Orthopaedic fracture fixation is effected by use of a tube with a spring extending through the tube bore and held under tension by terminal means which secure the device relative to a bone. The device can lie across the surface of a bone to bridge a fracture in the manner of a staple by using terminal members in the form of pins, screws or the like, and the spring tension can then serve to assist reduction of the fracture. Alternatively, the device can pass through the bone with terminal members held against opposite parts of the bone surface. In this case, the device may be one of a set used in threaded or other connection with an additional intramedullary nail or bone plate. Various mechanisms can be used for the terminal connections.
This invention concerns fracture fixing devices and more particularly such devices for orthopaedic use in fixing bone fractures.

More generally the invention provides a fracture fixing device comprising a tube, an elongate spring member dimensioned to pass longitudinally into the bore of a said tube, and terminal means for connection to the ends of said spring member to extend laterally relative thereto and afford fixation for the device in connection with a bone while holding said spring member under tension in said tube.

Development of the invention in fact commenced with one form thereof which is suited to use from outside a bone and which acts in a generally similar manner to a staple in that it can bridge a fracture in the bone and be secured to mutually fractured portions of the bone. The added advantage of the invention is that the spring is used in this application of the invention to apply force acting to reduce the fracture.

More particularly in this first form of the invention, the terminal means each comprise a pin, screw or equivalent component which is deployed laterally relative to the spring member longitudinal axis to act as the arms of a staple, and at least one end of the tube is slotted to receive the pin. In practice, the device is assembled with the pins held against the tube ends by the spring under tension, but without either pin received in a slot. The device can then be used to bridge a fracture, which may already be partly reduced, by suitably fixing the pins. After this fixing, the tube can be rotated to seat the relevant pin or pins in an associated slot, whereby the spring tension acts to reduce the fracture, or enhance an existing reduction.

It will be appreciated that there need be only one slot at one end of the tube, but there can be slots at both ends and/or more than one slot at each end. Also, it may be desirable to notch the tube, at least at a slotted end, to form a seat for the respective pin and reduce the possibility of undesired rotation of the pin into a slot during fixation or preliminary handling of the device. Naturally such notching should not be such as to render rotation of the tube relative to the pin too difficult when it is in fact required.

Also, while terminal means involving simple pins will be useful for many purposes, it may, as indicated above, be appropriate to provide other forms of device. For example, bone screws passing through an apertured spring terminal member which is itself received in a tube slot rather than the screw may be preferable in some circumstances.

The tube will normally be rigid, but this is not essential since it will be appreciated that the tube need only have sufficient longitudinal rigidity to maintain the terminal means at its ends against the spring tension acting therebetween.

Further development of the invention has led to a second form thereof which may be closely similar to the first form, but differs in that it will be employed normally as an ancillary to secure or enhance the stability of primary device such as an intramedullary nail or a bone plate. In this case the device of the invention is used from within the bone in the place of a bone plate screw, say, where the bone is thin, porous or otherwise of too poor quality for adequate conventional fixation, or in connection with an intramedullary nail, say,

where the medullary canal geometry is subject to too great a variation to rely on the conventional frictional stabilisation, as in the lower third of the femur.

In this form of the invention the terminal means can each comprise an apertured first terminal member connected with one end of the spring, and a second terminal member for disposition transverse to the spring longitudinal axis and connection to the first terminal member by a wire or other coupling member. In addition, the tube may be externally threaded at least part way along its length, or otherwise adapted in association with the primary device for connection therewith.

For example, the tube may be externally threaded along a central portion for screw connection with an intramedullary nail to extend laterally therefrom through a bone. In this case the nail is stabilized by connecting the first terminal members of the spring second terminal members of plate or button-like form located on the outer bone surface. Such connections can be made by wire passed through the aperture of the first terminal member and also through or round the second terminal member, and then twisted; by passing the first terminal member through the second terminal member, and then passing a locking pin through the aperture of the former member; or in any other convenient manner.

It will be appreciated that this mode of securement is particularly appropriate when the quality of the relevant bone is poor since the forces to which the securement is subjected are spread across the bone surface.

In another example, the device of the element may be connected towards one end thereof with a bone plate, in which case the bone plate can serve as part of the terminal means, i.e. the second terminal member, for one end of the spring.

