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DISTRACTION FRAME FOR EFFECTING HIP DISTRACTION

Abstract

A distraction frame includes a table mount for removably mounting the distraction frame to a surgical table; at least one horizontal strut mounted to the table mount; at least one vertical strut mounted to the at least one horizontal strut; and at least one distractor mounted to the at least one vertical strut, wherein the at least one distractor is configured for connection to a limb of a patient and for applying a distraction force to the limb of the patient; wherein the table mount comprises at least one wheel for selectively supporting the table mount above the floor and the at least one horizontal strut comprises at least one caster for selectively rollably supporting the at least one horizontal strut on the floor so that the distraction frame can be selectively moved to the surgical table supported by the at least one wheel and the at least one caster.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a divisional of U.S. patent application Ser. No. 18/158,446, filed Jan. 23, 2023, which is a divisional of U.S. patent application Ser. No. 15/890,124, filed Feb. 6, 2018, now U.S. Pat. No. 11,559,455, which claims the benefit of U.S. Provisional Application No. 62/455,238, filed Feb. 6, 2017, and U.S. Provisional Application No. 62/546,686, filed Aug. 17, 2017, the entire contents of each are hereby incorporated herein by reference.

FIELD OF THE INVENTION

[0002] This invention relates to medical apparatus in general, and more particularly to medical apparatus for effecting hip distraction.

BACKGROUND OF THE INVENTION

[0003] When performing surgical procedures on the hip joint, it is common to distract the hip joint prior to the surgery in order to provide additional room within the hip joint during the surgery and in order to better present selected anatomy to the surgeon. This hip distraction is commonly achieved by applying a distraction force to the distal end of the leg of the patient. Currently, a surgical boot is placed on the foot and lower leg of the patient, the surgical boot is connected to a distraction frame, and then the distraction frame is used to apply a distraction force to the surgical boot, whereby to apply a distraction force to the leg of the patient, whereby to distract and position the hip joint.

[0004] The present invention is intended to provide a new and improved distraction frame for applying a distraction force to the leg of the patient so as to effect hip distraction and to allow for leg positioning.

SUMMARY OF THE INVENTION

[0005] The present invention provides a new and improved distraction frame for applying a distraction force to the leg of the patient so as to effect hip distraction and to allow for leg positioning.

[0006] In one form of the invention, there is provided a distraction frame for use with a surgical table, wherein the surgical table comprises a base for positioning on a floor, the distraction frame comprising a table mount for fixation to the base of the surgical table; at least one horizontal strut mounted to the table mount; at least one vertical strut mounted to the at least one horizontal strut; and at least one distraction mechanism mounted to the at least one vertical strut, wherein the at least one distraction mechanism is configured for connection to a limb of a patient and for applying a distraction force to the limb of the patient; wherein the table mount is configured to transfer to the

floor a force moment imposed on the table mount when the at least one distraction mechanism applies a distraction force to a limb of a patient.
[0007] In another form of the invention, there is provided a method for distracting a limb of a patient, the method comprising: providing a distraction frame for use with a surgical table, wherein the surgical table comprises a base for positioning on a floor, the distraction frame comprising: a table mount for fixation to the base of the surgical table; at least one horizontal strut mounted to the table mount; at least one vertical strut mounted to the at least one horizontal strut; and at least one distraction mechanism mounted to the at least one vertical strut, wherein the at least one distraction mechanism is configured for connection to a limb of a patient and for applying a distraction force to the limb of the patient; wherein the table mount is configured to transfer to the floor a force moment imposed on the table mount when the at least one distraction mechanism applies a distraction force to a limb of a patient; positioning the patient on the surgical table; connecting the limb of the patient to the at least one distraction mechanism; and applying a distraction force to the limb of the patient using the at least one distraction mechanism.
[0008] In another form of the invention, there is provided a distraction frame comprising: a table mount for fixation to a surgical table; at least one horizontal strut mounted to the table mount; at least one vertical strut mounted to the at least one horizontal strut; and at least one distraction mechanism mounted to the at least one vertical strut, wherein the at least one distraction mechanism is configured for connection to a limb of a patient and for applying a distraction force to the limb of the patient; wherein the table mount comprises a surface for selectively contacting the floor, and further wherein the table mount comprises at least one wheel for selectively supporting the surface of the table mount above the floor; and wherein the at least one horizontal strut comprises at least one caster for selectively rollably supporting the at least one horizontal strut on the floor, and further wherein the table mount comprises at least one foot peg for selectively supporting the at least one caster above the floor; such that (i) the distraction frame can be moved to the surgical table supported by the at least one wheel and the at least one caster, and (ii) the distraction frame can be fixed adjacent to the surgical table supported by the surface of the table mount and the at least one foot peg.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0009] These and other objects and features of the present invention will be more fully disclosed or rendered obvious by the following detailed description of the preferred embodiments of the invention, which is to be considered together with the accompanying drawings wherein like numbers refer to like parts, and further wherein:
[0010] FIGS. **1** and **2** are schematic views showing a novel distraction frame formed in accordance with the present invention;
[0011] FIGS. **3**-**14** are schematic views showing details of the table mount of the novel distraction frame shown in FIGS. **1** and **2**;
[0012] FIG. **14**A is a schematic view showing how a distraction force applied to the leg of a patient creates a force moment at the table mount which is transferred to the operating room floor;
[0013] FIG. **14**B is a schematic view showing a foot pedal mechanism which may be used in place of the adjustable supports of the table mount shown in FIGS. **3**-**14**;
[0014] FIGS. **15**, **15**A-**15**C, **16**-**21**, **21**A-**21**C and **22**-**27** are schematic views showing details of the adjustable horizontal struts, the adjustable vertical struts, and elements attached to these struts, of the novel distraction frame shown in FIGS. **1** and **2**;
[0015] FIGS. **28**, **29**, **29**A-**29**C and **30**-**33** are schematic views showing further details of the adjustable vertical struts (and elements attached to these struts) of the novel distraction frame

shown in FIGS. **1** and **2**;
[0016] FIGS. **34** and **35** are schematic views showing how the novel distraction frame of FIGS. **1** and **2** can be positioned in transport mode for movement about a facility;
[0017] FIG. **36** is a schematic view showing how table tilt can be used to influence distraction after a patient's leg has been secured to a distraction frame; and
[0018] FIG. **37** is a schematic view showing another novel distraction frame formed in accordance with the present invention, wherein the distraction frame comprises a leg rest for supporting the non-operative leg of a patient.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The New and Improved Distraction Frame in General

