Threaded Plugs With Splay Resisting Thread Forms For Bone Anchor Receivers

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INVENTOR INFORMATION

NAME	CITY	STATE	ZIP CODE	COUNTRY
Jackson; Roger P.	Prairie Village	KS	N/A	US

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Abstract

A receiver assembly for securing an elongate rod to a bone anchor includes a receiver having a channel configured to receive the elongate rod and a helically wound receiver guide and advancement structure formed into interior surfaces of the receiver. The receiver assembly further includes a threaded plug configured for positioning within the channel to secure the elongate rod to the receiver in a locked configuration, with the threaded plug having a lower axially protruding portion configured to engage the rod so as to lock the rod in the receiver in the locked configuration.

Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS (1) This application is a continuation of U.S. patent application Ser. No. 16/987,741, filed Aug. 7, 2020, which is a continuation of U.S. patent application Ser. No. 16/005,873, filed Jun. 12, 2018, now U.S. Pat. No. 10,751,095, which is a continuation of U.S. patent application Ser. No. 15/867,095, filed Jan. 10, 2018, now U.S. Pat. No. 9,999,452, which is a continuation of U.S. patent application Ser. No. 14/043,139, filed Oct. 1, 2013, now U.S. Pat. No. 10,039,577, which is a continuation of U.S. patent application Ser. No. 12/583,821, filed Aug. 26, 2009, now U.S. Pat. No. 8,591,515, which is a continuation of U.S. patent application Ser. No. 10/996,349, filed Nov. 23, 2004, now U.S. Pat. No. 7,621,918, each of which is incorporated by reference in its entirety herein, and for all purposes.

BACKGROUND OF THE INVENTION

(1) The present invention relates to apparatuses and methods for use in performing spinal surgery and, in particular, to tools and methods of using such tools, especially for percutaneously implanting spinal screws and for implanting a rod for spinal support and alignment, using minimally invasive techniques.

(2) For many years, spinal osteosynthesis apparatuses have been utilized to correct spinal deformities, injuries or disease. In such procedures, elongate rods are surgically attached to vertebrae of the spine to provide support and/or to realign or reposition certain vertebrae. Such rods are secured to vertebrae utilizing bone screws and other spinal implants. In order to reduce the impact of such surgery on the patient, a desirable approach is to insert such implants percutaneously or with surgical techniques that are minimally invasive to the body of the patient.

(3) Problems arise when implantation tools designed for traditional surgery that is highly invasive are utilized in percutaneous surgery. The tools may be bulky, oversized or have irregular surfaces or protrusions. A projecting actuator arm or fastening member may be useful with respect to the spinal screw implantation process or the rod reduction process, but there is insufficient clearance to use such structure and/or such structure may produce additional invasive trauma which the percutaneous surgery is attempting to avoid.

(4) A percutaneous procedure also presents a problem with implantation of rods that are elongate and have historically required a long incision and open wound in order to provide for the length of the rod and the space required for the surgeon's hands to manipulate the rod. Such problems are then compounded by the implants and insertion tools used with the rod.

(5) Consequently, it is desirable to develop apparatuses and techniques that allow for the insertion of bone screws, the insertion and reduction of a rod into the bone screws and the securing of the rod to the bone screws with significantly less invasion into the body of the patient and with minimal surgical incision of the skin over the operational site.

SUMMARY OF THE INVENTION

(6) A tool assembly and a set of tools according to the invention is provided for percutaneously implanting bone screws and an associated spinal rod in a patient. The tool assembly includes an elongate guide tool with implant engaging members and a multi-purpose installation tool. The multi-purpose tool is a stabilizer for the guide tool implant engaging members which also functions as a rod stabilizer tang container and deployer and a rod pusher and reducer. The guide tool has a lower end configured with opposed implant engaging members for releaseable attachment to a spinal implant bone screw, hook, etc. The multi-purpose installation tool is elongate, and preferably includes a translation nut and attached sleeve which has a lower end for engaging and containing the rod stabilizer tang prior to rod insertion and later pushing on the rod for reduction. The translation nut is coaxial and freely rotatable with respect to the sleeve. The nut is configured for rotatable attachment to an upper end of the guide tool. The multi-purpose installation tool sleeve is attachable or securable to the guide tool in a first bone screw implantation orientation and in an alternative second rod pushing orientation. In the first, bone screw implantation orientation, the sleeve is disposed in a fixed, stationary position with respect to the guide tool, with the sleeve substantially surrounding the guide tool and retaining a flexible tang. In the second or rod pushing orientation, the sleeve is slidable along an axis of the guide tool and the nut can be rotated, thereby translating the rod pushing end between a first location substantially spaced from the guide tool end and a second location near the guide tool end for rod reduction.

(7) The tool assembly may further include a driver having a handle, a guide tool attachment portion and a stem, the stem having an end configured for rotatable engagement with a spinal implant screw. The driver is in coaxial relationship with both the guide tool and the multi-purpose installation tool when the stem is disposed within the guide tool with the guide tool attached to the multi-purpose installation tool. The attachment portion of the driver is configured for rigid attachment to the guide tool, preventing rotation of the driver in relation to the guide tool.

