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ROD REDUCTION INSTRUMENT AND METHOD FOR SPINAL SURGERY

Abstract

Disclosed rod reduction systems include an elongated housing having a longitudinal bore and a transverse channel extending through the elongated housing at a non-zero degree angle relative to the longitudinal bore. An insert is slideable within the transverse channel between an outwardly displaced position and an inwardly biased position. The insert includes a threaded portion and a longitudinal bore alignable with the longitudinal bore of the elongated housing. A reducer is slidably receivable within the longitudinal bore of the elongated housing. The reducer may have a longitudinal bore therethrough, a drive shaft positioned within the longitudinal bore of the reducer.

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Background/Summary

BACKGROUND

[0001] The present disclosure relates to rod reduction systems and methods of use thereof.

[0002] Current rod reduction systems generally require users to apply a large amount of force to properly utilize the rod reduction systems. For example, many rod reduction systems incorporate threaded zones allowing components of the system to be screwed together. However, users are often required to use a large amount of twisting force to engage components of the system with each other. This can lead to user fatigue up and down the entire arm—from the shoulder, through the elbow, to the wrist and hand. During surgical procedures, which can be exhausting for other reasons (length of the surgery, area of the body being operated on, amount of equipment used, etc.), it is undesirable for clinicians to become further fatigued through the required twisting force. Additionally, the required twisting force may be "handed," meaning individuals may not simply be able to switch out which hand they are exerting the twisting force with.

SUMMARY

[0003] The present disclosure relates to rod reduction instrument systems and methods of use thereof, particularly for use in spinal surgery. In various aspects, a rod reduction system includes an elongated housing having a longitudinal bore therethrough and a transverse channel extending through the elongated housing that is not perpendicular relative to the longitudinal bore. The elongated housing may also include an insert slideable within the transverse channel. The insert may be slideable between an outwardly displaced position and an inwardly biased position. Additionally, the insert includes a longitudinal bore therethrough, alignable with the longitudinal bore of the elongated housing, and a threaded portion. The rod reduction system may further include a reducer slidably receivable within the longitudinal bore of the elongated housing. The reducer may include a proximal end having a driver, a distal end, and a shaft extending from the proximal end to the distal end, where the shaft has a threaded portion. The rod reduction system may include (i) a first, rapid reduction position where the reducer displaces the insert to the outwardly displaced position such that the threaded portion of the insert does not engage the threaded portion of the shaft of the reducer, and (ii) a second, engaged position where the threaded portion of the insert in the inwardly biased position engages the threaded portion of the shaft of the reducer.

[0004] According to another aspect, a rod reduction system includes an inner shaft having a distal tip end and a threaded portion, and an elongated housing having a longitudinal bore therethrough to slidably receive the inner shaft. The elongated housing additionally has a transverse slot extending through the elongated housing at a predetermined angle relative to the longitudinal bore. Further, the elongated housing includes an actuator slideable within the transverse slot between an outwardly displaced position and an inwardly biased position. The actuator includes a longitudinal bore therethrough alignable with the longitudinal bore of the elongated housing and a threaded portion. The rod reduction system has a first mode and a second mode. The first mode may be a rapid reduction mode where the shaft displaces the actuator to the outwardly displaced position such that the threaded portion of the actuator does not engage the threaded portion of the shaft, allowing the shaft to bypass the threaded portion of the actuator. The second mode may be a driving mode, where the actuator is in the inward biased position such that the threaded portion of the actuator engages the threaded portion of the shaft.

[0005] According to another aspect, a method of using a rod reduction system may include positioning an insert within an elongated housing such that a longitudinal bore of the insert is aligned with a longitudinal bore of the elongated housing. Additionally, the method may include inserting a shaft into a proximal end of the longitudinal bore of the elongated housing to a first position and engaging external threads of the shaft by an internally threaded portion of the insert in the first position. The method may further include pushing the shaft into the longitudinal bore to a second position such that the external threads of the shaft are disengaged by the internally threaded

portion of the insert. Still further, the method may include twisting the shaft to a third position within the longitudinal bore, the third position being different than the first position and the second position.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The embodiments set forth in the drawings are illustrative and exemplary in nature and not intended to limit the subject matter defined by the claims. The following detailed description of the illustrative embodiments can be better understood when read in conjunction with the following drawings wherein like structure is indicated with like reference numerals and in which:

[0007] FIG. **1** is an exploded perspective view of a first system having an elongated housing assembly and a reducer rod;

[0008] FIG. **2**A is a first close-up view of a proximal end of the reducer rod and a distal end of the elongated housing assembly;

[0009] FIG. **2**B is a second close-up view where the proximal end of the reducer rod is received within the distal end of the elongated housing;

[0010] FIG. **3**A illustrates a front view of the elongated housing and FIG. **3**B illustrates a partial side view of the elongated housing;

[0011] FIG. **4**A illustrates a side view of the elongated housing of FIG. **3**A and FIG. **4**B illustrates a cross-sectional view of FIG. **4**A;

[0012] FIG. **5**A illustrates a side view of an insert from the elongated housing assembly of FIG. **1** and FIG. **5**B illustrates a front side perspective view of the insert;

[0013] FIGS. **6**A and **6**B illustrate front top perspective views of the insert of FIGS. **5**A-**5**B;

[0014] FIG. **7**A illustrates a cross-sectional view of the insert of FIG. **5**A and FIG. **7**B illustrates a close-up view of a threaded portion of the insert;

[0015] FIG. **8** illustrates a cross-sectional view of the threaded shaft portion of the reducer rod within the insert and just before disengaging the threaded portion of the insert;

[0016] FIG. **9** illustrates a cross-sectional view of the threaded shaft portion of the reducer rod within the insert and just before fully disengaging the threaded portion of the insert;

[0017] FIG. **10** illustrates a cross-sectional view of the threaded shaft portion of the reducer rod within the insert with the threads disengaged allowing for translation of the threaded shaft portion of the rod reducer;

[0018] FIG. **11** illustrates a side, partial cross-sectional view of the insert having a spring-loaded mechanism and positioned within a portion of the elongated housing;

[0019] FIG. **12** illustrates a side view of the insert engaging the threaded shaft portion of the reducer rod;

[0020] FIG. **13** illustrates a perspective view of the reducer rod of FIG. **1**;

[0021] FIG. **14**A illustrates a cross-sectional view of the proximal end of the reducer rod going through the insert of the elongated housing assembly and FIG. **14**B illustrates a cross-sectional view of the threaded portion of the insert engaging with a threaded shaft of the reducer rod;

[0022] FIG. **15** illustrates a perspective view of a second system having the elongated housing assembly, the reducer rod, and a tulip assembly;

[0023] FIG. **16** illustrates a first close-up view of a proximal end of the elongated housing and a portion of the tulip assembly;

[0024] FIG. **17**A illustrates a second close-up view of the proximal end of the elongated housing and a portion of the tulip assembly, and FIG. **17**B illustrates a third close-up view of the proximal end of the elongated housing and the portion of the tulip assembly;