[0019] The present invention provides a new and improved distraction frame for applying a distraction force to the leg of a patient so as to effect hip distraction.
[0020] More particularly, and looking first at FIGS. **1** and **2**, there is shown a novel distraction frame **5** formed in accordance with the present invention. Also shown in FIG. **1** is (i) a surgical table **10** for supporting a patient during surgery, wherein surgical table **10** comprises a base **15**, and (ii) a pair of surgical boots **20** for disposition on the feet and lower legs of the patient. Surgical table **10** may be of the sort well known in the art. Surgical boots **20** may be the novel surgical boots shown in the aforementioned FIGS. **1** and **2** and described and illustrated in detail in co-pending U.S. Patent Application Ser. No. 62/455,154 (Attorney's Docket No. FIAN-118 PROV), 62/546,629 (Attorney's Docket No. FIAN-124 PROV), and Ser. No. 15/889,998 (Attorney's Docket No. FIAN-118124), and/or surgical boots **20** may be conventional surgical boots of the sort well known in the art.
[0021] If desired, surgical table **10** may also comprise a novel table extender **23** which is configured to be mounted to the foot of surgical table **10**, whereby to provide additional support for the patient during a surgical procedure. Novel table extender **23** is preferably substantially radiolucent, so that X-ray imaging can be conducted on anatomy supported by novel table extender **23**. Novel table extender **23** is described and illustrated in detail in co-pending U.S. Patent Application Ser. No. 62/455,143 (Attorney's Docket No. FIAN-122 PROV), 62/546,600 (Attorney's Docket No. FIAN-125 PROV) and Ser. No. 15/890,047 (Attorney's Docket No. FIAN-122125). If desired, table extender **23** may comprise a distraction post **24**, which is the traditional means for facilitating hip distraction (e.g., by providing counter-traction to stabilize the patient on the surgical table and by levering the upper end of the leg of the patient against the distraction post so as to dislocate the femoral head from the acetabular cup). Such distraction posts are well known in the art of hip distraction.
[0022] Distraction frame **5** generally comprises a table mount **25**, a pair of adjustable horizontal struts **30** and a pair of adjustable vertical struts **35**.

Table Mount **25**

[0023] Table mount **25** (FIGS. **1**-**14**) generally comprises a body **40** and an extension assembly **43**.
[0024] Body **40** generally comprises a vertical surface **45**, a horizontal surface **50** and a recess **53**.
[0025] Vertical surface **45** of body **40** is intended to sit adjacent to, but slightly spaced from, base **15** of surgical table **10**. Alternatively, vertical surface **45** of body **40** may be in contact with base **15** of surgical table **10**. Or, alternatively, vertical surface **45** of body **40** may be set a distance off base **15** of surgical table **10**. Note that the ability to space vertical surface **45** of body **40** from base **15** of surgical table **10** can be advantageous, since it allows distraction frame **5** to work with a wide range of surgical tables.
[0026] Horizontal surface **50** of body **40** is intended to engage the operating room floor during hip distraction.
[0027] Recess **53** is intended to receive a retractable wheel assembly **205**, wherein retractable wheel assembly **205** is configured for selectively (i) projecting out of recess **53** so as to engage the floor and movably support body **40** of table mount **25** above the floor, such that distraction frame **5**

may be moved about a facility (for example, to move distraction frame **5** to another operating room or to a storage area), and (ii) retracting into recess **53** so as to disengage from the operating room floor and lower horizontal surface **50** of body **40** onto the operating room floor so as to prevent movement of distraction frame **5** (e.g., during a surgery).

[0028] In one preferred form of the invention, and looking now at FIGS. **1**-**12**, retractable wheel assembly **205** generally comprises a mount **210** for mounting to body **40** of table mount **25** (FIGS. **6** and **8**), and a base **215** movably mounted to mount **210**. A spring **220** spring biases base **215** upward into the interior of mount **210**. An axle **225**, supporting wheels **230**, passes through base **215**. As a result of this construction, when base **215** moves upward and downward relative to mount **210**, wheels **230** move upward and downward relative to body **40** of table mount **25**.

[0029] An actuation lever **235**, together with a linkage **240** and a bar **245**, cooperate with a recess **250** (FIG. **11**) on mount **210**, such that stepping down on actuation lever **235** forces wheels **230** downward, whereby to engage the floor and raise up body **40** (and hence table mount **25**) off of the floor, with bar **245** slipping into recess **250** so as to lock wheels **230** in their "down" position. Note that in this "down" position, table mount **25** is supported on wheels **230** such that distraction frame **5** may be moved about on a floor. A release lever **255**, also connected to linkage **240** (FIG. **10**), is provided for retracting wheels **230**, i.e., by stepping down on release lever **255**, linkage **240** moves bar **245** out of recess **250**, thereby allowing wheels **230** to retract upwards off of the floor, and hence allowing body **40** to settle onto the floor (i.e., with horizontal surface **50** of body **40** engaging the floor).

