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(71) Applicant: **TAMIS OTOGAZ SANAYI TICARET VE MUHENDISLIK HIZMETLERI ITHALAT IHRACAT LIMITED SIRKETI** [TR/TR]; Sanayi Sitesi Kılıcaslan Cd. No: 44, Samsun (TR).

(72) Inventor: **KAHVECIOGLU, Hakan**; Sanayi Sitesi Kılıcaslan Cd. No: 44, Samsun (TR).

(74) Agent: **DESTEK PATENT, INC**; Konak Mah. Lefkose Cad. NM Ofis Park, No: 36/5, 16110 Bursa (TR).

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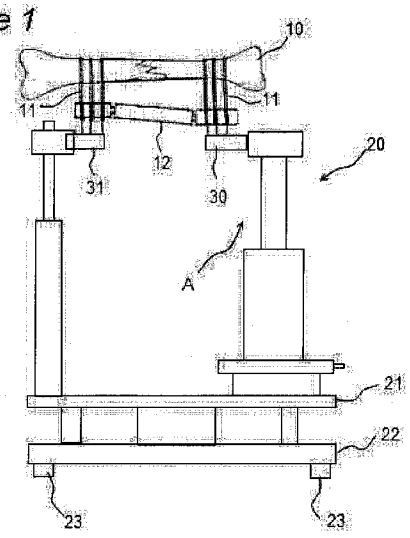
Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) Title: A FIXATION ROBOT FOR BONE FRACTURES

Figure 1



(57) Abstract: The present invention relates to a fixation robot (20) enabling the alignment of fractured bones (10) in orthopaedic operations, wherein it comprises the following: a fixed retainer jaw (31) connected to one piece of said fractured bone (10), a moving retainer jaw (30) connected to the other piece of said fractured bone (10) and a motion transfer assembly (A) providing motion to said moving retainer jaw (30).

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DESCRIPTION

A FIXATION ROBOT FOR BONE FRACTURES

Field of the Invention

The invention relates to a fixation robot, which performs the alignment of fractured bones automatically in the orthopedic operations carried out by means of an external fixation method and which is preferably controlled by means of a remote control.

Prior Art

In the arm and leg fractures, when the physician decides to proceed with the external fixator treatment by taking the factors such as location and status of the fracture into account, the following known procedure is followed. Threaded nails are placed externally only on fractured bone fragments without making an incision over the fractured bones pieces Then, physician directs their assistants by looking at the screen of a so called fluoroscopy device (a camera showing live image by shooting X-ray video). Assistants acting on the order of the physician manually move the fractured bones pieces of the patient and try to align the fractured bones. However, in most operations, they cannot perform the reduction desired by the physician since they don't have enough power to overcome the resistance of the muscles around the fractured bone.

In the meantime, operating fluoroscopy device continuously and intensely emits X-ray (radiation). Although the patient receives this radiation once in their life, it is not a preferred situation for the physician to be exposed to this radiation. Thus, even though exact reduction desired is not attained, physician turns the fluoroscopy device off as soon as "enough" reduction is obtained. This situation increases the risk of never bonding or incorrect bonding of the fractured bones.

Even though the reduction is practised as the physician desired, assistants have to wait during one minute, which is the required time for the physician to secure the fixator (screwing the bolts), without changing their positions and the force they apply. In practice this is not quite possible as the staff become tired

and reduces the force they apply unintentionally. Consequently, a poor or good reduction is provided, bolts of the fixator are tightened and the operation is terminated. External fixator is removed by the physician without the need for a second operation after bonding of the fractured bones at the end of the required time period and the treatment process is completed.

Patent no. WO 2002/069816 of Dutch origin is encountered during the patent search for the stabilization devices, so called fixator. The abstract of the patent application states the following: "The invention relates to an external fixation device for fractured bones having a carrying structure of interconnected elements comprising an extendible central body and clamps for bone screws respectively articulated on opposed ends of the central body."

