

VARIABLE ANGLE LIMB SUPPORT

Field of the Invention

[0001] The present invention generally relates to a device for supporting a limb in various angular positions, especially for supporting a lower limb in radiographic projection of the patello-femoral joint.

Background of the Invention

[0002] Radiographic projection of the patello-femoral joint is currently the best projection to demonstrate patello-femoral pathologies, particularly in the evaluation of patello-femoral disorders such as chondromalacia and recurrent subluxation. In common medical practice, a patient's lower limb is supported by a conventional fixed angle support, which provides a fixed knee-flexion of 30-40 degree between the long axis of the tibia and the long axis of the femur. A horizontal X-ray beam is directed towards the patello-femoral joint space, while the patient manually holds a film cassette to capture the penetrated X-ray beam.

[0003] FIG. 1 shows two types of conventional fixed angle supports, each having a fixed supporting angle θ in a range of 30-40 degree. Although the 30-40 degree knee-flexion is sufficient for demonstration of the patello-femoral joint space, it may not be optimal for certain pathological diagnosis, such as subluxation of the patella. It is desirable to obtain a series of patello-femoral projections at various degrees of knee-flexion for further diagnostic information.

[0004] In addition, the manual holding of the film cassette by the patient is unstable, resulting in distortion of the projection image, which impairs the required information for diagnosis. And the patient's close position towards the film cassette increases the overall radiation dose received, posing threat to the health of the patient.

Summary of the Invention

[0005] The present invention provides a limb support with a broad range of adjustability to support a limb at various angular positions. The limb support comprises a base frame disposed on a supporting surface, a pivoted structure in an inverted V-shape mounted on the base frame for supporting the limb at various pivot angles, and adjustment means for adjusting the pivot angle of the pivoted structure, wherein the distance from the apex of the pivoted structure to the supporting surface is maintained for different pivot angles. The pivoted structure comprises a first support member and a second support member, which are pivotally connected to each other, forming the inverted V-shape. When the support is used to support a lower limb in radiographic projection of the patello-femoral joint, the relative position of the patello-femoral joint with respect to the supporting surface remains unchanged during projections at various knee-flexion angles. Therefore, no adjustment is required to the height of the radioactive source.

[0006] According to one aspect of the invention, there is provided a limb support wherein the base frame has a J-shaped structure, which comprises a horizontal portion in contact with the supporting surface, and an arc portion extending upwards, and wherein the distal end of the first support member is supported by the horizontal portion of the base frame, whilst the distal end of the second support member is maneuverable along the arc portion of the base frame.

[0007] According to another aspect of the invention, there is provided a limb support, wherein the arc portion of the base frame is part of a circle. The circle has the center at the apex of the pivoted structure, which is of a pre-determined distance from the supporting surface; and the radius being the length of the second support member.

[0008] According to yet another aspect of the invention, there is provided a limb support, wherein the adjustment means comprises a plurality of sockets carved on the arc portion of the base frame, and a pin extended from the distal end of the second support member, wherein the distal end of the pin is operable to sit in any of the sockets so as to adjust the pivot angle between the first and second support members.

[0009] According to another aspect of the invention, there is provided a limb support, wherein the adjustment means comprises a groove carved along the arc portion of the base frame, a pin extended from the distal end of the second support member, the pin having the distal end disposed and restrained in the groove and operable to slide therein, and an extendable/retractable structure disposed and linking between the base frame and the second support member; wherein the longitudinal length of the extendable/retractable structure is adjustable, so as to adjust the pivot angle between the first and second support members. In one embodiment, the extendable/retractable structure is operable to extend/retract by a telescopic mechanism built therein. In another embodiment, the extension/retraction is motorized.

[0010] According to yet another aspect of the invention, there is provided a limb support, wherein the longitudinal lengths of the second support member and the horizontal portion of the base frame are adjustable so as to support limbs of various lengths. In one embodiment, the length adjustment is achieved by telescopic mechanisms built therein.

[0011] According to further another aspect of the invention, there is provided a limb support, further comprises a detachable holder. When the limb support is used in radiographic projection of the patello-femoral joint, the holder is operable to hold the X-ray film cassette. In one embodiment, the detachable holder comprises an upright post detachably connected to the base frame, and a vertical frame pivotally attached to the post for holding the X-ray film cassette.