[0030] Note that when wheels **230** are in their "retracted" position (FIG. **6**), the arm **257** (FIG. **12**) of actuation lever **235** and linkage **240** project "off-center" towards bar **245** (FIG. **7**), and when wheels **230** are in their "down" position, with bar **245** slipped into recess **250**, arm **257** of actuation lever **235** and linkage **240** project "off-center" away from bar **245** (FIG. **10**). Note also that when release lever **255** is to be used for retracting wheels **230**, release lever **255** essentially moves linkage **240** "over center", from its "off-center" position away from bar **245** (FIG. **10**) towards its "off-center" position towards bar **245** (FIG. **7**). Once release lever **255** moves linkage **240** "over center", the weight of the structure(s) being supported by wheels **230** (e.g., the weight of distraction frame **5**) provides the major force for retracting wheels **230** into recess **53**.

[0031] It will be appreciated that, in view of the foregoing construction, (i) stepping down on actuation lever **235** locks wheels **230** in their "down" position, so that table mount **25** is movably supported on wheels **230**, and (ii) stepping down on release lever **255** retracts wheels **230** into recess **53** of body **40**, whereby to allow horizontal surface **50** of body **40** to seat on the operating room floor.

[0032] In an alternative embodiment, retractable wheel assembly **205** may comprise a single-pedal mechanism of the sort well known in the art of material transport, with the single-pedal mechanism alternately moving wheels **230** between their upward and downward positions.

[0033] Recess **53** also serves to receive the proximal ends of adjustable horizontal struts **30** as will hereinafter be discussed.

[0034] Extension assembly **43** (FIGS. **3**, **6**, **8**, **13** and **14**) comprises a mount **54** which is mounted to body **40**, and a pair of L-shaped extensions **55** which extend away from mount **54** (and which extend away from body **40**). L-shaped extensions **55** are intended to extend on either side of base **15** of surgical table **10**. Thus, L-shaped extensions **55** essentially constitute "outriggers" which extend on either side of base **15** of surgical table **10**. Mount **54** (and hence L-shaped extensions **55**) is secured to body **40**. L-shaped extensions **55** are adjustably secured to mount **54** with clamps **57** (FIG. **3**), i.e., so that L-shaped extensions **55** are laterally adjustably securable relative to mount **54** (and hence body **40**). Thus, the laterally-adjustable L-shaped extensions **55** essentially constitute laterally-adjustable outriggers which extend on either side of base **15** of surgical table **10**. Note that laterally adjustably securing L-shaped extensions **55** to mount **54** is advantageous, since it allows distraction frame **5** to accommodate different widths of bases **15** of surgical tables **10**, i.e., by

allowing the outriggers (i.e., L-shaped extensions **55**) to be laterally adjusted so as to straddle bases **15** of different widths. Although clamps **57** are shown in the figures as extending with a vertical orientation, clamps **57** could also be mounted to the side of mount **54** so that they extend with a horizontal orientation.

[0035] A pair of L-shaped brackets **60** are slidably mounted to L-shaped extensions **55** and extend under base **15** of surgical table **10** so that the lower ends of L-shaped brackets **60** may be captured beneath table feet **62** (FIGS. **13** and **14**) of surgical table **10** (surgical tables **10** typically comprise rollers and retractable/extendable table feet, with the table feet being retracted so that the surgical tables are able to move on their rollers when the surgical tables are to be moved about a floor, and with the table feet being extended when the surgical tables are to be fixed in position on a floor). More particularly, L-shaped brackets **60** are slidable along extensions **55** so that L-shaped brackets **60** may be positioned beneath table feet **62** when the table feet are in their retracted position, and L-shaped brackets **60** each comprise a latch **63** for locking L-shaped brackets **60** in position along L-shaped extensions **55** (FIGS. **13** and **14**) when L-shaped brackets **60** are to be captured under the table feet when the table feet are extended to the floor. Positioning L-shaped brackets **60** under table feet **62** of surgical table **10** effectively holds distraction frame **5** in a fixed position relative to surgical table **10** by using the weight of surgical table **10** on L-shaped brackets **60**. Thus, with the present invention, distraction frame **5** does not need to be bolted to, or clamped to, surgical table **10** in order to effectively hold distraction frame **5** in a fixed position relative to surgical table **10**. This is a substantial advantage over prior art distraction frames.

[0036] Alternative constructions can include L-shaped extensions **55** of different lengths or of different cross-sectional shapes and sizes. L-shaped brackets **60** may be similarly varied in construction, for instance, they may not necessarily be positioned under table feet **62** of base **15** of surgical table **10**, but may engage elsewhere under base **15** of surgical table **10** so as to achieve the same engagement between the floor, L-shaped extensions **55** and base **15** of surgical table **10** (i.e., with L-shaped extensions **55** being captured to the floor by base **15** of surgical table **10**). By way of example but not limitation, L-shaped brackets **60** may be captured beneath another portion of base **15** of surgical table **10**. Note that L-shaped brackets **60** may also have a height adjustment feature so that the vertical distance between (i) the portion of the L-shaped bracket which is mounted to the L-shaped extensions **55**, and (ii) the portion of the L-shaped bracket which mounts to the surgical table **10**, can be varied. This feature can accommodate uneven floors where the distance between each of the L-shaped extensions **55** and the floor may vary.

[0037] A pair of adjustable supports **65** (FIG. **14**) are mounted to L-shaped extensions **55** and also engage the floor upon which surgical table **10** sits. Adjustable supports **65** are preferably positioned at the ends of L-shaped extensions **55** which are opposite to body **40**, however, adjustable supports **65** may alternatively be located anywhere along the length of L-shaped extensions **55**, possibly with the overall length of L-shaped extensions **55** varying. Adjustable supports **65** preferably comprise a threaded engagement with L-shaped extensions **55**, and preferably further comprise a locking nut **66** (FIG. **14**) to lock adjustable supports **65** relative to L-shaped extensions **55** once adjustable supports **65** are in their desired positions.