The other patent application is patent no. WO 2001/091654 of Italian origin, belonging to ORTHOFIX S.R.L. In this application the following is stated: "The invention relates to a new type of axial unilateral external splint device for stabilizing bone fractures, comprising an extendible rod-like middle body (2) and oppositely located bone screw clamps (5, 6) which are articulated to respective ends (3, 4) of the rod-like middle body (2) by means of ball joints. Advantageously, a ball-and-socket joint (16) is mounted to each clamp (5, 6), within a main body (20) with which a bone screw clamping arrangement (25, 26, 21, 22, 23) is associated or co-operates."

The United States patent U.S. 5662648A discloses a fixation device having multi-axial movement and comprising a second mechanism in association with thereof through an intermediate member. Fixator secured on the bone by means of stabilizing elements (screws) is characterized in that it can be oriented with a second mechanism, however, in different axes, wherein a structure provided with freedom of movement by means of multi-axial movements is described.

Object of the Invention

The object of the present invention is to obtain a device having different technical specifications and bringing a new approach in this field as compared to the fixator configurations used in the current state of the art.

An object of the present invention is to provide bringing bone ends into the same axis or aligning them automatically by means of a remote control without manual intervention and adjustment.

Another object of the present invention is to protect physicians and other operating room personnel from the radiation emitted from fluoroscopy device during the operation by means of the remote control feature thereof.

Further object of the present invention are to exactly align the two bone pieces in order to prevent possibility of not bonding of the fractured bone or minimize the delay in bonding; and to provide immobility of the bones during the time period required for securing the fixator.

Another object of the present invention is to realize a precise alignment thanks to the structure comprising a fixed jaw and a moving jaw, with the moving jaw having the ability to move with minimum parameters and to be just fixed with the desired parameter.

Another object of the present invention is to provide high mobility thanks to the six-axis movement ability of the moving jaw.

A further object of the present invention is to provide easy transportation of the fixation robot thanks to the portable structure as well as the advancing means thereof.

Another object of the present invention is to minimize the treatment period of fractured bones and hence to carry out large number of treatments in shorter time periods. At the same time, the objective of the present invention is to minimize the effort spent by the physician and technical committee.

The present invention relates to a fixation robot enabling the alignment of fractured bones in orthopaedic operations for the purpose of fulfilling the objectives described above, wherein it comprises the following: a fixed retainer jaw connected to one piece of said fractured bone, a moving retainer jaw connected to the other piece of said fractured bone and a motion transfer assembly providing motion to said moving retainer jaw.

Figures for a Better Understanding of the Invention

Figure 1 is a representational front view of the fixation robot according to the invention when fixator and bone are adapted.

Figure 2 is an individual perspective view of the fixation robot according to the invention.

Figure 3 is a perspective view of the fixation robot according to the invention from a different angle.

Figure 4 is a close-up perspective view of the cardan shaft transferring motion to the moving jaw of the fixation robot according to the invention.

Part Numbers

10-Bone

11-Connection nail

12-Fixator

20-Fixation robot

21-Carrying body

22-Lower plate

23-Y-plane advancer

24-X-plane advancer

25-Z-plane advancer

26-Moving column

27-Driving member

28-Encoder

29-Cardan shaft

30-Moving retainer jaw

31-Fixed retainer jaw

32-Intermediate member

33-Fixed jaw arm

34-Wheels

35-Nail slots

A-Motion transfer assembly

40-Controller

Detailed Description of the Invention

The present invention relates to a fixation robot (20) enabling the alignment of fractured bones (10) in orthopaedic operations, wherein it comprises the following: a fixed retainer jaw (31) connected to one piece of said fractured bone (10), a moving retainer jaw (30) connected to the other piece of said fractured bone (10) and a motion transfer assembly (A) providing motion to said moving retainer jaw (30).

Said motion transfer assembly (A) comprises a Y-plane advancer (23) parallel to the ground; an X-plane advancer (24) provided at an angle of 90° with respect to the Y-plane advancer (23) of the motion transfer assembly (A); a Z-plane advancer (25) moving vertically with respect to ground of the motion transfer assembly (A); a moving column (26) (A); a plurality of driving members (27) in association with said moving retainer jaw (30), wherein said driving members (27) are a motor and a reducer. Motion transfer assembly (A) also comprises encoders (28).