[0012] The objectives and advantages of the present invention will become apparent from the following detailed description of embodiments thereof in connection with the accompanying drawings.

Brief Description of the Drawings

[0013] Preferred embodiments according to the present invention will now be described with reference to the Figures accompanied herein, in which like reference numerals denote like elements.

[0014] FIG. 1 shows two conventional fixed angle supports for the radiographic patello-femoral projection.

[0015] FIG. 2 shows a perspective view of a variable angle limb support device in accordance with one embodiment of the present invention.

[0016] FIG. 3A shows a side view of the device in FIG. 2, illustrating the relative motion of the second support member during angular adjustment of the device, whilst FIG. 3B shows an enlarged view of the adjustment means in accordance one embodiment of the present invention.

[0017] FIG. 4A shows a perspective view of a variable angle limb supporting device with motorized adjustment means in accordance with another embodiment of the present invention; FIG. 4B shows an exploded view of the motorized adjustment means; and FIG. 4C and 4D show side views of the device with the extendable/retractable structure at the most retracted and extended positions respectively.

[0018] FIGs. 5A and 5B show side views of a variable angle limb support device for supporting limbs of different length, in accordance with yet another embodiment of the present invention; FIG. 5C shows a telescopic structure of the base frame shown in FIGs. 5A and 5B.

[0019] FIG. 6A shows a perspective view of a variable angle limb support device with a detachable holder in accordance with a further embodiment of the present invention, whilst FIG. 6B shows the device in use for the radiographic patello-femoral joint projection.

Detailed Description of the Invention

[0020] The present invention may be understood more readily by reference to the following detailed description of certain embodiments of the invention. However, it will be understood by those skilled in the relevant art that the present invention may be practised without these specific details. In other instances, well-known methods, procedures, and components have not been described in detail so as not to obscure the present invention.

[0021] FIG. 2 shows a perspective view of a variable angle limb supporting device in accordance with one embodiment of the present invention. The device 100

comprises a base frame **110** disposed on a supporting surface **106**, an inverted V-shaped pivoted structure **120** mounted on the base frame **110** for supporting the limb in various angular positions, and adjustment means **130** for adjusting the pivot angle formed by the pivoted structure **120**.

[0022] FIG. 3A shows a side view of the device **100** in FIG. 2. The base frame **110** comprises a vertical supporting structure **111**, and a J-shaped structure **112**. The J-shaped structure **112** has a horizontal portion **113** disposed on the planar supporting surface **106** (not shown in FIG. 3A), and an arc portion **114** extending from a first end **113a** of the horizontal portion **113** and stretching upwards. The lower end **111a** of the vertical supporting structure **111** is connected perpendicularly to a second end **113b** of the horizontal portion **113**.

[0023] In one embodiment of the base frame **110**, the vertical supporting structure **111** is rectangle shaped. In another embodiment, the vertical supporting structure **111** has a handle **115** attached for carrying and moving the device **100**. In yet another embodiment, a horizontal crosspiece is perpendicularly attached to the horizontal portion **113** for securing a stable support of the device **100** on the supporting surface **106**.

[0024] Still referring to FIG. 3A, the pivoted structure **120** has a first support member **121** and a second support member **122** pivotally connected to each other, forming the inverted V-shape and defining a pivot angle θ . The distal end **121a** of the first support member **121** is pivotally connected with the upper end **111b** of the vertical supporting structure **111**, whilst the distal end **122a** of the second support member **122** is maneuverable along the arc portion **114** of the base frame **110**. The relative position of the distal end **122a** of the second support member **122** to the arc portion **114** is controlled by the adjustment means **130**, thereby determining the degree of the pivot angle θ formed by the pivoted structure **120**.

[0025] In one embodiment of the pivoted structure, each support member **121** or **122** comprises a pivot arm, at least one bar attached to the pivot arm for defining a planar surface, and a cushion disposed on the planar surface for supporting the limb.

[0026] FIG. 3B shows an enlarged view of the adjustment means **130** for adjusting the pivot angle θ formed by the pivoted structure **120** in accordance with one embodiment of the present invention. The adjustment means **130** comprises a pin **131**

extending from the distal end **122a** of the second support member **122**, and a plurality of sockets **132** carved along the inner surface of the arc portion **114** of the base frame **110**. The tip of the pin **131** is operable to sit in any of the sockets **132**, to form a pin-socket joint. Once a pin-socket joint is secured, the position of the pivoted structured **120** on the base frame **110** is locked, and the pivot angle θ is fixed. The location of the sockets **132** along the arc portion **114** of the base frame **110** determines the range of the pivot angle θ and the adjustable angular interval.