[0038] It will be appreciated that, on account of the foregoing construction, when table mount **25** of distraction frame **5** is mounted to base **15** of surgical table **10** (e.g., by way of L-shaped brackets **60** being captured under table feet **62** of base **15** of surgical table **10**, and by adjustable supports **65** being positioned securely against the floor), and distraction frame **5** is thereafter used to apply a distraction force to the leg of a patient (e.g., via adjustable horizontal struts **30**, adjustable vertical struts **35**, etc.), any force moment produced at table mount **25** will be to transferred to the operating room floor via L-shaped extensions **55** and adjustable supports **65**, and via L-shaped extensions **55** and L-shaped brackets **60**. See, for example, FIG. **14**A, which shows how a distraction force **400** applied to the leg of a patient creates a force moment **405** at table mount **25** which is transferred to the operating room floor as a force **410** via L-shaped extension **55** and adjustable supports **65**, and

as a force **415** via L-shaped extensions **55** and L-shaped brackets **60**. This is highly advantageous since the force moments are transferred to the operating room floor and are not imposed on any mechanical connections between the distraction frame and the surgical table. Indeed, as noted above, the construction of the distraction frame of the present invention does not need to create a mechanical connection with the surgical table, the distraction frame of the present invention simply has its L-shaped brackets **60** clamped beneath table feet **62** of surgical table **10**.

[0039] Note that modifications to the materials of construction, or to the configuration of the design elements (e.g., L-shaped brackets **60**, adjustable supports **65**, etc.) may be made to alter the stiffness and performance of distraction frame **5** while still maintaining the same overall design to transfer the patient distraction forces to the floor of the operating room. For example, although adjustable supports **65** are generally shown in the figures as having a threaded adjustment, adjustable supports **65** could also be actuated (e.g., raised and lowered, and locked in place) with a foot pedal mechanism (see, for example, the foot pedal mechanism **67** shown in FIG. **14**B). In this alternative construction, foot pedal mechanism **67** may comprise a mechanism generally similar to the retractable foot pegs **97** discussed below.

Adjustable Horizontal Struts **30**

[0040] Each of the adjustable horizontal struts **30** (FIGS. **1-6**, **8**, **14**, **15**, **15**A-**15**C, **16-21**, **21**A-**21**C and **22-27**) comprises a proximal portion **75** and a distal portion **80**. Proximal portions **75** and distal portions **80** telescope relative to one another. A locking screw **85** (FIG. **15**) is provided to lock proximal portions **75** and distal portions **80** in position relative to one another. If desired, proximal portions **75** and distal portions **80** can be limited to discrete telescoping positions (e.g., to 3 discrete telescoping positions) or proximal portions **75** and distal portions **80** can be continuously telescopically variable relative to one another. In one preferred form of the invention, and looking now at FIGS. **15**A-**15**C, rollers **87** are mounted to proximal portions **75** of adjustable horizontal struts **30** and roll against the inside surfaces of distal portions **80**. This provides low friction movement as proximal portions **75** telescope relative to distal portions **80**.

[0041] Adjustable horizontal struts **30** are pivotally mounted to body **40** of table mount **25**. More particularly, proximal portions **75** of adjustable horizontal struts **30** are mounted to body **40** of table mount **25** with pivot mounts **90** (FIG. **5**). Pivot mounts **90** allow proximal portions **75** of adjustable horizontal struts **30** to be adjusted to the desired angular dispositions relative to body **40** of table mount **25**.

[0042] Adjustable horizontal struts **30** are detachable from body **40** of table mount **25** with locking pins **92** (FIG. **5**). When locking pins **92** are raised, adjustable horizontal struts **30** can be detached from body **40** of table mount **25**, providing the ability to disassemble distraction frame **5** so as to allow, for example, easier transport of distraction frame **5** to another location. In an alternative construction, adjustable horizontal struts **30** may be permanently attached to body **40** of table mount **25**.

[0043] Adjustable horizontal struts **30** comprise castors **95** which are disposed at the distal ends of distal portions **80** of adjustable horizontal struts **30**. Distal portions **80** of adjustable horizontal struts **30** also comprise retractable foot pegs **97**. When retractable foot pegs **97** are in their retracted positions (FIGS. **16** and **17**), the distal ends of distal portions **80** of adjustable horizontal struts **30** are supported on castors **95** such that the distal ends of distal portions **80** of adjustable horizontal struts **30** may roll relative to the floor. When retractable foot pegs **97** are in their extended positions (FIGS. **20** and **21**), the distal ends of distal portions **80** of adjustable horizontal struts **30** are supported on retractable foot pegs **97** such that the distal ends of distal portions **80** of adjustable horizontal struts **30** may not roll relative to the floor.

[0044] In one preferred form of the invention, and looking now at FIGS. **16-21** and **21**A-**21**C, retractable foot pegs **97** may comprise a shaft **300** which is movably mounted to a housing assembly **305** (which is, in turn, mounted to distal portion **80** of adjustable horizontal strut **30**). One end of shaft **300** comprises a foot **310** for selectively engaging the floor. The other end of shaft **300**

comprises a pedal **315** for selective engagement by the foot of a user. A spring **317** (FIG. **21**B) biases shaft **300** upward, so that foot **310** is normally withdrawn from the floor.