The fixation robot comprises a cardan shaft (29) associated with moving retainer jaw (30); nails (11) anchored on said bone (10); a fixator (12) located between these nails (11) and jaws (30, 31); an intermediate member (32) connected with said fixed retainer jaw (31); a fixed jaw arm (33); a carrying body (21) where said motion transfer assembly (A) is mounted; a lower plate (22) provided below said carrying body (21); wheels (34); and a hand controller (40) enabling the movement of said motion transfer assembly (A) in 6-axis.

Operating method of the fixation robot (20)

In figure 1, a representational two dimensional view of the fractured bone (10) held and fixed by the robot (20) is illustrated. One of the pieces of the two-piece

fractured bone (10) is connected to the fixed retainer jaw (31) and the other one is connected to the moving retainer jaw (30) by means of nails (11) and/or different screw type connection members. Fixator (12) is preferably used between the bone (10) and the jaws (31, 30). The used fixator (12) is already an available fixator (12).

Moving retainer jaw (30) is provided on the carrying body (21) and it is capable of multi-axial movement. For example, the linear movement in y-plane is provided by the Y-plane advancer (23) while the movement in x-plane is provided by the X-plane advancer (24). The movement in the direction perpendicular to these planes (23, 24) is provided by the Z-plane advancer (25). Driving members (27) and cardan shaft (29) are provided on the Z-plane advancer (25) (see figure 4), enabling rotational movement of the moving jaw (30) in different axes.

Rotational movement of the moving retainer jaw (30) in the x^1-axis is provided by the driving member (27) comprising a motor and reducer assembly. Axial rotational movement in the y^1-axis and z^1-axis is also provided by the same driving members (27). Driving members (27) are associated with the encoder (28), wherein the parameters are controlled by this encoder (28). Cardan shaft (29) provides the rotational movement in three axes (x^1,y^1,z^1) by means of motors (see figure 4).

Fixed retainer jaw (31) is fixed on the carrying body (21) by means of intermediate members (32) and fixed jaw arm (33). Fixation robot (20) is provided with a portable construction and its transportation to any other location is possible by means of the wheels (34) thereof. This construction provides ease of use and practicality.

Nail slots (35) are formed on the moving and fixed retainer jaws (30, 31), wherein connection nails (11) providing the connection between the fixator (12) and bones (10) are located in said slots (35) (see figure 3). The fixator (12) used herein can be an intermediate component with a flexible structure as well as a mechanism having multiple joints.

CLAIMS

1- A fixation robot (20) enabling the alignment of fractured bones (10) in orthopaedic operations, wherein it comprises the following:

- a fixed retainer jaw (31) connected to one piece of said fractured bone (10);

- a moving retainer jaw (30) connected to the other piece of said fractured bone (10); and

- a motion transfer assembly (A) providing motion to said moving retainer jaw (30).

2- A robot according to claim 1, wherein said motion transfer assembly (A) comprises a Y-plane advancer (23) parallel to the ground.

3- A robot according to claims 1 and 2, wherein said motion transfer assembly (A) comprises an X-plane advancer (24) at an angle of 90° with respect to the Y-plane advancer (23).

4- A robot according to claims 1, 2, and 3, wherein said motion transfer assembly (A) comprises a Z-plane advancer (25) moving vertically with respect to the ground.

5- A robot according to any preceding claim, wherein said motion transfer assembly (A) comprises a moving column (26).

6- A robot according to any preceding claim, wherein it comprises a motion transfer assembly (A) capable of moving in 6 axes.

7-A robot according to any preceding claim, wherein it comprises a plurality of driving members (27) associated with said moving retainer jaw (30) and providing rotational movement to moving retainer jaw (30) in x^1,y^1,z^1 axes.

8- A robot according to claim 7, wherein said driving members (27) are a motor and a reducer.

9- A robot according to any preceding claim, wherein said motion transfer assembly (A) comprises encoders (28).

10- A robot according to any preceding claim, wherein it comprises a cardan shaft (29) associated with said moving retainer jaw (30).