[0025] FIG. **18** illustrates a partially exploded perspective view of a third system having the

elongated housing assembly, the reducer rod, the tulip assembly, and a driver handle;
[0026] FIG. **19** illustrates an assembled view of the third system of FIG. **18** in pre-tightened configuration;
[0027] FIG. **20** illustrates an assembled view of the third system of FIG. **18** in a tightened configuration;
[0028] FIG. **21**A illustrates a front view of FIG. **20** and FIG. **21**B illustrates the front view of FIG. **21**A with the driver handle removed;
[0029] FIG. **22** illustrates a partially exploded view of the third system of FIG. **20**;
[0030] FIG. **23**A a front view of FIG. **22** where the driver handle is engaged and FIG. **23**B illustrates the front view of FIG. **23**A with the driver handle removed;
[0031] FIG. **24** illustrates an exploded view of FIG. **23**B;
[0032] FIG. **25** illustrates a partial close-up cross-sectional view of the proximal end of the elongated housing engaged with the tulip assembly;
[0033] FIGS. **26**A through **26**C illustrate depression of arms of the elongated housing and removal of the tulip assembly from the elongated housing assembly;
[0034] FIG. **27** illustrates a perspective view of FIG. **26**B where the arms of the elongated housing assembly have been depressed and the tulip assembly is separated from the proximal end of the elongated housing;
[0035] FIG. **28** partially illustrates the tulip assembly; and
[0036] FIG. **29** illustrates a flowchart of an example method of using a rod reduction system of the present disclosure.

DETAILED DESCRIPTION

[0037] The present disclosure relates to rod reduction systems for use in spinal surgeries, such as between a first and second vertebral bone.
[0038] FIG. **1** is an exploded perspective view of a first system **100** having an elongated housing assembly **10** and a reducer rod, rod reducer or inner shaft **30**. The elongated housing assembly **10** includes an elongated housing **11** and an insert **20** received within a portion of the elongated housing **11**. The elongated housing **11** includes a distal end **12**, which may have a first set of distal arms **12***a*, a proximal end **13**, and a body **14** extending therebetween. The elongated housing **11** may also include a second set of arms **18** that are engaged or received by the body **14**. The elongated housing **11** and/or the body **14** defines a longitudinal bore or channel **15** (which may correspond to a longitudinal axis of the elongated housing **11**) extending from the distal end **1213** to the proximal end **1312**. The proximal end **13** of the elongated housing may correspond to the proximal end of the longitudinal bore **15**. Likewise, the distal end **12** may correspond to the distal end of the longitudinal bore **15**.
[0039] The reducer rod or inner shaft **30** may include a distal end **31**, a proximal end defined by a proximal engagement mechanism **33**, and a body **35** extending therebetween. Contained within shaft **30** is a drive shaft having a proximal end **75***a* extending beyond the proximal end of shaft **30**. The longitudinal bore **15** may be for receiving at least a portion of the reducer rod **30** (also referred to herein as “an inner shaft”). Specifically, referring the FIGS. **2**A and **2**B, the distal end **31** of the reducer rod **30** may be aligned and positioned within the proximal end **13** of the elongated housing **11** and the longitudinal bore **15**. As described elsewhere, the insert **20** of the housing **11** also includes a longitudinal bore **24** that aligns with the longitudinal bore **15** of the housing **11**. Thus, when the reducer rod **30** is received in the longitudinal bore **15** of the elongated housing **11**, the reducer rod **30** is similarly received in the longitudinal bore **24** of the insert.
[0040] FIGS. **3**A through **4**B illustrate various views of the elongated housing **11** from the elongated housing assembly **10** of FIGS. **1** through **2**B. Specifically, FIG. **3**A illustrates a front view of the elongated housing **11**, FIG. **3**B illustrates a partial side view of the elongated housing **11**, FIG. **4**A illustrates a side view of the elongated housing **11** of FIG. **3**A, and FIG. **4**B illustrates a cross-sectional view of FIG. **4**A. As before, the elongated housing includes a distal end **12**, which

may include distal arms **12***a*, a proximal end **13**, and a body **14** extending between the distal end **12** and the proximal end **13**. The elongated housing **11** and/or the body **14** defines a longitudinal bore or channel **15** that extends from the distal end **12** (e.g., the space between the arms **12***a*) and the proximal end **13**.

[0041] Extending transverse or crosswise through the longitudinal bore **15** and the elongated housing **11** is an opening or slot **16** (referred to herein as "the opening," "the transverse opening," and/or "the transverse slot"). The transverse opening may have a non-perpendicular angle relative to the longitudinal bore. As seen most clearly in FIGS. **3**B and **4**B, the transverse opening **16** crosses the longitudinal bore **15** at a non-perpendicular angle relative to the longitudinal bore **15** and the elongated housing **11**. The transverse opening **16** may cross the longitudinal bore **15** at an angle A ranging from at least about 20° to about 80°, from at least about 10° to about 60°, from at least about 50° to about 85°, from at least about 40° to about 75°, and/or from at least about 60° to about 75°, relative to the longitudinal bore **15** (and the body **14** of the elongated housing **11**). For example, the angle A may be about 25°, 40°, 55°, 65°, 70°, or an angle within a range defined by any two of the foregoing values. The transverse opening **16** receives the insert **20**. The transverse opening **16** may define one or more voids **19** for receiving a portion of the spring-loaded mechanism **60** of the insert **20**. In other configurations, the transverse opening **16** may have a 90 degree angle relative to longitudinal bore **15** (i.e., may be a standard slot running crosswise through the longitudinal bore).

[0042] FIGS. **5**A through **7**B illustrate various views of the insert **20** that is received within the transverse opening **16**. Referring to FIGS. **5**A through **6**B, the insert **20** includes a body **23** having a front end **21** and a back end **22**. Defined within at least one side surface of the body **23** may be a groove **27** for receiving a spring-loaded mechanism **60** (FIG. **12**). The spring-loaded mechanism **60** biases the insert **20** within the transverse opening **16** in an inwardly biased position. The body **23** also defines a longitudinal bore **24** extending through the body **23**. The longitudinal bore **24** includes an internally threaded portion **25** for engaging with external threads **37** of the reducer rod **30** (see FIG. **8**) and a non-threaded portion **26** opposite the internally threaded portion **25**. The internally threaded portion **25** may also include a ramped portion **25***r* (which may also correspond to a thread **28** of the threaded portion **25**) for guiding the distal end **31** of the reducer rod **30** into and through the insert **20**.

[0043] Referring to FIGS. **7**A and **7**B, the internally threaded portion **25** includes a plurality of threads **28**, which may be buttress threads. Each individual thread **28** includes a ramped undercut portion **29**, which may be ramped at an angle **29***a*. The angle **29***a* corresponds to a ramped undercut **39** of threads **37** of the reducer rod **30** having an angle **37***a* (see FIG. **8**). The angle **29***a* may range from about 30° to about 45°, such as 35°, 40°, 42°, or an angle within a range defined by any two of the foregoing values. Correspondingly, the angle **37***a* of the threads **37** may range from about 30° to about 45°, such as 35°, 40°, 42°, or an angle within a range defined by any two of the foregoing values. The ramped undercut **29** of each thread **28** facilitates a ratchet-type motion between the threaded portion **36** of the reducer rod **30** and the threaded portion **25** of the insert **20**. In other configurations, other angles and threading types can also be used.