[0045] Shaft **300** also comprises a track **320**, and housing assembly **305** also comprises a finger **325** which rides in track **320**. One end of finger **325** is pivotably mounted to housing assembly **305** while the other end of finger **325** comprises a projection **327** (FIG. **21**A) which rides in track **320**. Track **320** and finger **325** are configured so that when a user steps on pedal **315**, driving foot **310** downward, finger **325** rides upward in a portion **328** (FIG. **21**) of track **320** until finger **325** hits a peak **330** (FIG. **17**) in track **320**. When the user thereafter steps off of pedal **315**, finger **325** settles into a recess **335** (FIG. **17**) formed in track **320**, whereby to lock foot **310** in its extended position (FIGS. **19** and **20**), with distal portion **80** of adjustable horizontal strut **30** supported on retractable foot peg **97** (i.e., with castors **95** not in contact with the floor). When the user thereafter steps on pedal **315** again, finger **325** rides out of recess **335** and down a portion **338** (FIG. **17**) of track **320** until finger **325** settles into a well **340** (FIG. **17**), whereby to lock foot **310** in its retracted position (FIGS. **16** and **17**), with distal portion **80** of adjustable horizontal strut **30** supported on castor **95**. In this way, pedals **315** may be used to cycle retractable foot pegs **97** between their extended and retracted positions.

[0046] In one preferred form of the invention, shaft **300** comprises a gas shock assembly **345** (FIG. **21**A) so that foot **310** can adjustably contact the floor. More particularly, in this form of the invention, gas shock assembly **345** comprises a rod **350** (FIG. **21**A) which is secured to pedal **315**, and a cylinder **355** (FIG. **21**A) which is movably mounted to rod **350**. Foot **310** is secured to cylinder **355**. As a result of this construction, the separation between pedal **315** and foot **310** can adjust to some extent as needed, e.g., when distraction frame **5** is applying a distraction force to the leg of the patient, distal portion **80** of adjustable horizontal strut **30** can tend to lift upward relative to the floor, and gas shock assembly **345** can act to keep foot **310** firmly engaging the floor, with a certain minimum amount of force (which can be varied by adjusting the gas shock force and overall travel).

[0047] Adjustable horizontal struts **30** also comprise bearing rails **99** (FIGS. **15**, **15**A-**15**C, **16**, **20** and **22**-**27**) and gear racks **100** disposed on distal portions **80** of adjustable horizontal struts **30**. Bearing rails **99** and gear racks **100** serve as a means to selectively lock adjustable vertical struts **35** at a specific location along distal portions **80** of adjustable horizontal struts **30** as will hereinafter be discussed.

Adjustable Vertical Struts **35**

[0048] Each of the adjustable vertical struts **35** (FIGS. **1**, **2**, **16**, **20**, **22**-**29**, **29**A-**29**C and **30**-**33**) comprises a lower portion **105** (FIG. **2**), an intermediate portion **107**, and an upper portion **110**. Lower portions **105** comprise mounts **115** (FIG. **22**) for adjustably securing adjustable vertical struts **35** to bearing rails **99** and gear racks **100** disposed on distal portions **80** of adjustable horizontal struts **30**. Lock/release mechanisms **120** (FIG. **24**) are provided for locking/releasing adjustable vertical struts **35** at particular dispositions along bearing rails **99** and gear racks **100** disposed on distal portions **80** of adjustable horizontal struts **30**. Note that the lock/release mechanisms **120** are normally “locked” when in their “default” condition, such that mounts **115** and gear racks **100** prevent unintentional travel of adjustable vertical struts **35** along adjustable horizontal struts **30**, e.g., such as when performing a hip distraction.

[0049] In one preferred form of the invention, mounts **115** comprise bearings **121** (FIG. **22**) which roll along bearing rails **99**, allowing adjustable vertical struts **35** to travel along the length of distal portions **80** of adjustable horizontal struts **30**. This is for the purpose of allowing the user to adjust the positions of adjustable vertical struts **35** on distal portions **80** of adjustable horizontal struts **30** in order to provide different configurations for the distraction frame during a hip arthroscopy procedure (e.g., to flex or extend the leg of a patient).

[0050] Lock/release mechanisms **120** are used to lock (or release) adjustable vertical struts **35** to (or from) adjustable horizontal struts **30**. More particularly, lock/release mechanisms **120** each

comprise a control **122** (FIGS. **24** and **25**) which is used to engage/disengage a gear lock **123** (which is housed in mount **115**) to/from gear rack **100**. Control **122** may be disposed within a handle **124**. In one embodiment, when control **122** (e.g., a trigger) is activated, a cable **125** (FIG. **25**) is pulled which disengages gear lock **123** from gear rack **100** (e.g., by pivoting a lever **126** which pivots gear lock **123** away from gear rack **100**). A spring (not shown) returns gear lock **123** back to its engaged state when control **122** (e.g., a trigger) is released, i.e., when lock/release mechanism **120** is in its "default" condition.

[0051] Upper portions **110**, intermediate portions **107** and lower portions **105** telescope relative to one another. Locking screws **127** (FIGS. **28** and **29**) are provided to lock upper portions **110** relative to intermediate portions **107**. If desired, upper portions **110** and intermediate portions **107** can be limited to discrete telescoping positions (e.g., to 5 discrete telescoping positions) or upper portions **110** and intermediate portions **107** can be continuously telescopically variable relative to one another. Handles **130** may be provided for lifting or lowering upper portions **110** and intermediate portions **107** of adjustable vertical struts **35** relative to lower portions **105** of adjustable vertical struts **35**. In one preferred form of the invention, and looking now at FIGS. **29**A-**29**C, rollers **128** are mounted to intermediate portions **107** and roll along the inner surfaces of lower portions **105**. This provides low friction movement as intermediate portions **107** telescope relative to lower portions **105**.

