameter of the cap nut which is utilized for drawing together the bone fragments. On the other hand, this outer diameter of the cap nut must be relatively substantial in order to make it possible to thread the cap nut onto the exterior of the threaded trailing end portion of the sleeve. The resulting rather large-diameter bore in the bone fragments is, however, frequently undesirable and often unacceptable, either because the dimensions of the bone do not permit the use of bores of such diameter or because the use of such bores would lead to excessive destruction of bone material in the region of the fracture, or for other medical considerations.

A further difficulty with the prior art is the fact that the known connectors are difficult to expand. The diameter of the bore must correspond to the outer diameter of the cap nut, as pointed out before, and the outer diameter of the cap nut is necessarily larger than the outer diameter of the expansion sleeve of the connector, with the result that the external surface of the expansion sleeve does not contact the inner wall bounding the bore in the bone. When the expander element is then drawn into the expansible leading portion, the sleeve turns as the screw utilized for drawing the expander element into the expansible portion is rotated. Of course, unless the sleeve remains stationary and the screw turns with reference to it, the expander element

cannot be drawn into the expansible portion and no expansion, or at most improper expansion, will take place. An attempt has already been made to overcome this problem, by providing the trailing end of the sleeve with a slot in which a special tool can be engaged to prevent rotation of the sleeve. However, this requires the sleeve to have a relatively large outer diameter, and because the outer diameter of the cap nut must be greater than the outer diameter of the sleeve, this results in a further overall increase of the outer diameter of the connector and, consequently, of the bore hold which must be provided for it. Also, the necessity for utilizing a special tool to hold the sleeve against rotation, and the manipulations required to engage the sleeve with the tool and subsequently to release it, make the insertion and expansion of the connector rather complicated and time-consuming, a significant disadvantage particularly in view of the fact that it delays the duration required for the operation, which duration is for medical reasons to be as short as possible in order to reduce the stress on the patient from X-ray observation—which is necessary to control proper insertion—and anesthesia.

Still another disadvantage of the prior art results from the fact that the cap nut or cap screw cannot of course extend over the entire length of the intermediate portion connecting the trailing end portion and the expansible leading end portion. This means that between the leading end portion and the trailing end portion the intermediate portion does not contact the wall of the bore. However, precisely in this region—which is traversed by the intermediate portion—the bone fracture is usually located and with the prior-art constructions the fracture is thus not supported, that is the bone fragments are not supported with reference to one another in the region of the fracture. This permits relative shifting or sliding displacement of the bone fragments with reference to one another in the plane of the fracture, and although the fragments can be drawn against one another, the possibility of sliding relative displacement defeats the intention of making them remain stationary with reference to one another until they grow back together.

SUMMARY OF THE INVENTION

It is, accordingly, a general object of the present invention to overcome the aforementioned disadvantages of the prior art.

More particularly it is an object of the present invention to provide an improved medical appliance in form of a connector for fractured bones, which avoids the disadvantages of the prior art.

A concomitant object of the invention is to provide such an improved connector which can be utilized in a bore of minimum diameter.

A further object of the invention is to provide such an improved connector which, while capable of being utilized in a bore of minimum diameter, does not require the use of special tools for preventing rotation of the sleeve, and whose sleeve is in fact reliably prevented from such rotation by other means.

Still another object of the invention is to provide such an improved connector which permits—immediately after its insertion and expansion—the placing of load upon the fractured bone without any danger of relative displacement of the bone fragments.

In pursuance of the above objects, and of others which will become apparent hereafter, one feature of the invention resides in a medical appliance, namely a connector for fractured bones, which comprises a sleeve adapted for insertion into a fractured bone bridging the fracture thereof, and having an expansible leading end portion adapted to be located in one bone fragment, an externally threaded open trailing end portion adapted to communicate with the exterior of the other bone fragment, and an intermediate portion. Expander means is provided for expanding the leading end portion and includes an expander screw threaded through the sleeve. An internally threaded cap screw is connected with the trailing end portion of the sleeve and has a cap screw head exteriorly engaging and bearing upon the other bone fragment. At least one rotation-preventing rigid rib projects beyond the outer circumference of the intermediate portion and extends longitudinally of the latter over at least the major part of the distance between the leading and trailing end portions.

The trailing end portion may have a diameter smaller than that of the intermediate portion, and the outer diameter of the cap nut may correspond to that of the intermediate portion. However, the trailing end portion may also have the same diameter as the intermediate portion and may be provided with internal screw threads, with both the threads on the cap nut and the threads on the expander screw being dimensioned to mesh with these internal screw threads.