In any event, the above and other possible variations within the more general scope of the invention will be better appreciated following consideration of exemplary embodiments thereof as illustrated in the accompanying drawings, in which:

FIG. 1 illustrates an embodiment of the invention in side elevation.

FIG. 2 illustrates the embodiment of FIG. 1 in longitudinal section.

FIG. 3 illustrates a modification of the embodiment of FIGS. 1 and 2.

FIG. 4 diagrammatically illustrates another embodiment of the invention in association with an intramedullary nail, and

FIG. 5 similarly illustrates a modification of the embodiment of FIG. 4 in association with a bone plate.

The embodiment of FIGS. 1 and 2 comprises a rigid circular cylindrical tube 1, having at one end a pair of diametrically opposed notches 2 and a longitudinal slot 3 located at a circumferentially central position between the notches. A helical spring 4 extends through the tube, but is shorter than the tube when unstressed. Terminal means for the ends of the spring 4 are provided by respective integral L-shaped components 5. In each component 5, one arm 6 of the L-shaping is screw-threaded for connection in the associated end of the spring, while the other arm 7 is tapered towards its free end to serve as a pin extending radially across and beyond the relevant end of the tube.

The embodiment is shown ready for use, with the relevant pin seated in one of the notches 2 and the other
pin aligned therewith, and the spring is of such length relative to the tube that the spring must be extended under tension to achieve the illustrated disposition of parts. After fixation in this disposition with the pins secured in respectively different parts of a fractured bone and the tube bridging the fracture, rotation of the tube causes the notch-seated pin to pass into the slot 3 whereat the spring pulls the pins closer together and so reduces the fracture. Naturally, the spring tension is sufficiently high that, even when relaxed by the closing movement of the pins, the reduced tension is still useful.

In the modification illustrated by FIG. 3 for the above embodiment, the terminal means 5 is replaced by a two-part terminal comprising separate first and second members 8 and 10. The first member 8 is in the form of an apertured plate 11 with a screw 12 extending from its edge in the plane of the plate, while the second member 10 is a bone screw dimensioned to pass through the aperture of the plate 11 with the screw head seating in or against the plate. The screw of the first member connects with one end of the spring as in the original embodiment, and the plate engages radially across the relevant end of the tube, in the notch or slot, to hold the spring under tension in similar manner to the previously proposed pin. Securement to the bone is, of course, effected by the bone screw in place of the pin.

The further embodiment of FIG. 4 is similar to that of FIG. 3 and corresponding reference numerals are used where appropriate. However, the terminal means for the spring differ in that the second member is not a bone screw but a disc 12 having two apertures 13 therein towards its center so that this member is, for practical purposes, like a button. In fact the member in question is used like a button in that the tube of the device is passed laterally through a bored passage in a bone, and the spring is tensioned between its ends by threading a wire w through the aperture of the first terminal component, passing the free ends of the wire through the respective apertures of the disc with the disc located over the adjacent end of the bored passage, and then tightening and twisting the wire to secure the resultant terminal connection. This mode of fixation is useful, as noted above, when the relevant bone is of poor quality for more conventional fixation techniques and the wire securement can conveniently be effected by use of the apparatus described in co-pending Great Britain Patent Application No. 38988/71.

The device of FIG. 4, as so far described, can be used in its own right for fixing an oblique fracture since it will serve to hold the fractured parts together in a lateral sense under the spring tension, while resisting movement in the longitudinal sense of the bone by virtue of the rigidity of the tube around the spring. In this last connection, it is to be noted that the tube will not engage the second members of the terminal means, but there need be no significant movement between these members and the main body of the device if the main body terminates closely adjacent the bone surface areas in which the bored passage emerges.

However, the situations in which the device of FIG. 4 may be used alone are more likely to be those in which use is normally made of an elongate fracture fixing member, such as an intramedullary nail or a bone plate, to provide rigidity along the longitudinal direction of the bone against lateral movement in a fracture. Accordingly, the device of FIG. 4 is shown in association with an intramedullary nail.

For this last purpose the nail, denoted at 14 is provided with a plurality of lateral threaded bores 15 which are spaced apart in uniform and parallel manner along the length of the nail, and each bore 15 can be associated with the device so far described when provided with a threaded portion 16 around the central part of its tube. Briefly, to achieve this arrangement, the nail is located along the relevant medullary canal, the bone is bored laterally to form passages communicating with the canal in locations corresponding to the bores of the nail, the tubes of the associated devices are passed into the bores in the bone for screw connection with the nail, and the devices are secured by way of their springs and terminal means as described above. Naturally, not all of the bores of the nail need be necessarily used in association with the fixation devices, but a regular sequence of bores is provided in the nail to allow selection to suit different circumstances.