11- A robot according to any preceding claim, wherein it comprises nails (11) anchored on said bone (10) and a fixator (12) provided between these nails (11) and jaws (30, 31).

12- A robot according to any preceding claim, wherein it comprises an intermediate member (32) connected with said fixed retainer jaw (31) and a fixed jaw arm (33).

13- A robot according to any preceding claim, wherein it comprises a carrying body (21) onto which said motion transfer assembly (A) is mounted.

14- A robot according to any preceding claim, wherein it comprises a lower plate (22) and wheels (34) located below the carrying body (21).

15- A robot according to any preceding claim, wherein it comprises a hand controller (40) enabling the movement of motion transfer assembly (A) in 6 axes.

16- A robot according to any preceding claim, wherein it comprises nail slots (35) formed on said jaws (30, 31).

17- A robot according to claim 11, wherein said fixator (12) is made of an elastic material.

18- A method enabling the alignment of fractured bones (10) in orthopaedic operations, wherein it comprises the following steps:

- connecting one of the fractured bones (10) with the fixed retainer jaw (31);

- connecting the other fractured bone (10) with the moving retainer jaw (31);

- providing movement to the moving retainer jaw (31) by means of the motion transfer assembly (A) in multiple axes until fully aligning the ends of fractured bone (10).

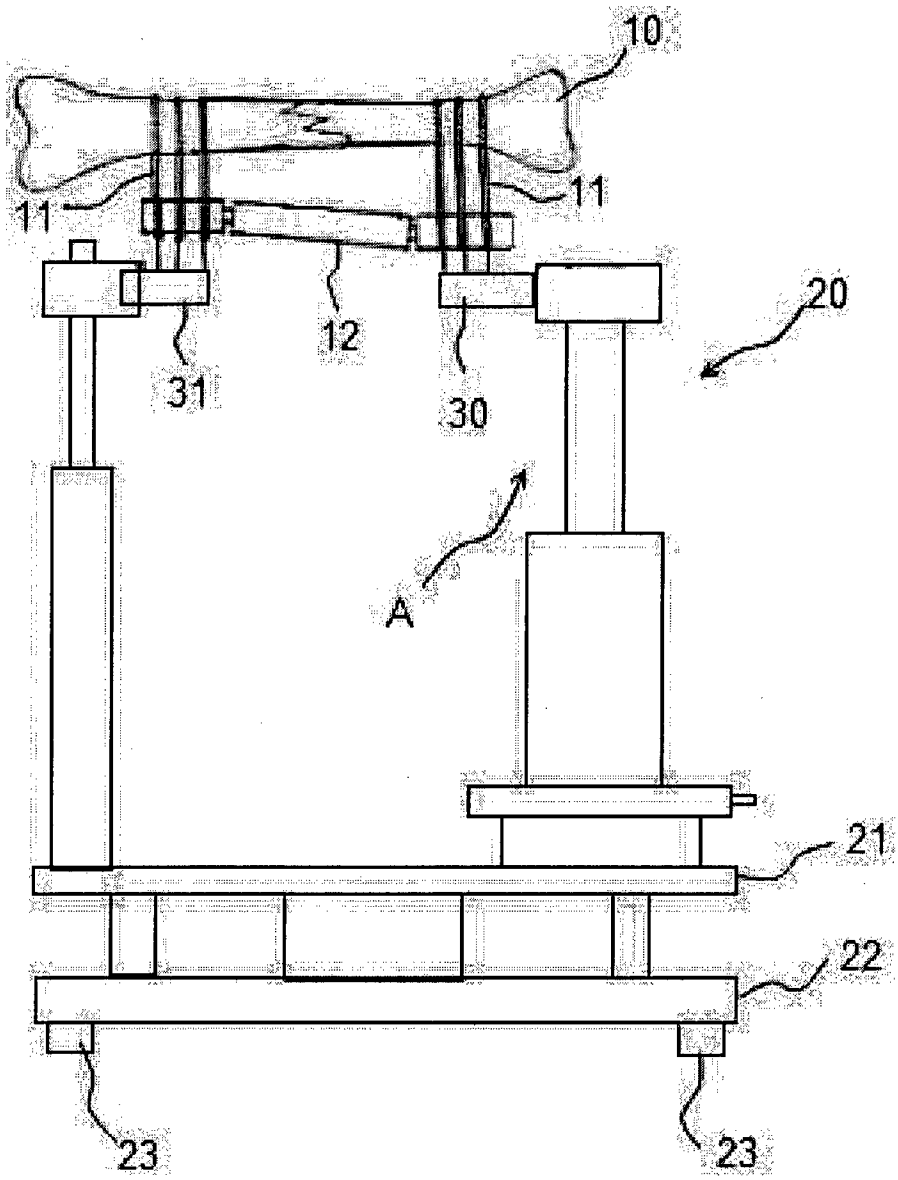
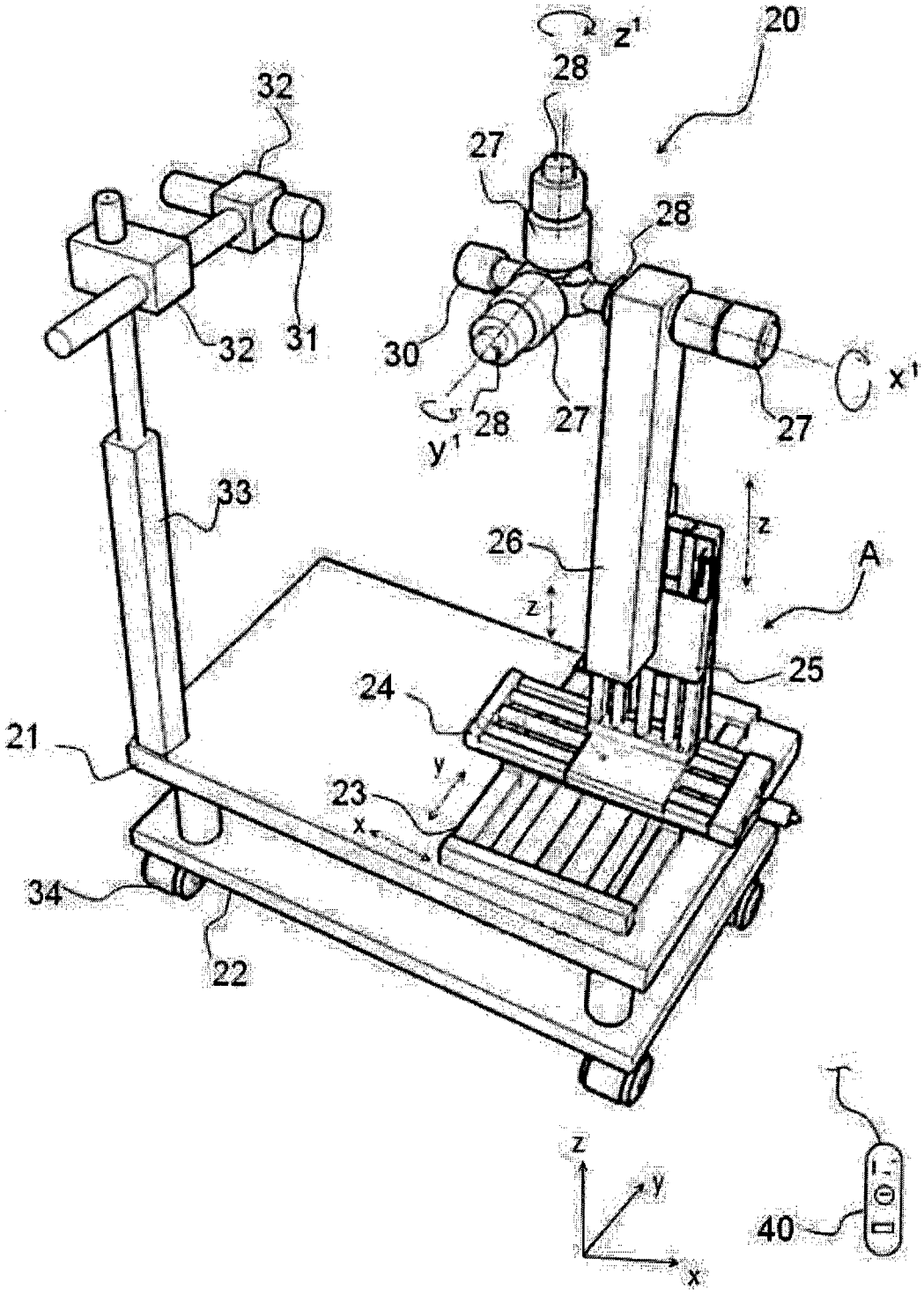