The rib or ribs may be continuous over the entire length thereof, or they may be discontinuous. They may also extend over the major portion of the distance between the leading and trailing end portions, that is over the major portion of the length of the intermediate portion, or preferably they may extend over the entire length.

The novel connector according to the present invention can be constructed as an element having the smallest possible outer diameter, and consequently capable of being used with a bore of the smallest possible inner diameter, and having the highest possible degree of rotation prevention. Because of their relatively substantial length the rib or ribs extend into large-area contact with the bone material surrounding the bore hole, being driven into such material, and thus provide a highly substantial protection against turning of the sleeve during expanding of the leading end portion, without having to accept the danger that the ribs might destroy or damage the bone material with which they are in contact.

If the diameter of the leading end portion is less than that of the intermediate end portion, the entire outer diameter of the connector can be constant, because the difference between the smaller diameter of the trailing end portion and the larger diameter of the intermediate end portion (and of the leading end portion before the expansion thereof) corresponds to the difference between the inner and outer diameter of the cap nut. With such a construction the connector tightly and firmly engages the bone fragments over its entire length, preventing them from a relative displacement. Also, the construction permits a very small outer diameter overall, and consequently a similarly small inner diameter of the bore required. The expander screw engages with its head a shoulder provided for this purpose on the trailing end portion of the sleeve, and this shoulder requires only little space. In consequence the outer diameter of the intermediate portion need be selected only by considerations of the requisite strength and of the bore hole which can be formed in a bone of given dimensions.

If the outer diameter of the sleeve of the connector is uniform throughout, and the cap nut is threaded into an interior thread provided in the trailing end portion of the sleeve, the small diameter overall of course is achieved in that the cap nut extends into the interior of the trailing end portion.

The first-mentioned embodiment, with the reduced-diameter trailing end portion, is preferably utilized for repairing fractures in the femur. To use it a nail is first driven into the femur at the requisite angle, bridging the fracture. Subsequently a tubular drill is placed over this nail and a hole is drilled about the nail having an inner diameter corresponding to the outer diameter of the connector. The nail is then removed again, having served only as a guide for the drill, and the connector is inserted into the bore. However, it is also possible to simply drive the connector into the bone about the nail, with the nail extending through the center of the sleeve of the connector and with the screw serving to subsequently expand the leading end portion being omitted while the connector is thus being inserted. Once the insertion has been carried out, the nail is withdrawn and the expander screw is threaded into the sleeve until it engages the expanding element which is lodged in the leading end portion of the sleeve, drawing it axially and rearwardly into the sleeve to spread the same. The entire axial force necessary for drawing the expanding element into the sleeve and expanding the latter, is absorbed by the sleeve so that damage to the bone is prevented. Subsequently the cap nut is threaded onto the reduced-diameter trailing end portion until its head engages the outer side of the second bone fragment, whereupon continued tightening of the cap nut results in drawing of the two bone fragments together until they firmly contact one another along the fracture.

The other above-mentioned embodiment, in which the cap nut is threaded into the interior of the trailing end portion with the sleeve having constant diameter throughout, is advantageously used for repairing fractures in tubular or hollow bones. To employ this embodiment, a bore is formed in the hollow bone extending in the region of the bone marrow longitudinally of the bone. Thereupon the connector—which can be provided in different lengths in accordance with the respective tubular bone with which it is to be used and the location of the fracture which is known to be frequently encountered in such bones—is inserted into the bore to such an extent until its expansible leading end portion is lodged at a location where it can best be anchored in view of the bone configuration. Now the expanding screw is turned in a sense drawing the expander element deeper into the sleeve and expanding the leading end portion. A torque wrench can be used in this embodiment, as well as in the previous one, to assure that the use of excessive force in the expansion is avoided which could lead to cracking of the bone. After the anchoring the cap nut is threaded into the open end of the trailing end portion of the sleeve until the bone fragments are drawn together and abut along their fracture line.

The novel features which are considered as characteristic for the invention are set forth in particular in

the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a somewhat diagrammatic illustration showing a connector according to one embodiment of the invention inserted into a femur;

FIG. 2 is a section taken on line II—II of FIG. 1; and

FIG. 3 is a view similar to FIG. 1 but showing a connecting element according to an embodiment of the invention inserted into a tubular bone.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Discussing the drawing in detail, and firstly the embodiment illustrated in FIGS. 1 and 2, it will be seen that the connector is generally identified with reference numeral 1 and preferably consists of rust-free steel, although other materials may also be suitable. The connector 1 utilizes, as shown in the drawing, a sleeve 2 having a radially expansible leading end portion 3 and a smaller-diameter trailing end portion 4. A cap nut 5 can be threaded over the end portion 4. The outer diameter of the sleeve—except for the trailing end portion 4—and of the cap nut 5 are identical.