[0044] Referring to FIGS. **8** to **10**, when the reducer rod **30** is introduced into the longitudinal bore **15** of the housing **11** and the longitudinal bore **24** of the insert **20** of the housing, the threaded portion **36** of the reducer rod **30** comes into contact with the threaded portion **25** of the insert **20**. A user of the rod reduction system **100** can twist the reducer rod **30** to engage the threaded portion **25** of the insert **20** and move the reducer rod **30** through the elongated housing **11** and the insert **20**. Alternatively, the user can continue to apply force to the reducer rod **30** and engage a bypass or ratchet-type movement between the threaded portion **36** of the reducer rod **30** and the threaded portion **25** of the insert **20**. Specifically, the ramped undercut **39** of the threads **37** will slide against ramped undercut **29** of the threads **28**, allowing the reducer rod **30** to move within and through the elongated housing **11** and the insert **20**. This bypass or ratchet motion can continue until the distal

end **31** of the reducer rod **30** hits a stopping point, at which point a driver handle or other tool can be used to twist the reducer rod **30** to engage the threaded portion **25** of the insert **20** and move the reducer rod **30** through the elongated housing **11** and the insert **20**.

[0045] FIGS. **11** and **12** illustrate the spring-loaded mechanism **60** of the insert **20** received within the groove **27**. The spring-loaded mechanism **60** includes a spring **61** and a rapid release tab **62** for rapid releasing the reducer rod **30** from the elongated housing **11**. The rapid release tab **62** is received by and extends through the void **19** defined within the transverse opening **16** (see FIGS. **4**A and **4**B). As discussed, the spring-loaded mechanism **61** biases the insert **20** toward the inwardly biased position within the transverse opening **16**. When the insert **20** is displaced to the outwardly displaced position, the spring-loaded mechanism acts to automatically retract the insert **20** back to the inwardly biased position when an outward displacement force has been removed from the insert **20**. When it is desirable to remove the reducer rod **30** from the elongated housing assembly **10**, the tab **62** can be pressed which will cause the insert **20** to be moved to the outwardly displaced position and disengage the internally threaded portion **25** from the externally threaded portion **36**. With the threads **28**, **37** disengaged from each other, the reducer rod **30** can be pulled from the proximal end **13** of the elongated housing **11**, thereby removing the reducer rod **30** from the elongated housing **11**.

[0046] FIG. **13** illustrates a perspective view of the reducer rod **30** of FIG. **1**. As before, the reducer rod **30** includes the distal end **31**, the engagement mechanism **33**, and the body **35** extending therebetween. The body **35** includes an externally threaded portion **36** positioned between the distal end **31** and the engagement mechanism **33**. The proximal end **13** of the reducer rod **30** may be a handle engagement end having a first, larger engagement mechanism **33** and, extending beyond the proximal end of the rod reducer **30** is the proximal end of drive shaft **75**, which is a second, smaller engagement mechanism **34**. The first, larger engagement mechanism **33** and the second, smaller engagement mechanism may each be a nut or another appropriate engagement mechanism for, for example, a handle. Any suitable engagement mechanism desired can be used. The distal end **31** of the reducer rod **30** may be insertable into the proximal end **13** of the elongated housing **11** and, depending on a position of the reducer rod **30** within the elongated housing **11**, may be received by the longitudinal bore **15** at the distal end **12** of the elongated housing **11**. The body **35** may be fully or partially received within the longitudinal bore **15** of the elongated housing **11**, depending on the position of the reducer rod **30** within the elongated housing **11**.

[0047] FIG. **14**A illustrates the distal end **31** of the reducer rod **30** going through the insert **20** of the elongated housing assembly **10** and FIG. **14**B illustrates the threaded portion **25** of the insert **20** engaging with the threaded portion **36** of the reducer rod **30**. Also shown in these figures is the drive shaft **75** contained within reducer rod **30**. FIG. **14**A further illustrates the distal end **75***b* of drive shaft **75** to which is removably secured a set screw **78**. As before, the distal end **31** of the reducer rod **30** is insertable into the proximal end **13** of the elongated housing **11**. The reducer rod **30** may be further inserted into the elongated housing **11**, such that the distal end **31** passes into and through the longitudinal bore **24** of the insert **20**, as seen in FIG. **14**A. Inserting the distal end **31** through the longitudinal bore **24** of the insert **20** causes the insert **20** to move or slide within the transverse opening **16** of the elongated housing **11**. Specifically, the insert **20** slides from an inwardly biased position (where the insert **20** is fully seated and received within the transverse opening **16**) to an outwardly displaced position relative to the longitudinal bore **15**, where the insert **20** is not fully seated and received within the transverse opening **16**. The spring-loaded mechanism **60** biases the insert **20** in the inwardly biased position, keeping the insert **20** seated and received within the transverse opening **16** until action by the reducer rod **30**.

[0048] As the reducer rod **30** is still further inserted into the elongated housing **11**, the threaded portion **36** of the reducer rod **30** will also pass into and through the longitudinal bore **24** of the insert **20**, as seen in FIG. **14**B. As described, the threads **37** of the threaded portion **36** can ratchet past the threads **28** of the internally threaded portion **25** of the insert **20**. With the insert **20** in the

outwardly displaced position, the threads **28** are easier to ratchet past by the threads **37**. When the reducer rod **30** is no longer forced through and into the elongated housing **11**, the spring-loaded mechanism **60** of the insert **20** will cause the insert to "snap back" into the inwardly biased position, such that the threads **28** of the internally threaded portion **25** engage the threads **37** of the externally threaded portion **36** of the reducer rod **30**.

[0049] Turning now to FIG. **15**, a perspective view of a second system **110** is shown. This second system has an elongated housing assembly **10**, a reducer rod **30**, and a tulip assembly **40**. Similar to the system **100** of FIGS. **1**-**14**B, the elongated housing assembly **10** includes the elongated housing **11** and the insert **20** slidably received within a portion (e.g., the transverse opening **16**) of the elongated housing **11**. The reducer rod **30** includes the distal end **31**, the externally threaded portion **36** (both illustrated as received within the elongated housing **11**), and the first driver engagement mechanism **33**. Attached to the distal end **12** of the elongated housing **11** is a tulip assembly **40**, which includes a screw **41**, a rod **42**, and a housing **43** configured to engage the distal end **12**.

[0050] FIG. **16** illustrates a first close-up view of the distal end **12** of the elongated housing **11** and a portion of the tulip assembly **40**. As illustrated, the housing **43** of the tulip assembly **40** can be grasped or otherwise attached to the elongated housing **11** by the arms **12***a* of the distal end **12**. Also visible are the second set of arms **18** that may facilitate grasping and release of the housing **43** by the distal end **12** of the elongated housing **11**. Each distal arm **12***a* may include or define a cut-out **45** for receiving and guiding the rod **42** to the housing **43** and, more specifically, to a groove **44** within the housing **43**. Each of the cut-outs **45** and the groove **44** are shaped and sized to correspond to a diameter or size of the rod **42**. As the distal end **31** of the reducer rod **30** moves through the longitudinal bore **15** of the elongated housing **11**, a position of the rod **42** within the longitudinal bore **15** will change.