[0027] In one embodiment of the pin, the pin **131** is T-shaped, having a first portion **131a** in line with the longitudinal axis of the second supporting member **122** and a second portion **131b** perpendicular thereto and operable to fit in the linear sockets **132**. In another embodiment, the pin **131** is rod-shaped with a round tip fitting in the point sockets **132**.

[0028] Now referring back to FIG. 3A, the relative motion of the pivoted structure **120** controlled by the adjustment means **130** is illustrated. When the distal end **122a** of the second support member **122** is moved upwards and the pin **131** is locked in the socket **132** closer to the upper end of the arc portion **114** of the base frame **110**, the pivot angle θ is decreased. And the arc portion **114** of the base frame **110** and the adjustment means **130** are so configured that during adjustment, the distance from the apex of the pivoted structure **120** to the supporting surface **106** (not shown in FIG. 3A) is maintained.

[0029] In one embodiment, the arch portion **114** is configured as part of a circle. The circle has the center at the apex of the pivoted structure, which is of a pre-determined distance from the supporting surface **106**; and the radius being the longitudinal length of the second support member **122** plus that of the pin **131**.

[0030] FIG. 4A shows a perspective view of a variable angle limb supporting device with motorized adjustment means in accordance with another embodiment of the present invention. The device **200** has a similar configuration with the early embodiment **100** shown in FIG. 3, except for the adjustment means. The motorized adjustment means **230** comprises a groove **232** carved along the inner surface of the arc portion **214**, a pin **231** extending from the distal end **222a** of the second support member **222**, the tip of which is disposed and operable to slide in the groove **232**, an extendable/retractable

structure **234** disposed between the horizontal portion **213** of the base frame **210** and the second support member **222** for positioning the second support member **222**, a motorization unit **233** secured to the horizontal portion **213** of the base frame **210**, and a coupling means **235** for coupling the motorization unit **233** to the extendable/retractable structure **234**.

[0031] FIG. 4B illustrates an exploded view of the motorized adjustment means **230** shown in FIG. 4A. The extendable/retractable structure **234** includes a hollow housing **237** and a shaft **236** operable to extend therein. The housing **237** has a first end **237a** with internally carved threads **237c**, and a second end **237b** pivotally connected to the second support member **222**. The shaft **236** has a first end **236a** rotably connected to a holder **239** via a bearing **238**, and a second end **236b** with external threads **236c** to engage with the internal threads **237c** of the housing **237**. The holder **239** is pivotally mounted on the horizontal portion **213** of the base frame **210**. The motorization unit **233** comprises a power **233a** (not shown in FIG. 4D), a motor **233b** (not shown in FIG. 4D) electronically connected to the power, and a controller **233c** (not shown in FIG. 4D) for controlling the speed and rotation direction of the motor. The coupling means **235** is a pair of bevel gears. The first bevel gear **235a** is mechanically connected to the motor **233b**, whilst the second gear **235b** is coupled with the shaft **236**.

[0032] In operation, when the power **233a** is switched on and the controller **233c** is actuated, the motor **233b** drives the rotation of the shaft **236** through the coupled bevel gears **235**. The interaction between the shaft **236** and the housing **237** via the engaging threads causes the housing **237** to move along the longitudinal axis of the shaft **236**, and to push or pull the second support member **222** supported thereon, with the pin **231** sliding up or down along the groove **232**. In this way, the position of the pivoted structure **220** and the pivot angle θ is adjusted as desired. FIG. 4C and 4D illustrate side views of the device **200** with the extendable/retractable structure **234** at the most retracted and extended positions respectively.

[0033] In one embodiment of the controller, the controller **233c** is a fuzzy control system. In another embodiment, the controller **233c** is an analogue control system. In yet another embodiment, the controller **233c** is a digital control system.

[0034] In one embodiment of the coupling means, the coupling means 235 is a worm gear.