Figure 1


z¹
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27
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Figure 2

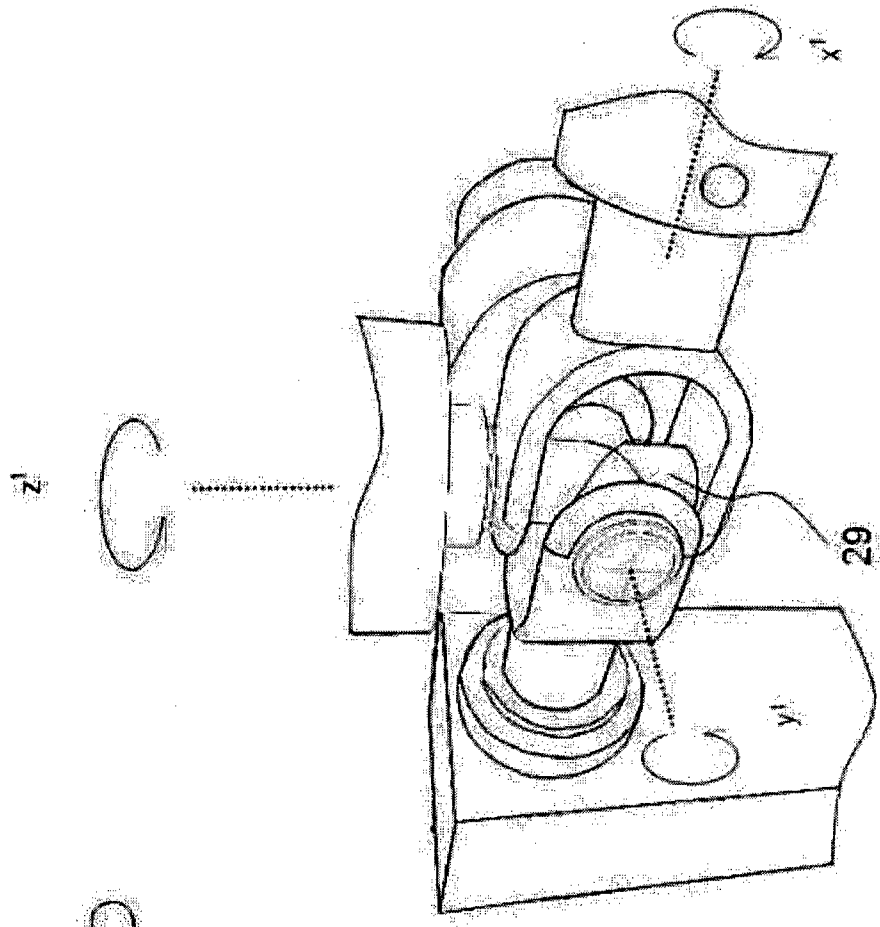

Figure 4

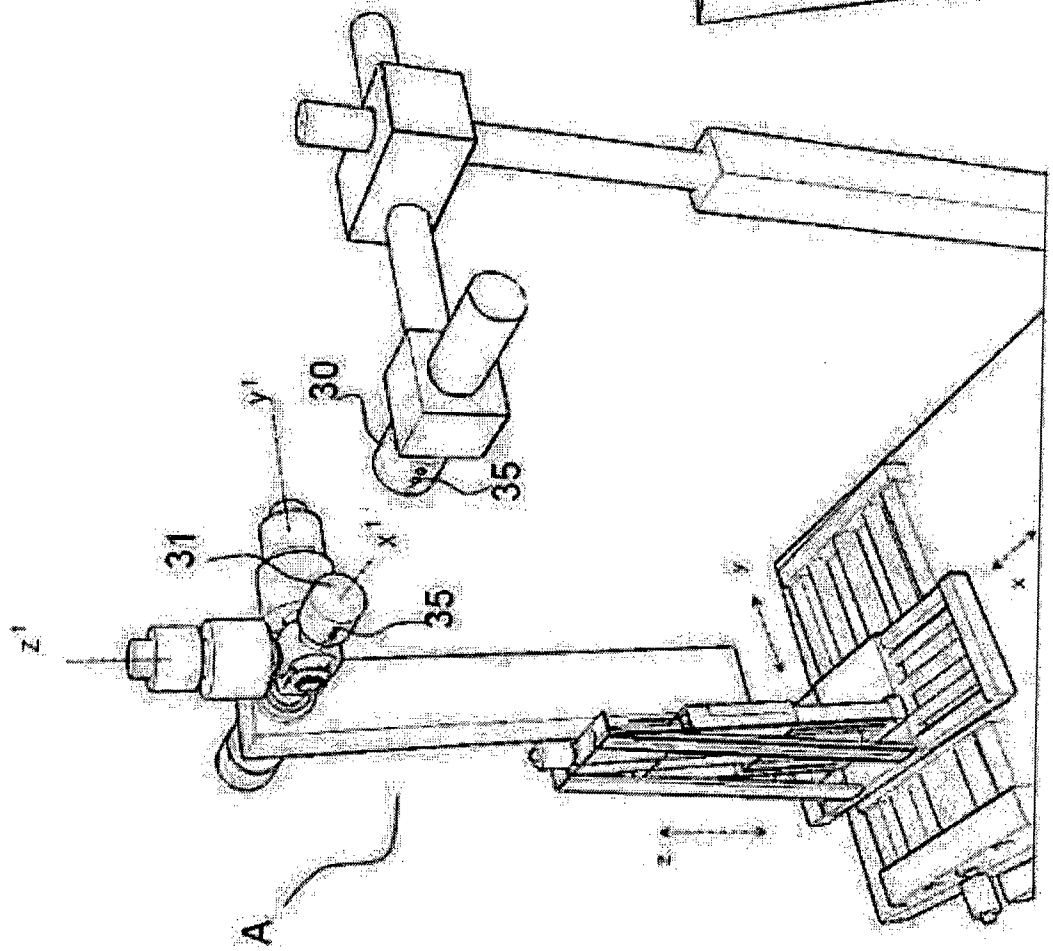

Figure 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/TR2013/000062

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B17/64 A61B17/88 A61B19/00
ADD.

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)
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 practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2010/138715 A1 (SYNTHES USA LLC [US]; SYNTHES GMBH [CH]; MAST JEFFREY W [US]; POLIMENI) 2 December 2010 (2010-12-02)	1-9, 11-17
Y	paragraphs [0006] - [0018]; figures 1-9 paragraph [0021]; figure 13	10
Y	US 5 728 095 A (TAYLOR HAROLD S [US] ET AL) 17 March 1998 (1998-03-17) claims 1, 6	10

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 July 2013	30/07/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Schnurbusch, Daniel

1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/TR2013/000062

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.: 18
because they relate to subject matter not required to be searched by this Authority, namely:

see FURTHER INFORMATION sheet PCT/ISA/210

2. [ ] Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

[ ] The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

[ ] No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.1

Claims Nos.: 18

Method claim 18 defines a method for treatment of the human or animal body by therapy and surgery practised on the human or animal body, because "[...] alignment of fractured bones in orthopaedic operations [...] connecting one of the fractured bones with [a jaw...and] providing movement to the [...] jaw by means of the motion transfer assembly [...] until fully aligning the ends of fractured bone [...]" (claim 18) is seen as a surgical and therapeutical step performed on a patient. Therefore no search has been performed for the subject-matter of this claim (see Article 17 (2) PCT and Rule 39.1.(iv) PCT) and no written opinion is required for the subject-matter of this method claim (see Rule 43bis.1 and Rule 67.1 (iv) PCT).

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/TR2013/000062

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