[0051] Specifically, the rod **42** will be advanced to the groove **44** of the housing **43** of the tulip assembly **40**. FIG. **17**A illustrates a second close-up view of the distal end **12** of the elongated housing **11** and the rod **42**, and FIG. **17**B illustrates a third close-up view of the distal end **12** of the elongated housing **11** and the rod **42**. Visible in FIG. **17**A is the distal end **31** of the reducer rod **30** extending into the longitudinal bore **15** just distal of the rod **42**. As the reducer rod **30** is further advanced into the longitudinal bore **15**, the distal end **31** will come into contact with the rod **42**. In some embodiments, when the distal end **31** contacts the rod **42**, axial translation of the reducer rod **30** will be stopped; that is, the reducer rod **30** can no longer be forced through the elongated housing **11** via the ratchet or bypass motion and a driver handle or other tool may need to be engaged for further proximal movement of the reducer rod **30** and the rod **42**. In some embodiments, when the distal end **31** contacts the rod **42**, the reducer rod **30** may be further translated axially until the rode **42** is forced distally at least partially into the housing **43**.

[0052] Turning now to FIGS. **18**-**20**, a third system **120** is illustrated. FIG. **18** illustrates a partially exploded perspective view of the third system **120** incorporating the second system **110** (with the elongated housing assembly **10**, the reducer rod **30**, and the tulip assembly **40**) with a handle **50**. FIG. **19** illustrates the third system **120** of FIG. **18** in pre-tightened configuration and FIG. **20** illustrates the third system **120** in a tightened configuration. As illustrated, the threaded portion **36** of the reducer rod **30** is contained within the body **14** and the longitudinal bore **15** of the elongated housing **11**. The proximal end **75***a* of the drive shaft **75** is free for engagement with the handle **50**.

[0053] The handle **50** includes a first engagement end **51** for engaging the first, larger engagement mechanism **33** of the reducer rod **30** and an opposing second engagement end **52** for engaging the second, smaller engagement mechanism **34** of the drive shaft **75** that is within the reducer rod **30**. When the first engagement end **51** interacts with the engagement mechanism **33** of the reducer rod **30**, the reducer rod **30** may be twisted or rotated through twisting or rotation of the handle **50**. For example, as illustrated in FIG. **19**, the first engagement end **51** has engaged the first, larger engagement mechanism **33**. A user may grasp and twist the handle **50**, thereby rotating the reducer rod **30** and "screwing" the reducer rod **30** further into the body **14** and the longitudinal bore **15** of

the elongated housing **11**. The handle **50** may include an internal cavity for receiving portions of the proximal end **13** of the reducer rod **30**, such as for receiving the second, smaller engagement mechanism **34** when the handle **50** is engaged with the first, larger engagement mechanism **33**.
[0054] When the second engagement end **52** interacts with the engagement mechanism **34** of the drive shaft **75**, the drive shaft may be rotated through twisting or rotation of the handle **50**. The drive shaft may twist or rotate past the distal end of the reducer rod **30** and in some embodiments the drive shaft may directly engage the head of the tulip assembly **40** to apply a tightening force to the tulip assembly **40** (see FIG. **22** below).
[0055] Threaded portion **36** of the reducer rod **30** will engage with the internally threaded portion **25** of the insert **20**, allowing the reducer rod **30** to be moved distally or proximally through the elongated housing **11** depending on the direction that the handle **50** is rotated. As illustrated in FIG. **20**, the reducer rod **30** has been screwed into the elongated housing **11** until the first engagement end **51** (and the not visible first, larger engagement mechanism **33**) abuts the proximal end **13** of the elongated housing **11**. As also seen in FIG. **20**, the rod **42** has been moved distally towards the tulip assembly **40** through the screwing or twisting motion of the reducer rod **30** and the handle **50**. This distal advancement of the reducer rod **30** and the rod **42** places the tulip assembly **40** in condition for use in surgical procedures.
[0056] FIG. **21**A illustrates a front view of FIG. **20** and FIG. **21**B illustrates the front view of FIG. **21**A with the handle **50** removed. In FIG. **21**A, the first engagement end **51** is illustrated abutting the proximal end **13** of the elongated housing **11**. In FIG. **21**B, the first larger engagement mechanism **33** is illustrated abutting the proximal end **13** of the elongated housing **11**. In both views, the rod **42** is illustrated near the housing **43** of the tulip assembly **40**, but may not be fully seated in the groove **44** (see FIGS. **17**A-**17**B).
[0057] FIG. **22** illustrates the system of FIG. **18** with the handle **50** in an opposed position. Specifically, the handle **50** is oriented such that the second engagement end **52** is toward the second system **110** for engagement with the second, smaller engagement mechanism **34** of the drive shaft **75**. As before, the handle **50** may be twisted and rotated; however, by rotating the second, smaller engagement mechanism **34**, the drive shaft **75** positioned within the rod reducer **30** is distally advanced relative to the rod reducer **30**. Such rotation via the second engagement end **52** may fully seat the rod **42** within the groove **44** of the housing **43** of the tulip assembly **40**, thereby placing the tulip assembly **40** in condition for use in surgical procedures.
[0058] In some embodiments, the reducer rod **30** is configured to stop short of fully advancing the rod **42** into the groove **44** of the housing **43**. In such embodiments, full advancement may only be achieved by distally advancing the drive shaft **75** so that the set screw **78** that is positioned on the distal end **75***b* of the drive shaft **75** provides the final force to the rod **42** to fully advance the rod **42** into the groove **44**. In some embodiments, this additional advancement of the drive shaft **75** is not carried out until at least some of the external threads of the set screw **78** have engaged at least some of the internal threads on the housing **43**.
[0059] This delayed or staged advancement of the rod **42** may allow the housing **43** to remain moveable relative the screw **41** until the final tightening of the set screw **78**. This may be possible where the housing **43** contains an insert (not illustrated) configured to immobilize the screw **41** relative the housing **43** when the insert is fully depressed within the housing **43**, which may be achieved by fully pressing the rod **42** into the groove **44** of the housing **43**.
[0060] FIG. **23**A illustrates a front view of FIG. **22** where the handle **50** is engaged with the second engagement mechanism **34** and FIG. **23**B illustrates the front view of FIG. **23**A with the handle **50** removed. In FIG. **23**A, the second engagement end **52** is illustrated engaged with the second engagement mechanism **34** to finish seating the rod **42** within the groove **44** of the housing **43** of the tulip assembly **40**. The same twisting motion may be applied to the handle **50** as with the first engagement mechanism **33**.
[0061] FIG. **24** illustrates the reducer rod **30** substantially fully received within the elongated

housing **11** and the tulip assembly **40** with the rod **42** fully seated within the housing **43**. The distal end **31** of the reducer rod **30** abuts the rod **42** at the distal end **12** of the elongated housing **11**. Visible through one or more windows **14***w* defined in the body **14** of the elongated housing **11** are indicia **38** on the reducer rod **30**. The window(s) **14***w* provide a view into the longitudinal bore **15**. The indicia **38** may visually communicate a position of the reducer rod **30** within the body **14** and the longitudinal bore **15**. In other configurations, the reducer rod may have different indicia or no indicia.

[0062] FIG. **25** illustrates a partial close-up cross-sectional view of the distal end **12** of the elongated housing **11** engaged with the tulip assembly **40**. The drive shaft **75** having a distal end **75***b* is also illustrated as is a set screw **78** removable secured to the distal end **75***b* of the drive shaft **75**. As illustrated, the rod **42** is received within the groove **44** and the housing **43** of the tulip assembly **40** is received between the distal arms **12***a* at the distal end **12** of the elongated housing **11**. Specifically, pins **18***p* located near the distal end **12** grasp the housing **43** (e.g., mate with indentations in the housing **43**), thereby securing the tulip assembly **40** to the distal end **12** of the elongated housing.