[0035] In one embodiment of the device, the device 300 has the similar extendable/retractable structure 334 as shown in FIG. 4B for angular adjustment of the pivoted structure 320, however, which is manually powered. A handle is attached to the shaft 336 for manually driving the rotation.

[0036] In another embodiment of the device, the extendable structure/retractable 234 is a telescopic structure, the extending/retracting movement of which is locked or released by locking means.

[0037] FIG. 5A and 5B show a variable angle limb support device in accordance with yet another embodiment of the present invention. The device 500 has a similar configuration with the earlier embodiment 100 shown in FIG. 3, except that the longitudinal lengths of the second support member 522 and the horizontal portion 513 of the base frame 510 are adjustable by built-in telescopic structures 540, so as to adapt the device 500 to limbs of different lengths. Due to the similar structure, only the telescopic structure 540 built in the horizontal portion 513 of the base frame 510 is described below in detail.

[0038] FIG. 5C shows an enlarged view of the telescopic structure 540 built in the horizontal portion 513 of the base frame 510 as illustrated in FIG. 5B. The telescopic structure 540 has a receiving member 541, and an extending member 542 positioned and operable to slide therein. The extending member 542 has a plurality of lock apertures 543 along the longitudinal axis, each of which can be aligned with a lock aperture 544 (not shown in FIG. 5C) in the receiving member 541. A locking pin 545 is operable to be inserted through the pair of aligned lock apertures so as to fix the relative position of the receiving member 541 and extending member 542, thereby defining the longitudinal length of the horizontal portion 513.

[0039] The telescopic structures 540 of the device 500 are so configured that the length of the second support member 522 and the horizontal portion 513 of the base frame 510 can be adjusted proportionally. As a result, the distance H from the apex of the pivot structure 520 to the supporting surface 506 is maintained throughout adjustment.

FIG. 5A and 5B show side views of the device with the telescopic structures **540** at the most retracted and extended positions respectively.

[0040] In one embodiment of the device **500**, the telescopic structure **540** is employed to connect the pin **531** to the second support member **520**.

[0041] FIG. 6A shows a perspective view of a variable angle limb support device in accordance with a further embodiment of the present invention. Compared to the embodiment **100** shown in FIG. 3, the device **600** further comprises a detachable holder **650**. The holder **650** has a post **651**, an arm **653** connected to the post, and a frame **652** supported by the arm **653**. The post **651** is detachably mounted at the side of the vertical supporting structure **611**. The arm **653** is operable to pivot about the post **651** and move along the length of the post **651**. The frame **652** is in a 90 degree rotated U shape and mounted to the arm **653** via a linker **654**.

[0042] FIG. 6B shows a perspective view of the device **600** in FIG. 6A when it is in use for the radiographic projection of patello-femoral joint. The upper leg **602** of a patient **601** is placed on the first support member **621**, and the lower leg **603** on the second support member **622**, wherein the knee cap **604** is supported on the apex of the pivoted structure **620**. The pivot angle θ corresponds to the knee flexion. An X-ray film cassette **605** is disposed in the frame **652**. The position of the film cassette **605** can be adjusted by pivoting the arm about **653** and/or by raising or lowering the arm along the post **651**. The patient **601** can comfortably lie back and away from the X-ray film cassette **605** during projection process, to minimize the exposure to the X-ray.

[0043] While the present invention has been described with reference to particular embodiments, it will be understood that the embodiments are illustrative and that the invention scope is not so limited. Alternative embodiments of the present invention will become apparent to those having ordinary skill in the art to which the present invention pertains. Such alternate embodiments are considered to be encompassed within the spirit and scope of the present invention. Accordingly, the scope of the present invention is described by the appended claims and is sported by the foregoing description.

Claims

1. An device for supporting a limb in various angular positions, the device comprising:

a base frame disposed on a supporting surface;

a pivoted structure in an inverted V-shape mounted on the base frame for supporting the limb at various pivot angles, the pivoted structure having:

a first support member; and

a second support member pivotally connected to the first support member;

and

adjustment means for adjusting the pivot angle between the first and second support members;

wherein the distance from the apex of the pivoted structure to the supporting surface is maintained for different pivot angles.

2. The device according to claim 1, wherein the base frame having a J-shaped structure, which comprises a horizontal portion in contact with the supporting surface, and an arc portion extending upwards; and

wherein the distal end of the first support member is supported by the horizontal portion of the base frame, whilst the distal end of the second support member is maneuverable along the arc portion of the base frame.