[0052] In one form of the invention, gas shocks **132** (FIG. **26**) may be provided within the bodies of lower portions **105** of adjustable vertical struts **35** to help carry the loads of upper portions **110** and intermediate portions **107** of adjustable vertical struts **35** (and any loads carried thereby, e.g., the leg of a patient). In one embodiment, gas shocks **132** are housed within inner lumens of vertical struts **35**, with one end of gas shocks **132** being mounted to mount **115** and the other end of gas shocks **132** being mounted to intermediate portions **107**. However, it should be appreciated that gas shocks **132** may be used across all three portions of adjustable vertical struts **35** (i.e., lower portions **105**, intermediate portions **107** and upper portions **110**), or between a pair of portions **105**/**107**/**110**, preferably between lower portions **105** and intermediate portions **107**, but gas shocks **132** may also be used between upper portions **110** and intermediate portions **107**.

[0053] By way of example but not limitation, where gas shocks **132** are provided to assist in adjusting the dispositions of upper portions **110** and intermediate portions **107** of adjustable vertical struts **35**, gas shocks **132** are configured to apply an upward force on intermediate portions **107** of adjustable vertical struts **35** (and hence on upper portions **110**, which are connected to intermediate portions **107**), and gas shocks **132** include lock mechanisms **133** (FIGS. **26** and **27**) for locking gas shocks **132** in a particular disposition. A button **134** (FIGS. **26** and **27**) is depressed to disengage lock mechanism **133** such that gas shocks **132** are free to apply an upward force to upper portions **110** and intermediate portions **107** of adjustable vertical struts **35** (and any loads carried thereby) relative to lower portion **105** of adjustable vertical struts **35**. More particularly, the depression of button **134** pushes a rod **134**A (FIGS. **26** and **27**), which then pivots a wheel **134**B, which then pulls cable **134**C, which then lifts one end of a finger **135**, whereby to force the other end of finger **135** to depress lock mechanism **133**. When button **134** is released, a spring (not shown) biases the foregoing elements in the opposite direction so as to release lock mechanism **133**.

[0054] In lieu of a gas shock, alternative constructions may include springs or counter-weight systems to balance the loads carried by adjustable vertical struts **35**.

[0055] Hinge joints **137** (FIGS. **1**, **2** and **30-33**) are disposed at the upper ends of upper portions **110** of adjustable vertical struts **35**. Distraction mechanisms **140** are mounted at the top ends of upper portions **110** of adjustable vertical struts **35** via hinge joints **137**. Universal joints **145** are disposed at the ends of distraction mechanisms **140**. Mounts **150** are configured to releasably engage surgical boots **20**, such that surgical boots **20** can be releasably secured to distraction mechanisms **140** (and hence to distraction frame **5**). Levers **155**, disposed at the opposing ends of distraction mechanisms **140**, are used by the user to operate distraction mechanisms **140**. More

particularly, the user rotates lever **155** which, in turn, advances or retracts mount **150**, and hence advances or retracts surgical boot **20**. Distraction mechanisms **140** are of the sort well known in the art and generally comprise a mechanism which provides a significant mechanical advantage for the user. With this mechanical advantage, the user can apply a significant amount of distraction force to the leg of the patient. In one form of the invention, distraction mechanisms **140** comprise a force gauge **157** (FIGS. **30**-**33**) which indicates the actual force being applied by distraction mechanisms **140** to the leg of a patient. The user can, for example, minimize potential injury to the patient if the force does not exceed a certain threshold. Force gauge **157** may be mechanical (e.g., a simple "fish scale" device with lines and numbers) or electronic (e.g., with a digital readout).

[0056] In one preferred form of the invention, the various components of distraction frame **5** are constructed so that distraction frame **5** can be "collapsed" into a compacted form, e.g., with adjustable horizontal struts **30** being telescoped into a reduced length and with adjustable vertical struts **35** being telescoped into a reduced length; and with adjustable vertical struts **35** being disposed parallel to adjustable horizontal struts **30**; and with distraction mechanisms **140** being disposed parallel to adjustable vertical struts **35** and adjustable horizontal struts **30**; and with L-shaped extensions **55** being inverted so that L-shaped brackets **60** and adjustable supports **65** face upward and with L-shaped extensions **55** being reversed relative to body **40** of table mount **25** so that L-shaped extensions **55** are set back over adjustable horizontal struts **30**. In addition, wheels **230** of table mount **25** are in their "down" position, and retractable foot pegs **97** of adjustable horizontal struts **30** are in their "up" position so that adjustable horizontal struts **30** rest on castors **95**, such that distraction frame **5** rides on wheels **230** and castors **95**. See FIGS. **34** and **35**. In this configuration, distraction frame **5** can be transported to another operating room or other location in the hospital (e.g., a storage location). Effectively, in this configuration, distraction frame **5** does not require a separate piece of equipment for mobility (e.g., a tote, a dolly, etc.). This provides significant convenience for the hospital staff.

Use Of Distraction Frame **5**

[0057] Distraction frame **5** is preferably used as follows.

[0058] First, distraction frame **5** is assembled so that adjustable horizontal struts **30** are mounted to table mount **25**, adjustable vertical struts **35** are mounted to adjustable horizontal struts **30**, and distraction mechanisms **140** are mounted to upper portions **110** of adjustable vertical struts **35** (if these components are not already mounted to one another). In addition, L-shaped extensions **55** are set so that L-shaped brackets **60** and adjustable supports **65** face downward, and L-shaped extensions **55** are attached to body **40** of table mount **25** so that L-shaped extensions **55** extend away from adjustable horizontal struts **30** (if these components are not already set in this position).