[0063] FIGS. **26**A through **26**C schematically illustrate depression of the second set of arms **18** of the elongated housing **11** and removal of the tulip assembly **40** from the distal end **12** of the elongated housing assembly **11**. FIG. **27** illustrates a perspective view of FIG. **26**B where the arms **18** of the housing assembly **10** have been depressed and the tulip assembly **40** is separated from the distal end **12** of the elongated housing **11**. When the arms **18** are depressed, the pins **18***p* (see FIG. **25**) will be released from the housing **43** of the tulip assembly **40**, such that the tulip assembly **40** can be separated from the distal end **12**. Notably, the rod **42** seated in the groove **44** of the housing **43** is separated from the distal end **12** of the elongated housing **11** with the remainder of the tulip assembly **40**. FIG. **28** partially illustrates the tulip assembly **40**. Specifically, the rod **42** is illustrated as fully seated in the groove **44** of the housing **43**. The screw **41** extends proximally from the housing **43**. In some embodiments, the screw **41** may be integral with the housing **43**.

[0064] According to one method of use, the reducer rod **30** will be inserted into the proximal end **13** of the elongated housing **11**. The reducer rod **30** may be initially forced or pushed into the longitudinal bore **15** of the elongated housing **11** to a first position. In the first position, the distal end **31** of the reducer rod **30** extends through the longitudinal bore **24** of the insert **20** until the distal end **31** hits a chamfer **25***r* or ramped portion (FIG. **7**A) or internal, sloped surface of the insert **20**. This chamfer **25***r* stops initial proximal advancement of the reducer rod **30** through the elongated housing **11**. Additional force may be applied to the reducer rod **30** to ratchet the threaded portion **30** of the reducer rod **30** past the internally threaded portion **25** of the insert **20** to a second position. The additional force applied to the reducer rod **30** displaces the insert **20** within the transverse opening **16** of the elongated housing.

[0065] Specifically, the insert **20** moves from an inwardly biased position to an outwardly displaced position. While the insert **20** is in the outwardly displaced position, the threaded portion **36** of the reducer rod **30** may be ratcheted past the threaded portion **25** of the insert **20** to the second position. In the second position, further proximal movement of the reducer rod **30** is stopped because the distal end **31** of the reducer rod **30** contacts the rod **42** in the longitudinal bore **15** of the elongated housing **11**.

[0066] Once the distal end **31** of the reducer rod **30** contacts the rod **42**, the handle **50** may be removably attached to the reducer rod **30**. The first engagement end **51** of the handle **50** may engage the first, larger engagement mechanism **33** of the reducer rod **30**. The handle **50** may be twisted or rotated, thereby twisting the reducer rod **30**, and screwing the threaded portion **36** of the rod **30** through the threaded portion **25** of the insert **20**. The reducer rod **30** may be twisted in this way to a third position, where distal advancement of the reducer rod **30** causes the rod **42** to be distally advanced within the longitudinal bore **15**. In the third position, the rod **42** abuts the housing **43** of the tulip assembly **40** but may not yet be fully seated in the groove **44** of the housing **43**. The

second engagement end **52** of the handle **50** may then engage the second, smaller engagement mechanism **34** of the drive shaft. Again, the handle **50** may be twisted to distally advance the drive shaft **75**, thereby fully seating the rod **42** within the groove **44** of the housing **43** of the tulip assembly **40**.

[0067] It will be appreciate that reduction systems can be used in various implementations and surgical devices, such as those for rod reduction, MIST instruments, interbody instruments, etc.

[0068] FIG. **29** illustrates a flowchart of an example method **300** of using a rod reduction system, such as any one of the rod reduction systems **100**, **110**, **120** illustrated in FIGS. **1**-**28**. The method **300** may include inserting a rod reducer **30** into a distal end of the longitudinal bore of the elongated housing to a first position, at **305**. For example, the reducer rod may be the reducer rod **30** being inserted into the longitudinal bore **15** of the elongated housing **11** from the elongated housing assembly **10** (see FIG. **1**). The first position may be where the distal end **31** of the reducer rod **30** contacts the chamfer **25***r* of the insert **20** positioned within the elongated housing **11**.

[0069] Inserting the reducer rod **30** into the proximal end **13** of the longitudinal bore **15** of the elongated housing **11** to a first position may include positioning the distal end **31** of the reducer rod **30** at the proximal end of the longitudinal bore **15** of the elongated housing **11**. Additionally, inserting the reducer rod **30** includes forcing the distal end **31** of the reducer rod **30** into the longitudinal bore **15** of the elongated housing **11** and past a proximal chamfer of the insert **20**. The distal end **31** of the reducer rod **30** is inserted through the longitudinal bore **24** of the insert **20** such that the reducer rod **30** displaces the insert **20** from an inwardly biased position within the transverse opening **16** to an outwardly displaced position. Additional force causes the body **35** of the inner shaft **30** to continue into the longitudinal bore **24** of the insert **20**.

[0070] However, the threaded portion **25** of the insert **20** has not engaged the externally threaded portion **36** of the reducer rod **30**. The method **300** may also include pushing the rod reducer **30** into the longitudinal bore to a second position such that the external threads of the rod reducer are disengaged by the internally threaded portion of the insert, at **310**. That is, the threaded portion **36** of the body **35** may be forced past the internally threaded portion **25** of the insert **20** through a ratchet-type movement or translation of the threads of both the internally threaded portion **25** and the threaded portion **36** of the reducer rod **30**. When forcing the reducer rod **30** through the insert **20** and past the internally threaded portion **25** of the insert **20**, the reducer rod **30** displaces the insert **20** from an inwardly biased position within the transverse opening **16** to an outwardly displaced position relative to the elongated housing **11** to allow the threaded portion of the rod reducer **30** to translate past the threaded portion of the insert.

[0071] The external threads **36** of the rod reducer **30** may ratchet past the threads **27** of the threaded portion **25** of the insert, such as illustrated in FIGS. **8**-**10**. The ramped undercut **39** of the external threads **36** will slide past the ramped undercut **29** of the threads **28** of the threaded portion **25**. The second position may be where the distal end **31** of the reducer rod **30** collides with the rod **42** positioned within the elongated housing **11**, between the distal arms **12***a* (see FIG. **16**).

[0072] The method **300** may further include driving the reducer rod into the longitudinal bore to a third position such that the external threads of the reducer rod are engaged by the internally threaded portion of the insert, at **315**. A handle **50** may engage the proximal engagement mechanism **33** of the reducer rod **30** with the first engagement end **51** of the handle **50**. As the reducer rod **30** is driven the by handle **50**, the externally threaded portion **36** of the reducer rod **30** engages with the threaded portion **25** of the insert **20** and the reducer rod **30** is axially advanced through the longitudinal bore **15** of the elongated housing **11**. In the third position, the rod **42** moves axially through the elongated housing **11** with the reducer rod **30**.

[0073] The method **300** further includes driving a drive shaft into the reducer rod distally beyond a distal end of the reducer rod, at **320**. The drive shaft may be the drive shaft **75**, which is positioned within a longitudinal bore of the reducer rod **30** and has a proximal end **75***a* with a second, smaller engagement mechanism **34** and a distal end **75***b* opposite the proximal end **75***a*. The second,

smaller engagement mechanism **34** may be engaged by the handle **50**, specifically a second engagement end **52**. Once the handle **50** is engaged with the drive shaft **75**, the drive shaft **75** may be driven by rotation of the handle **50**. By rotating the second, smaller engagement mechanism **34**, the drive shaft **75** positioned within the rod reducer **30** is distally advanced relative to the rod reducer **30**. Such rotation via the second engagement end **52** may fully seat the rod **42** within the groove **44** of the housing **43** of the tulip assembly **40**, thereby placing the tulip assembly **40** in condition for use in surgical procedures.