For completeness in FIG. 4, an associated jig 17 is shown whereby the lateral bores can be made in the bone to correspond with the bores in the nail which are to be employed for fixation. This jig comprises a primary elongate member 18 having a first end portion 20, formed with a sequence of lateral bores 21 corresponding to those of the nail, and a second end portion 22 extending from the first and formed with two spaced lateral bores 23 parallel to the bores 21. The bores 21 are extended on opposite sides of the portion 20 by tubular members 24, and at least one of the bores 21 nearer the free end of portion 20 communicates with an orthogonal threaded bore 25 which receives a screw 26. The jig comprises a secondary elongate member 27 similar to portion 22 of the primary member in overall geometry and the provision of two lateral bores 28. The secondary member is connectable with the primary member in parallel disposition by two tie rods 30 which pass at their opposite ends through corresponding ones of the bores 23 and 28, the tie rod ends being threaded for securement by nuts 31.

The secondary member 27 differs in the provision of a longitudinal bore 32 therethrough and a pin 33 extending parallel thereto from the end of the secondary member nearer to the first end portion 20 of the primary member. This bore and pin respectively cooperate with correspondingly disposed stopped bores 34 and 35 in one end of the nail, the bore 34 being threaded.

In use of this jig, an initial lateral bore is made in the bone to communicate with the medullary canal, and the nail is passed into the canal, with the end of the nail having the stopped bores 34 and 35 outermost relative to the entry point, until one of the innermost lateral bores of the nail is aligned with the initial bore in the bone. Then a rod 36 with a threaded end 37 is passed into the bore to screw into the aligned bore of the nail, while the other end of the rod 36 is passed into the corresponding bore 21 of the primary member 18. Additionally, the secondary member 27 is abutted against the outermost end of the nail with the pin 33 located in the stopped bore 35, the longitudinal bore 32 of the secondary member is aligned with the stopped bore 34 of the nail, and a screw 38 is passed through the bore 32 to engage bore 34. Then the primary and secondary members are connected by the tie rods 30, and the rod...
3,807,394

36 secured by the screw 26, the tie rods secured by the nuts 31, and the secondary member secured with the nail by the screw 38, to provide a rigid ladder-like arrangement of the jig and nail. The bores 21 of the jig primary member are then fixed in alignment with the bores 15 of the nail, and the former serve as guides for drilling lateral bores in the bone to communicate with the nail and receive fixation devices.

In addition to providing enhanced securement in the presence of poor bone, the fixation is enhanced, as noted earlier, for a nail used in cancellous regions which do not normally offer adequate frictional engagement. The more particular nail form and associated fixation devices of FIG. 4 have been developed with the last advantage in mind for use in the lower third of the femur, and the nail is shaped for accommodation in this region with access from the knee but without requiring the otherwise necessary, but not necessarily successful, use of a nail of such length as to extend along a major part of the femur. Also it will be appreciated that the jig can be connected with the nail from either side.

The difficulty of fixation in poor bone is more likely to become apparent in connection with bone plates, which are normally fixed with screws, and FIG. 5 illustrates a modification of the fixation device of FIG. 4 in association with such a plate. The principal modification of the device is the provision of external threading 40 at one end of the tube of the device, rather than the center, for screw connection with threaded bores 41 in a bone plate 42. Also, while the terminal means for the fixation device spring can be as shown in FIG. 4, differently modified means are shown at the two ends of the device in FIG. 5 to further illustrate the possibility of variation within the more general scope of the invention.

At the end of the device for connection with the bone plate, the terminal means comprise a first member 8 of apertured plate form as in FIG. 3, while the bone plate serves as the second member. More particularly, the aperture of the bone plate has a radial slot extension 43 through which the first member plate can pass and be locked by rotation in the manner of a turn-buckle.

At the other end, the device again employs a terminal device comprising a first member 8 of apertured plate form, but instead of association with a double-apertured button for connection by wire, the second member comprises a disc 44 with a slot 45 through which the member 8 can pass to be locked by a pin 46 threaded through its aperture.