When the leading end portion 3 is to be expanded in the part 6 of the femur, the expander element 7 is drawn axially rearwardly into the sleeve by means of the expander screw 8. The head of the screw 8 is smaller than the outer diameter of the sleeve 2 or the trailing end portion 4 so that it contacts only the sleeve 2 or the trailing end portion 4 as it is turned in a sense drawing the expander element 7 deeper into the sleeve 2. This avoids transmission of axial stresses into the bone.

The outer periphery of the sleeve 2 is provided with one or more ribs 10 which extend over a substantial part or all of the length of the intermediate portion of the sleeve 2 between the trailing end portion 4 and the leading end portion 3 thereof. The ribs 10 are distributed about the circumference of the sleeve 2 and serve to prevent the sleeve 2 from rotating as the screw 8 is turned in a sense drawing the expander element 7 deeper into the expansible leading portion 3. The ribs 10 are rigid and extend into the bone material of the fragments 6, 6', as illustrated.

The cap nut 5 is provided with a head 11 which in turn utilizes a washer 12 in order to increase the contact area with the bone fragment 6'. To increase the elasticity of the leading end portion 3 an annular groove 13 is provided in the sleeve 2 where the intermediate portion of the sleeve joins the expansible leading end portion 3 thereof. The leading end of the expansible end portion 3 may be upset in radially inward direction to prevent bone matter from entering the interior of the sleeve when the latter is inserted into the bone.

Coming to the embodiment in FIG. 3 it will be seen that here the connector is identified in toto with reference numeral 21. This connector has a sleeve 22 provided with the leading end portion 23 which is to be expanded, the cap nut 24 which can be threaded into the interior thread 25 of the sleeve 22, and the expander element 27 which is to be drawn into the sleeve 22 in a sense expanding the expansible leading end portion 23 by means of the expander screw 28. The outer threads 29 of the screw 28 correspond to the inner threads 25 of the sleeve 22 with which they mesh.

The outer end of the expander element 27, that is the one which faces outwardly of the sleeve 22, diverges in the direction towards the sleeve 22 so that, when the element 27 is drawn into the expansible end portion 23, it will expand the nut and anchor the sleeve in the bone fragment 36.

When the anchoring is completed, the cap nut 24 is threaded into the internal threads 25 of the sleeve 22 until it engages the outer side of the bone fragment 36' to thereby draw the fragments 36 and 36' together until they abut one another along the fracture line. The contact area between the bone fragment 36' and the head of the cap nut 24 may be further increased by providing a washer 32 which is interposed between them and which may also be constructed—in a manner known per se—to prevent the cap nut from becoming undesirably loosened. As in the previously described embodiment of FIGS. 1 and 2, the embodiment of FIG. 3 is again provided with one or more circumferentially distributed rigid ribs 10 which project beyond its circumference and into the bone material surrounding the bore in which the connector is lodged. These ribs also extend over most or all of the distance between the trailing and leading end portions of the sleeve and may, as in the embodiment of FIGS. 1 and 2, be continuous or discontinuous, that is be in sections.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of constructions differing from the types described above.

While the invention has been illustrated and described as embodied in a medical appliance, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

1. As a medical appliance, a connector for fractured bones, comprising a sleeve adapted for insertion into a fractured bone bridging the fracture thereof, and having an expansible leading end portion adapted to be located in one bone fragment, a threaded open trailing end portion adapted to communicate with the exterior of the other bone fragment, and an intermediate portion; expander means for expanding said leading end portion, and including an expander screw threaded through said sleeve, a threaded cap screw connected with said trailing end portion of said sleeve and having a cap screw head exteriorly engaging and bearing upon said other bone fragment; and at least one rotation-preventing rigid rib projecting beyond the outer cir-

cumference of said intermediate portion and extending longitudinally of the latter over at least the major part of the distance between said leading and trailing end portion.

2. An appliance as defined in claim **1**, wherein said rib extends over the entire distance between said leading and trailing end portions.

3. An appliance as defined in claim **1**; and further comprising additional ribs similar to said one rib and projecting beyond the circumference of said intermediate portion, all of said ribs being spaced circumferentially of said intermediate portion.

4. An appliance as defined in claim **3**, wherein at least some of said ribs are continuous.

5. An appliance as defined in claim **1**, said trailing end portion having a lesser outer diameter than said intermediate portion.

6. An appliance as defined in claim **1**, said sleeve having an internal threaded, and said expander screw and cap screw both having external threads dimensioned to mesh with said internal thread.

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