Embodiments

[0074] The following embodiments are provided as examples only of specific configurations, materials, arrangements, etc. contemplated by the authors of this disclosure:

[0075] Embodiment 1. A rod reduction system comprising an elongated housing having a first longitudinal bore therethrough, and a transverse channel extending through the elongated housing at a non-perpendicular angle relative to the first longitudinal bore, the elongated housing further comprising an insert slideable within the transverse channel between an outwardly displaced position and an inwardly biased position, the insert having a first longitudinal bore therethrough alignable with the first longitudinal bore of the elongated housing, and the insert comprising a threaded portion; and a reducer slidably receivable within the first longitudinal bore of the elongated housing, the reducer having a proximal end, and a distal end opposite the proximal end, with a shaft extending from the distal end to the proximal end, the shaft having a threaded portion; wherein the rod reduction system comprises (i) a first, rapid reduction position wherein the reducer displaces the insert to the outwardly displaced position such that the threaded portion of the insert does not engage the threaded portion of the shaft of the reducer, and (ii) a second, engaged position wherein the threaded portion of the insert in the inwardly biased position engages the threaded portion of the shaft of the reducer.

[0076] Embodiment 2. The rod reduction system of Embodiment 1, further comprising a handle for engaging the proximal end of the reducer.

[0077] Embodiment 3. The rod reduction system of Embodiment 1 or Embodiment 2, wherein the non-perpendicular angle relative to the first longitudinal bore comprises an angle of about 40 degrees to about 80 degrees.

[0078] Embodiment 4. The rod reduction system of Embodiment 1 or Embodiment 2, wherein the non-perpendicular angle relative to the first longitudinal bore comprises an angle of about 60 degrees to about 75 degrees.

[0079] Embodiment 5. The rod reduction system of Embodiment 1 or Embodiment 2, wherein the non-perpendicular angle relative to the first longitudinal bore comprises an angle of about 70 degrees.

[0080] Embodiment 6. The rod reduction system of any one of Embodiments 1, 2, 3, 4, or 5, wherein the first longitudinal bore of the insert has an angle corresponding to the non-perpendicular angle of the transverse channel, an exterior of the body defining at least one pocket for receiving a spring.

[0081] Embodiment 7. The rod reduction system of Embodiment 6, wherein the spring biases the insert towards the inwardly biased position, allowing the threaded portion of the insert to engage the threaded portion of the shaft.

[0082] Embodiment 8. The rod reduction system of Embodiment 6, wherein the body of the insert defines the first longitudinal bore and the first longitudinal bore includes a proximal chamfer, wherein the distal end of the reducer must pass the proximal chamfer to displace the insert to the outwardly displaced position.

[0083] Embodiment 9. The rod reduction system of any one of Embodiments 1 through 8, wherein the threaded portion of the insert comprises threads having an angled surface corresponding to an angled surface of thread of the threaded portion of the reducer.

[0084] Embodiment 10. The rod reduction system of any one of Embodiments 1 through 9,

wherein the reducer comprises a second longitudinal bore therethrough, and wherein the rod reduction system further comprises a drive shaft positioned within the second longitudinal bore, the drive shaft having a proximal end and a distal end having a working tip.

[0085] Embodiment 11. The rod reduction system of Embodiment 10, wherein the proximal end of the drive shaft is configured to engage a handle, and wherein the working tip at the distal end of the drive shaft is configured to releasably engage a set screw.

[0086] Embodiment 12. The rod reduction system of Embodiment 10 or 11, wherein the proximal end of the drive shaft extends proximally of the proximal end of the reducer.

[0087] Embodiment 13. The rod reduction system of any one of Embodiments 1 through 12, wherein the distal end of the elongated housing is configured to releasably engage a tulip of a pedicle screw, the tulip having a saddle configured to receive a portion of a fixation rod.

[0088] Embodiment 14. The rod reduction system of any one of Embodiments 1 through 13, wherein the distal end of the elongated housing is configured to accommodate a fixation rod generally defining an axis that is substantially perpendicular to the first longitudinal bore, and wherein the reducer is configured to be advanced distally relative to the elongated housing in order to translate distally the fixation rod accommodated by the elongated housing.

[0089] Embodiment 15. The rod reduction system of Embodiment 14, wherein the reducer is configured to advance the fixation rod at least partially into the tulip without fully seating the fixation rod in the tulip.

[0090] Embodiment 16. The rod reduction system of Embodiment 15, wherein the drive shaft is configured to be advanced distally relative to the reducer in order to fully seat the fixation rod in the tulip.

[0091] Embodiment 17. The rod reduction system of Embodiment 16, wherein the a set screw is removable attached to the working tip of the drive shaft when the draft fully seats the fixation rod in the tulip.

[0092] Embodiment 18. The rod reduction system of Embodiment 17, wherein the reducer advances the fixation rod into the tulip sufficiently enough to allow the set screw to at least partially engage with the tulip.

[0093] Embodiment 19. The rod reduction system of Embodiment 18, wherein the tool tip of the drive shaft advances the set screw distally by rotating the set screw, which rotation causes threads of the set screw to engage corresponding threads of the tulip, such that at least a portion of the force applied to the fixation rod is applied by the set screw while the set screw is engaged with the tulip.

[0094] Embodiment 20. A rod reduction system comprising an inner shaft having a distal tip end, and a threaded portion; and a housing having a longitudinal bore therethrough to slidably receive the inner shaft, and a transverse slot extending through the housing at a predetermined angle relative to the longitudinal bore, the housing further comprising an actuator slideable within the transverse slot between an outwardly displaced position and an inwardly biased position, the actuator having a longitudinal bore therethrough alignable with the longitudinal bore of the housing, and the actuator longitudinal bore comprising a threaded portion; the rod reduction system having a first mode and a second mode, wherein the first mode comprises a rapid reduction mode wherein the shaft displaces the actuator to the outwardly displaced position such that the threaded portion of the actuator does not engage the threaded portion of the shaft, which allows the shaft to bypass the threaded portion of the actuator; and the second mode comprises a driving mode wherein the actuator is in the inward biased position such that the threaded portion of the actuator engages the threaded portion of the shaft.

[0095] Embodiment 21. The rod reduction system of Embodiment 20, wherein the rod reduction system has a third mode comprising a rapid release mode wherein the actuator is pressed from the inward biased position to the outwardly displaced position such that the threaded portion of the actuator disengages the threaded portion of the shaft to allow the shaft to be translated proximally relative to the housing.