3. The device according to claim 2, wherein the arc portion is part of a circle, the circle having

the center at the apex of the pivoted structure, which is of a pre-determined distance from the supporting surface; and

the radius being the longitudinal length of the second support member.

4. The device according to claim 1, wherein the base frame further comprises a vertical supporting structure having a lower end fixed to the horizontal portion of the base

frame, and an upper end to which the distal end of the first support member is pivotally connected.

5. The device according to claim 2, wherein the vertical supporting structure is rectangular-shaped.

6. The device according to claim 1, wherein the base frame further comprises at least one crosspiece attached to the horizontal portion for stabilizing the contact between the base frame and the supporting surface.

7. The device according to claim 1, wherein each support member of the pivoted structure comprises:

- a pivot arm;
- at least one bar attached to the pivot arm for defining a planar surface; and
- a cushion disposed on the planar surface for supporting the limb.

8. The device according to claim 1, wherein the adjustment means comprises:
a plurality of sockets carved on the arc portion of the base frame; and
a pin extended from the distal end of the second support member;
wherein the distal end of the pin is operable to sit in any of the sockets so as to adjust the pivot angle between the first and second support members.

9. The device according to claim 7, wherein the pin is T-shaped

10. The device according to claim 7, wherein the pin is rod-shaped.

11. The device according to claim 1, wherein the adjustment means comprises:
a groove carved along the arc portion of the base frame;
a pin extended from the distal end of the second support member, the pin having the distal end disposed and restrained in the groove and operable to slide therein; and

an extendable/retractable structure disposed and linking between the base frame and the second support member;

wherein the longitudinal length of the extendable/retractable structure is adjustable, so as to adjust the pivot angle between the first and second support members.

12. The device according to claim 11, wherein the extendable/retractable structure has a first and a second end pivotally connected to the horizontal portion of the base frame and the second support member respectively.

13. The device according to claim 11, wherein the extendable/retractable structure is operable to extend/retract by a telescopic mechanism built therein.

14. The apparatus of claim 13, wherein the extendable/retractable structure comprises:

a hollow housing having internal threads; and

a shaft extending into the hollow housing and having external threads for engaging the internal threads thereof;

wherein rotation of either the shaft or the housing is operable to cause longitudinal movement of the shaft within the housing, so as to adjust the longitudinal length of the extendable/retractable structure.

15. The device according to claims 14, wherein the extendable/retractable structure further comprises:

a motorization unit for driving the rotation of either the shaft or the housing; and

a coupling means for transferring rotary motion generated by the motorization unit to either the shaft or the housing;

16. The device according to claim 15, wherein the motorization unit comprises:

a power;

a motor electronically connected with the power; and

a controller for controlling speed and rotation direction of the motor.

17. The device according to claim 16, wherein the controller is a fuzzy control system.
18. The device according to claim 16, wherein the controller is an analogue control system.
19. The device according to claim 16, wherein the controller is a digital control system.
20. The device according to claim 15, wherein the coupling means is a set of bevel gears.
21. The device according to claim 15, wherein the coupling means is worm gears.
22. The device according to any one of claims 8-21, wherein the longitudinal length of the pin is adjustable by a telescopic mechanism built therein.
23. The device according to any one of the preceding claims, wherein the longitudinal lengths of the second support member and the horizontal portion of the base frame are adjustable by telescopic mechanisms built therein, so as to support limbs of various lengths.
24. The device according to claim 22 or 23, wherein the telescopic mechanism comprises:
 - a receiving member having a lock aperture;
 - an extending member slidably positioned in the receiving member, and having a plurality of lock apertures along the longitudinal axis alignable with the lock aperture in the receiving member; and
 - a locking pin operable to be inserted through a pair of the aligned lock apertures so as to lock relative movement of extending member to the receiving member.

25. The device according to any of the preceding claims, which further comprises a detachable holder.
26. The device according to claim 25, wherein the detachable holder comprises:
a post detachably connected to the base frame; and
a vertical frame pivotally attached to the post.
27. The device according claim 26, wherein the vertical frame is operable to be moved along or parallel to the longitudinal axis of the post.
28. The device according to claim 26 or 27, wherein the vertical frame is operable to hold a X-ray film cassette.