[0059] Then distraction frame **5** is wheeled up to surgical table **10** on wheels **230** of retractable wheel assembly **205** and castors **95** of adjustable horizontal struts **30**, and distraction frame **5** is assembled to surgical table **10** by mounting table mount **25** to base **15** of surgical table **10**, e.g., by setting L-shaped extensions **55** on both sides of base **15** of surgical table **10**, positioning L-shaped brackets **60** beneath table feet **62** of surgical table **10**, retracting wheels **230** of retractable wheel assembly **205** so that horizontal surface **50** of body **40** seats on the floor, and then lowering feet **62** of surgical table **10** onto L-shaped brackets **60**. Adjustable supports **65** are also adjusted as necessary to make secure contact to the floor.

[0060] Next, distraction frame **5** is approximately configured for the size of the patient, the size of the surgeon, and the procedure to be conducted. This is done by setting the angles of adjustable horizontal struts **30** relative to table mount **25** (and hence relative to surgical table **10**), setting the lengths of adjustable horizontal struts **30**, setting the dispositions of adjustable vertical struts **35** on adjustable horizontal struts **30**, and setting the heights of adjustable vertical struts **35**.

[0061] Then the patient's feet and legs are placed into, and secured to, surgical boots **20**. Surgical boots **20** are secured to distraction mechanisms **140** disposed at the top ends of upper portions **110**

of adjustable vertical struts **35**. Further adjustments may be made to distraction frame **5** as necessary.

[0062] Distraction may occur with the surgical table set in a horizontal position or in an inclined position (e.g., with the patient in the so-called Trendelenburg position). For purposes of example but not limitation, distraction will now be discussed in the context of the patient having their leg distracted while in the Trendelenberg position.

[0063] The patient is tilted on the surgical table to the Trendelenburg position. This is accomplished with the surgical table controls. Preferentially the amount of Trendelenburg angle is **15** degrees or less. To accommodate this change in patient position, distraction frame **5** may be adjusted again as needed. In particular, the height of adjustable vertical struts **35** might be increased to maintain the patient in a planar position (relative to the table top) or with a small amount of hip flexion; horizontal struts **30** may then be adjusted so as to minimize distraction forces applied to the hip. It is also beneficial that during the application and removal of the Trendelenburg angle, lock/release mechanism **120** of mount **115** is able to be maintained in an unlocked position. This allows for the change in angle relative to distraction frame **5** without putting undue stresses on the patient as the leg length changes relative to the horizontal plane of adjustable horizontal strut **30**.

[0064] Next, distraction frame **5** is more precisely configured to begin the procedure to be conducted. This is done by more precisely setting the angles of adjustable horizontal struts **30** relative to table mount **25** (and hence relative to surgical table **10**), more precisely setting the dispositions of adjustable vertical struts **35** on adjustable horizontal struts **30**, and more precisely setting the heights of adjustable vertical struts **35**, more precisely setting the length and angle of the distraction mechanisms **140**, and more precisely setting the angle of surgical boots **20**.

[0065] The patient's hip may then be distracted by the surgical team by unlocking lock/release mechanism **120** of mount **115** and pulling distally on adjustable vertical struts **35**, e.g., via handle **124**. From this starting position, at least 8 inches of travel along the horizontal struts **30** is provided for the surgical team to apply this pulling force to the patient. Then distraction mechanisms **140** (disposed at the top ends of upper portions **110** of adjustable vertical struts **35**) are adjusted as needed so as to apply the desired distraction force to the distal end of the patient's leg. From the starting position, at least 4 inches of additional travel is provided within distraction mechanism **140** to apply force to the patient's leg. Any combination of these applications of traction is envisioned, as needed for the patient's treatment.

[0066] Once the patient's hip is appropriately distracted, a surgical procedure may then be conducted on the distracted hip.

[0067] It should be appreciated that distraction frame **5** of the present invention provides the ability to attain more C-arm positions than prior art distraction frames. This is due to the fact that distraction frame **5** mounts to base **15** of surgical table **10** and not to the end of the surgical table. Therefore, the space immediately under table extender **23** and above table mount **25** and adjustable horizontal struts **30** is open and allows the C-arm X-ray machine to be manipulated with a high degree of freedom.

[0068] It should also be appreciated that distraction frame **5** of the present invention has 8 degrees of freedom: (1) gross traction extension/retraction (moving adjustable vertical struts **35** away from/toward the patient); (2) adduction/abduction of adjustable horizontal struts **30** pivoting about body **40**; (3) adjustable vertical struts **35** raising and lowering; (4) distraction mechanisms **140** (fine traction) pivoting on adjustable vertical struts **35**; (5) distraction mechanisms **140** (fine traction) retracting/advancing; and (6), (7) and (8) surgical boots **20** rotating and pivoting about universal joints **145**. The 8 degrees of freedom provided by distraction frame **5** are superior to the 3-5 degrees of freedom typically provided by the prior art, thereby providing the surgeon with the ability to position the patient's leg in a greater number of positions and orientations. This allows the surgeon to access anatomy that they could not previously be accessed with the distraction systems of the prior art.