[0096] Embodiment 22. The rod reduction system of Embodiment 20 or 21, wherein threads of the threaded portion of the actuator define an angle parallel to an angle of threads of the threaded portion of the inner shaft.
[0097] Embodiment 23. The rod reduction system of any one of Embodiments 20, 21, or 22, wherein the actuator comprises a spring-loaded mechanism for engaging the threaded portion of the shaft.
[0098] Embodiment 24. The rod reduction system of any one of Embodiments 20 through 23, wherein in the rapid reduction mode, an angled surface of threads of the threaded portion of the inner shaft slides against an angled surface of threads of the threaded portion of the actuator, allowing the shaft to displace the actuator to the outwardly displaced position.
[0099] Embodiment 25. The rod reduction system of any one of Embodiments 20 through 24, wherein in the rapid reduction mode, the shaft displaces the actuator with a ratchet-type motion.
[0100] Embodiment 26. The rod reduction system of any one of Embodiments 20 through 25, wherein the predetermined angle relative to the longitudinal bore comprises an angle of at least 50° relative to the longitudinal bore.
[0101] Embodiment 27. The rod reduction system of any one of Embodiments 20 through 26, wherein the longitudinal bore of the actuator comprises the threaded portion and a non-threaded portion, the longitudinal bore having an angle relative to the actuator corresponding to the predetermined angle of the transverse slot.
[0102] Embodiment 28. A method of using a rod reduction system, the method comprising positioning an insert within an elongated housing such that a longitudinal bore of the insert is aligned with a longitudinal bore of the elongated housing; inserting a shaft into a proximal end of the longitudinal bore of the elongated housing to a first position; engaging external threads of the shaft by an internally threaded portion of the insert in the first position; pushing the shaft into the longitudinal bore to a second position such that the external threads of the shaft are disengaged by the internally threaded portion of the insert; and twisting the shaft to a third position within the longitudinal bore, the third position being different than the first position and the second position.
[0103] Embodiment 29. The method of Embodiment 28, wherein positioning an insert within the elongated housing comprises sliding a body of the insert into a slot extending crosswise to the longitudinal bore of the elongated housing, the slot being non-perpendicular to the longitudinal bore and the body having an angle matching the non-perpendicular angle of the slot; and aligning the longitudinal bore of the insert with the longitudinal bore of the elongated housing.
[0104] Embodiment 30. The method of Embodiment 28 or Embodiment 29, wherein inserting a shaft into a proximal end of the longitudinal bore of the elongated housing to a first position comprises positioning a distal end of the shaft at the proximal end of the longitudinal bore of the elongated housing; and forcing the distal end of the shaft into the longitudinal bore of the elongated housing and past a proximal chamfer of the insert.
[0105] Embodiment 31. The method of any one of Embodiments 28, 29, or 30, further comprising disengaging the external threads of the shaft from the internally threaded portion of the insert and removing the shaft from the elongated housing.
[0106] Embodiment 32. The method of Embodiment 31, wherein disengaging the external threads of the shaft from the internally threaded portion of the insert comprises pressing the insert from an inwardly biased position where the internally threaded portion of the insert engaged with the external threads of the shaft to an outwardly displaced position such that the external threads of the shaft separate from the internally threaded portion of the insert.
[0107] Embodiment 33. A method of using a rod reduction system, the method comprising: [0108] releasably securing a distal end of an elongated housing to a tulip assembly of a pedicle screw; [0109] distally advancing, in a first configuration, a rod reducer contained within the elongated housing to push a fixation rod toward the tulip assembly; [0110] distally advancing, in a second configuration, the rod reducer to push the fixation rod at least partially into a saddle of the tulip

assembly; [0111] wherein the elongated housing comprises a first longitudinal bore to house the rod reducer, a transverse slot that is non-perpendicular to the first longitudinal bore, an insert positioned within the transverse slot having a bore substantially aligned with the first longitudinal bore, at least a portion of the bore having internal threads configured to engage with threads on an exterior surface of the rod reducer; and [0112] wherein the insert is configured to transition between the first configuration and the second configuration, the first configuration achieved when the rod reducer is translated distally relative to the elongated housing pushing against the threads of the insert causing the insert to translate within the slot from a resting position, the second configuration achieved when a biasing element returns the insert to its resting position such that the threads of the slot engage the threads of the rod reducer so that rotation of the rod reducer produced axial translation of the rod reducer relative to the elongated housing.

[0113] Embodiment 34. The method of Embodiment 33, further comprising: [0114] distally advancing, in a third configuration, a drive shaft contained within the rod reducer to push the fixation rod fully into the saddle of the tulip assembly; [0115] wherein the rod reducer comprises a second longitudinal bore to house the drive shaft, the second longitudinal bore having internal threads configured to engage external threads of the drive shaft so that rotation of the drive shaft relative to the rod reducer axially translates the drive shaft relative to the rod reducer.

[0116] Embodiment 35. The method of Embodiment 34, wherein a set screw is releasably secured to a distal end of the drive shaft, such that distal advancement of the set screw brings it into contact with the tulip assembly, and wherein rotation of the set screw causes a thread on the set screw to threadingly engage a thread of the tulip assembly.

[0117] Embodiment 36. The method of Embodiment 37, further comprising: disengaging the distal end of the elongated housing from the tulip assembly.

[0118] Embodiment 37. An advancement mechanism comprising: [0119] an elongated housing having a longitudinal bore extending therethrough from a proximal end to a distal end, the elongated housing having a slot extending across the longitudinal bore at an angle to the longitudinal bore that is less than 90 degrees; [0120] an insert positioned in the slot and configured to translate within the slot from a resting position to a displaced position, the insert having a bore extending therefore, the bore being substantially aligned with the longitudinal bore, the bore having at least one internal thread; [0121] an inner shaft having exterior threads configured to engage at least one internal thread of the bore, the inner shaft sized to fit within the longitudinal bore.

[0122] Embodiment 38. The advancement mechanism of Embodiment 37, further comprising a biasing element configured to maintain the insert in the resting position and to return the insert to the resting position after the insert has been moved to the displaced position.

[0123] Embodiment 39. The advancement mechanism of Embodiment 37 or 38, wherein a first distal advancement of the inner shaft within the longitudinal bore causes displacement of the insert from the resting position to the displaced position, wherein the first distal advancement is achieved by applying a distal force on the inner shaft.

[0124] Embodiment 40. The advancement mechanism of any one of Embodiment 37, 38, or 39, wherein a second distal advancement of the inner shaft is achieved by rotating the inner shaft relative to the elongated housing, which rotation causes the second distal advancement because the exterior threads of the inner shaft are threadingly engaged with the at least one internal thread of the bore when the insert is in the resting position.

[0125] While particular embodiments have been illustrated and described herein, it should be understood that various other changes and modifications may be made without departing from the spirit and scope of the claimed subject matter. Moreover, although various aspects of the claimed subject matter have been described herein, such aspects need not be utilized in combination. It should also be noted that some of the embodiments disclosed herein may have been disclosed in relation to a particular approach (e.g., lateral); however, other approaches (e.g., anterior, posterior, transforaminal, etc.) are also contemplated.

[0126] Unless otherwise indicated, all numbers expressing quantities of ingredients, properties such as molecular weight, reaction conditions, and so forth used in the specification and claims are to be understood as being modified in all instances by the term “about.” Accordingly, unless indicated to the contrary, the numerical parameters set forth in the specification and attached claims are approximations that may vary depending upon the desired properties sought to be obtained by the embodiments of the present disclosure. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims, each numerical parameter should at least be construed in light of the number of reported significant digits and by applying ordinary rounding techniques. Notwithstanding that the numerical ranges and parameters setting forth the broad scope of the present disclosure are approximations, the numerical values set forth in the specific examples are reported as precisely as possible. Any numerical value, however, inherently contains certain errors necessarily resulting from the standard deviation found in their respective testing measurements. In one embodiment, the terms “about” and “approximately” refer to numerical parameters within 10% of the indicated range.