Clearly, both ends of the tube of the fixation device of FIG. 5 can be threaded for association with respective bone plates on opposite sides of the bone. Also, it will be apparent that screw connection of the fixation device and plate is not essential, since the plate can simply serve as an integrated second terminal means member for a plurality of fixation devices.

While the invention has been more particularly described with reference to a number of specific embodiments thereof, it has been made very clear that it is susceptible to wide variation in its superficially simple form. These variations will suit different practical applications in orthopaedic fracture fixing, but exhibit a common characteristic of providing tension by way of a spring extending between fixation points, while the spring is stiffened laterally by an encompassing tube.

I claim:

1. An orthopaedic fracture fixing device comprising a tube, an elongate spring member located under tension along the bore of said tube, and a pair of terminal means connected with respective ends of said spring member, said terminal means extending externally of the tube laterally relative to the longitudinal direction of said tube across the ends of the tube for securing said spring member relative to a bone and holding said spring member, under tension, against relaxation into said tube.

2. A device according to claim 1 wherein said terminal means each comprise a pin adapted for fixation in said bone by penetration thereinto, which component is deployed laterally relative said spring member, and said tube is slotted in a longitudinal sense from at least one end thereof to slidably receive said component.

3. A device according to claim 1 wherein said terminal means each comprise a discrete first terminal member connected with the respective end of said spring member, and a discrete second terminal member, separably interconnected with said first terminal member.

4. A device according to claim 3 wherein said first terminal member is of apertured form, and said second terminal member is formed with two apertures, and said terminal means each further comprise a length of wire of which an intermediate portion passes through said first terminal member, and the free end portions of said wire pass respectively through said two apertures, to connect said terminal members by twisting said wire free end portions.

5. A device according to claim 3 wherein each of said first and second terminal members is of apertured form, the aperture of said second terminal member receiving the apertured part of said first terminal member therethrough, and each of said terminal means further comprising a locking pin passing through said apertured part.

6. A device according to claim 3 wherein said second terminal member is of apertured form, and said first terminal member is passed at least partly through said second terminal member and thereafter rotated about said longitudinal direction to extend across said second terminal member.

7. A device according to claim 3 wherein the external surface of said tube is threaded at least part way along the length thereof, an additional fracture fixing member internally threaded for screw connection with said threaded external surface.

8. A fracture fixing assembly comprising a plurality of devices according to claim 3 in each of which the respective tube is externally threaded over an intermediate portion thereof, and an elongate intramedullary member having a plurality of threaded lateral bores therethrough individually receiving said devices in screw connection.

9. A fracture fixing assembly comprising a plurality of devices according to claim 3 and at least one elongate bone plate constituting said second terminal in common for one set of corresponding ends of said devices.

10. A fracture fixing assembly comprising a plurality of devices according to claim 7 in each of which said threading extends over an end portion of the respective tube, and an elongate bone plate having a plurality of threaded lateral bores therethrough to individually receive said devices in screw connection.
11. An orthopaedic fracture fixing device, comprising:
   a rigid tube having a longitudinal bore;
   a coil spring received in and extending along said bore;
   a first terminal means extending laterally externally
   of the tube adjacent one end of the tube;
   first means connecting one end of the spring to said
   first terminal means;
   a second terminal means extending laterally exter-
   nally of the tube adjacent the other end of the tube;
   second means connecting the other end of the spring
   to the second terminal means, the length of the
   spring relative to the tube being such that the sec-
   ond terminal means is pulled against the other end
   of the tube by the spring and maintains the spring
   in tension;
   interdigitable protrusion and recess means on said
   second terminal means and said tube other end, ar-
   ranged to not interdigitate until the tube is rotated
   about its longitudinal axis to a predetermined dis-
   position relative to the second terminal means
   whereupon the tension on said spring means pulls
   the protrusion and recess means into interdigi-
   tation, thus moving the second terminal means
   toward the first terminal means;
   the length of the spring relative to the tube being
   such that the spring remains tensioned when said
   protrusion and recess means are interdigitated;
   whereby the first and second terminal means may be
   connected to a bone on opposite sides of a fracture
   thereof with the protrusion and recess means not
   interdigitated, and the tube rotated relative to the
   second terminal means to interdigitate the protru-
   sion and recess means, thus permitting the spring
   to shorten, drawing the first and second terminal
   means together and thus reducing the fracture.

   * * * * *