[0069] The distraction frame of the present invention also allows for more deep flexion of the patient's hip due to the increased degrees of freedom provided by the distraction frame and due to the disassociation of the height of the distraction frame (where the patient's foot connects to the distraction frame) relative to the top of the surgical table. Because the patient's foot can be raised (by adjustment of the vertical struts) independently of the patient's horizontal position, additional flexion can be achieved by the distraction frame of the present invention.
[0070] In addition to the foregoing, it should also be appreciated that distraction frame **5** is able to accommodate a wide range of patient heights, i.e., from approximately 4′10″ to approximately 6′10″. This ability to accommodate a wide range of patient heights is due to the more numerous degrees of freedom combined with the adjustable nature of various components of distraction frame **5**, e.g., the adjustability of adjustable horizontal struts **30**.
[0071] Significantly, adjustable vertical struts **35** can be positioned away from surgical table **10**; this provides more space for the surgical staff to maneuver at the end of the table during surgical preparation, including while a patient is being transferred onto the surgical table.
[0072] It should also be appreciated that, in addition to manipulating distraction frame **5** to effect hip distraction, the surgical table may also be manipulated to effect hip distraction. More particularly, and looking now at FIG. **36**, the bed **160** of surgical table **10** can typically be moved up/down, moved cephalad/caudal, tilted head-to-toc, and tilted side-to-side. If a patient is positioned on bed **160** of surgical table **10** and the patient's feet are attached to distraction frame **5**, then movement of bed **160** of surgical table **10** in a cephalad direction will have the same effect as applying tension to the leg by means of turning levers **155** of distraction mechanisms **140** so as to move the foot in a caudal direction.
[0073] It should be appreciated that a patient can be in either a lateral decubitus position or a supine position on surgical table **10**. In a lateral decubitus position, the patient lays on their side on the surgical table with the non-operative leg supported by the table and the operative leg supported by distraction frame **5**. In the supine position, the operative leg is supported by distraction frame **5** and the non-operative leg would rest on surgical table **10** and table extender **23**. However, table extender **23** typically stops above the knee of the patient, so the non-operative leg has limited support.
[0074] To this end, in an alternative construction, one of adjustable vertical struts **35** may replace its hinge joint **137**, distraction mechanism **140**, universal joint **145**, mount **150**, force gauge **157** and lever **155** with a leg board **165** (FIG. **37**) which is mounted to one of the adjustable vertical struts. Since the non-operative leg sees no force during distraction and is typically not manipulated, the non-operative leg does not need to be secured to distraction frame **5** but can simply be supported by leg board **165**.
[0075] It should also be appreciated that distraction frame **5** may be used for orthopedic procedures other than hip arthroscopy, e.g., distraction frame **5** may be used for hip trauma, total hip replacement, etc.
Modifications Of The Preferred Embodiments
[0076] It should be understood that many additional changes in the details, materials, steps and arrangements of parts, which have been herein described and illustrated in order to explain the nature of the present invention, may be made by those skilled in the art while still remaining within the principles and scope of the invention.

Claims

1. A distraction frame comprising: a table mount for removably mounting the distraction frame to a surgical table; at least one horizontal strut mounted to the table mount; at least one vertical strut mounted to the at least one horizontal strut; and at least one distractor mounted to the at least one vertical strut, wherein the at least one distractor is configured for connection to a limb of a patient

and for applying a distraction force to the limb of the patient; wherein the table mount comprises at least one wheel for selectively supporting the table mount above a floor and the at least one horizontal strut comprises at least one caster for selectively rollably supporting the at least one horizontal strut on the floor so that the distraction frame can be selectively moved to the surgical table supported by the at least one wheel and the at least one caster, wherein the at least one wheel is configured to retract so that a surface of the table mount seats on the floor when the distraction frame is mounted to the surgical table.

2. (canceled)

3. The distraction frame of claim 1, wherein the at least one horizontal strut comprises at least one foot peg for selectively supporting the at least one caster above the floor.

4. The distraction frame of claim 3, wherein the distraction frame is configured to be selectively fixed adjacent to the surgical table supported by the surface of the table mount and the at least one foot peg.

5. The distraction frame of claim 3, wherein the at least one foot peg has an adjustable length.

6. The distraction frame of claim 3, wherein the at least one foot peg is retractable into a portion of the at least one horizontal strut such that the at least one foot peg is selectively engaged with the floor.

7. The distraction frame of claim 6, wherein the at least one horizontal strut comprises a pedal configured to translate the at least one foot peg between the portion of the at least one horizontal strut and the floor.

8. The distraction frame of claim 1, wherein the at least one wheel is retractable into a portion of the table mount.

9. The distraction frame of claim 8, wherein the table mount comprises one or more levers configured to translate the at least one wheel between the portion of the table mount and the floor for selectively moving the distraction frame.

10. The distraction frame of claim 1, wherein the at least one horizontal strut is pivotally mounted to the table mount.

11. The distraction frame of claim 1, wherein a length of the at least one horizontal strut is telescopically adjustable.

12. The distraction frame of claim 1, wherein the at least one horizontal strut comprises a gas cylinder to counterbalance at least a portion of the weight of the at least one horizontal strut and/or at least a portion of the weight carried by the at least one horizontal strut.

13. The distraction frame of claim 1, wherein the at least one vertical strut is movably mounted to the at least one horizontal strut.

14. The distraction frame of claim 1, wherein a length of the at least one vertical strut is telescopically adjustable.

15. The distraction frame of claim 1, wherein the at least one vertical strut comprises a gas cylinder to counterbalance at least a portion of the weight of the at least one vertical strut and/or at least a portion of the weight carried by the at least one vertical strut.

16. The distraction frame of claim 1, wherein the at least one distractor is hingeably mounted to an upper portion of the at least one vertical strut.

17. The distraction frame of claim 1, wherein the at least one distractor comprises at least one surgical boot configured to receive the limb of the patient.

18. The distraction frame of claim 1, wherein the table mount comprises a first portion positioned in front of a front of a base of the surgical table when the table mount is mounted to the surgical table and at least one second portion that extends along a side of the base, and the at least one second portion is configured to transfer directly to the floor a force moment imposed on the table mount when the at least one distractor applies the distraction force to the limb of the patient.

19. The distraction frame of claim 18, wherein the at least one second portion comprises at least one outrigger, wherein the at least one outrigger is adjustably secured to the first portion so as to be

laterally adjustable relative to the base of the surgical table.

20. The distraction frame of claim 19, wherein the at least one outrigger comprises at least one support for contacting the floor.

21. The distraction frame of claim 20, wherein the at least one support transfers directly to the floor the force moment imposed on the table mount when the at least one distractor applies the distraction force to the limb of the patient.