[0127] The terms “a,” “an,” “the,” and similar referents used in the context of describing the embodiments of the present disclosure (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. Recitation of ranges of values herein is merely intended to serve as a shorthand method of referring individually to each separate value falling within the range. Unless otherwise indicated herein, each individual value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., “such as”) provided herein is intended merely to better illuminate the embodiments of the present disclosure and does not pose a limitation on the scope of the present disclosure. No language in the specification should be construed as indicating any non-claimed element essential to the practice of the embodiments of the present disclosure.

[0128] Groupings of alternative elements or embodiments disclosed herein are not to be construed as limitations. Each group member may be referred to and claimed individually or in any combination with other members of the group or other elements found herein. It is anticipated that one or more members of a group may be included in, or deleted from, a group for reasons of convenience and/or patentability. When any such inclusion or deletion occurs, the specification is deemed to contain the group as modified thus fulfilling the written description of all Markush groups used in the appended claims.

[0129] Certain embodiments are described herein, including the best mode known to the author(s) of this disclosure for carrying out the embodiments disclosed herein. Of course, variations on these described embodiments will become apparent to those of ordinary skill in the art upon reading the foregoing description. The author(s) expects skilled artisans to employ such variations as appropriate, and the author(s) intends for the embodiments of the present disclosure to be practiced otherwise than specifically described herein. Accordingly, this disclosure includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the present disclosure unless otherwise indicated herein or otherwise clearly contradicted by context.

[0130] Specific embodiments disclosed herein may be further limited in the claims using consisting of or consisting essentially of language. When used in the claims, whether as filed or added per amendment, the transition term “consisting of” excludes any element, step, or ingredient not specified in the claims. The transition term “consisting essentially of” limits the scope of a claim to the specified materials or steps and those that do not materially affect the basic and novel characteristic(s). Embodiments of this disclosure so claimed are inherently or expressly described and enabled herein.

[0131] Furthermore, if any references have been made to patents and printed publications throughout this disclosure, each of these references and printed publications are individually incorporated herein by reference in their entirety.
[0132] In closing, it is to be understood that the embodiments disclosed herein are illustrative of the principles of the present disclosure. Other modifications that may be employed are within the scope of this disclosure. Thus, by way of example, but not of limitation, alternative configurations of the embodiments of the present disclosure may be utilized in accordance with the teachings herein. Accordingly, the present disclosure is not limited to that precisely as shown and described.

Claims

1. A rod reduction system comprising an elongated housing having a first longitudinal bore therethrough, and a transverse channel extending through the elongated housing at a non-perpendicular angle relative to the first longitudinal bore, the elongated housing further comprising an insert slideable within the transverse channel between an outwardly displaced position and an inwardly biased position, the insert having a body with a first longitudinal bore therethrough alignable with the first longitudinal bore of the elongated housing, and the insert comprising a threaded portion; and a reducer slidably receivable within the first longitudinal bore of the elongated housing, the reducer having a proximal end, and a distal end opposite the proximal end, with a shaft extending from the distal end to the proximal end, the shaft having a threaded portion; and wherein the rod reduction system comprises (i) a first, rapid reduction position wherein the reducer displaces the insert to the outwardly displaced position such that the threaded portion of the insert does not engage the threaded portion of the shaft of the reducer, and (ii) a second, engaged position wherein the threaded portion of the insert in the inwardly biased position engages the threaded portion of the shaft of the reducer.
2. The rod reduction system of claim 1, further comprising a handle for engaging the proximal end of the reducer.
3. The rod reduction system of claim 1, wherein the non-perpendicular angle relative to the first longitudinal bore comprises an angle of about 40 degrees to about 80 degrees.
4. The rod reduction system of claim 1, wherein the non-perpendicular angle relative to the first longitudinal bore comprises an angle of about 60 degrees to about 75 degrees.
5. The rod reduction system of claim 1, wherein the non-perpendicular angle relative to the first longitudinal bore comprises an angle of about 70 degrees.
6. The rod reduction system of claim 1, wherein the first longitudinal bore of the insert has an angle corresponding to the non-perpendicular angle of the transverse channel, and an exterior of the body defining a pocket for receiving a spring.
7. The rod reduction system of claim 6, wherein the spring biases the insert towards the inwardly biased position, allowing the threaded portion of the insert to engage the threaded portion of the shaft.
8. The rod reduction system of claim 6, wherein the body of the insert defines the first longitudinal bore and the first longitudinal bore includes a proximal chamfer, wherein the distal end of the reducer must pass the proximal chamfer to displace the insert to the outwardly displaced position.
9. The rod reduction system of claim 1, wherein the threaded portion of the insert comprises threads having an angled surface corresponding to an angled surface of thread of the threaded portion of the reducer.
10. The rod reduction system of claim 1, wherein the reducer comprises a second longitudinal bore therethrough, and wherein the rod reduction system further comprises a drive shaft positioned within the second longitudinal bore, the drive shaft having a proximal end and a distal end having a working tip.
11. The rod reduction system of claim 10, wherein the proximal end of the drive shaft is configured

to engage a handle, and wherein the working tip at the distal end of the drive shaft is configured to releasably engage a set screw.

12. The rod reduction system of claim 10, wherein the proximal end of the drive shaft extends proximally of the proximal end of the reducer.

13. The rod reduction system of claim 12, wherein the distal end of the elongated housing is configured to releasably engage a tulip of a pedicle screw, the tulip having a saddle configured to receive a portion of a fixation rod.

14. The rod reduction system of claim 13, wherein the distal end of the elongated housing is configured to accommodate a fixation rod generally defining an axis that is substantially perpendicular to the first longitudinal bore, and wherein the reducer is configured to be advanced distally relative to the elongated housing in order to translate distally the fixation rod accommodated by the elongated housing.

15. The rod reduction system of claim 14, wherein the reducer is configured to advance the fixation rod at least partially into the tulip without fully seating the fixation rod in the tulip.

16. The rod reduction system of claim 15, wherein the drive shaft is configured to be advanced distally relative to the reducer in order to fully seat the fixation rod in the tulip.

17. The rod reduction system of claim 16, wherein the set screw is removably attached to the working tip of the drive shaft when the drive shaft fully seats the fixation rod in the tulip.

18. The rod reduction system of claim 17, wherein the reducer advances the fixation rod into the tulip sufficiently enough to allow the set screw to at least partially engage with the tulip.

19. The rod reduction system of claim 18, wherein the working tip of the drive shaft advances the set screw distally by rotating the set screw, which rotation causes threads of the set screw to engage corresponding threads of the tulip, such that at least a portion of the force applied to the fixation rod is applied by the set screw while the set screw is engaged with the tulip.

20. A method of using a rod reduction system, the method comprising: positioning an insert within an elongated housing such that a longitudinal bore of the insert is aligned with a longitudinal bore of the elongated housing; inserting an inner shaft into a distal end of the longitudinal bore of the elongated housing to a first position; engaging external threads of the inner shaft by an internally threaded portion of the insert in the first position; pushing the inner shaft into the longitudinal bore to a second position such that the external threads of the inner shaft are disengaged by the internally threaded portion of the insert; and twisting the inner shaft to a third position within the longitudinal bore, the third position being different than the first position and the second position.