(8) A tool set according to the invention includes at least a pair of end guide tools. Each end guide tool includes an elongate body having opposed implant engaging members with lower attachment structure adapted for attachment to a respective bone screw. The body has an inner surface defining an elongate and laterally opening channel. Preferably, the guide tool body further defines an elongate opening communicating with the channel and a back wall with a flexible holding structure, the wall and holding structure disposed opposite the lateral opening. The back wall flexible holding structure includes first and second elongate and parallel slits in the lower back wall portion creating a movable tab or tang disposed between the first and second slits. The flexible flap or tang partially defines the elongate channel. Furthermore, during insertion procedures, the tang may be pushed so as to flex, hinge or spring at an upper end thereof and so that a lower end angulates and translates outwardly or to a location lateral relative to a remainder of the back wall, with the channel adapted to receive a respective rod therein. When an end of the rod is inserted in the lower end channel, the tang may be resiliently flexed further outwardly to accommodate the length of the rod while maintaining, containing and stabilizing the rod in a desired position relative to bone screws.

(9) The multi-purpose installation tool is attachable to the end guide tool in a first, bone screw implantation configuration position and in an opposite second, rod pushing configuration or position. In the first position, an elongate slot or opening in the sleeve of the tool support is aligned with and fixed in adjacent relationship to the channel opening of the end guide tool, with the sleeve of the tool being held adjacent to the back wall portion and retaining the spring tang. In the second, rod pushing position, the end guide tool back wall portion and the tool sleeve opening are fixed in adjacent relationship with the back wall tang portion protrudable into the tool sleeve opening.

(10) An intermediate guide tool according to the invention includes an end with opposed first and second implant engaging legs defining a longitudinal pass-through opening, passageway or slot for receiving a rod therethrough. When attached to a multi-purpose installation tool in the first, bone screw implantation orientation, the tool sleeve is disposed in a fixed, stationary position substantially surrounding and supporting both the intermediate guide tool legs. In the second or rod pushing orientation, the sleeve is in sliding relation along an axis of the intermediate guide tool, with the sleeve and associated rod pushing end translatable along the first and second legs between a first location

spaced from the intermediate guide tool end and a second location adjacent or near the guide tool end.

(11) A vertebral support rod implantation kit according to the invention, adapted for use with a plurality of vertebrae, includes a plurality of polyaxial bone screws, each bone screw being adapted for implantation in one vertebra, each of the bone screws having an attachment structure. The kit also includes an elongate rod having first and second ends, the rod sized and shaped to extend between a pair of end bone screws of the plurality of bone screws. The kit further includes a plurality of closure tops with each closure top being sized and shaped to mate with a respective bone screw and capture or retain the elongate rod within a cavity or channel defined by the respective arms of the bone screw. Additionally, the kit includes a pair of end guide tools, and may include one or more intermediate guide tools, each guide tool being attachable to multi-purpose installation tools, as described herein and bone screw drivers, the drivers being configured to be rigidly attached to a respective end guide tool or intermediate guide tool.

(12) In a method according to the invention, a spinal fixation tool assembly is assembled by first attaching a bone screw head of a spinal implant screw to a mating attachment structure disposed at a first end of an elongate guide tool implant engaging member, the guide tool defining a laterally opening channel and having a second attachment structure disposed at a second end thereof. The guide tool and attached spinal implant screw are then inserted into a multi-purpose installation tool, the tool having a translation nut and a sleeve. The nut is rotated in a first direction to mate the tool support with the second attachment structure on the guide tool and translate the sleeve to a location near the guide tool first end. Then, a driver is inserted into the guide tool channel, the driver having a handle and a spinal implant screw engagement end. The driver is attached to the guide tool at the second attachment structure with the driver engagement end engaging the spinal implant screw.

(13) A method according to the invention may also include the steps of inserting the attached driver, multi-purpose installation tool, guide tool and spinal implant screw into an incision, especially a minimally invasive incision sized to snugly or closely receive the assembled tools and bone screw, and into contact with a vertebra, followed by turning the driver handle. By turning the handle, the driver, the associated tools and the spinal implant screw are rotated as one assemblage or unit, driving the spinal implant screw into the vertebra.

(14) Further method steps according to the invention include detaching the drivers from the attached guide and multi-purpose installation tools and withdrawing the drivers from the incisions, followed by detaching the multi-purpose installation tools from the end guide tools and thereby deploying the end tangs. It may also be desirable to detach the multi-purpose installation tools from the intermediate guide tools, if any.

(15) According to the invention, during rod insertion, a respective multi-purpose installation tool may be utilized for rod reduction and accordingly replaced on each end guide tool with the sleeve opening thereof aligned with the end guide tool flexible wall or tang to allow the tang to remain flexed outward. Then a rod first end may be inserted into an incision through which one of the end guide tools has been inserted, and then guided into a channel of an adjacent end or intermediate guide tool. The rod is then guided into and through all remaining channels with first and second ends of the rod each in contact with a flexible wall or deployed tang of a respective end guide tool with the tangs biasing against the rod ends, and with the rod extending through all associated guide tools. The multi-purpose installation tool sleeve is then utilized as a rod pusher by rotating the nut and sliding the closed end of the sleeve toward the lower guide tool end, the sleeve end contacting the rod and pushing the rod toward the bone screw.

(16) The attachment structure for joining the guide tool to the bone screw includes radial mating projections and receivers or grooves that allow the guide tool to be twisted on and twisted from the head of the bone screw. For example, an external attachment on the bone screw head can have tapered undercut upper surfaces. It is foreseen that other attachment structure could be used such as clip-on/clip-off, clip-on/twist-off, snap-on/snap-off, snap-on/twist-off, spring-on/spring-off, spring-on/twist-off, set screws, etc. The attachment structure secures the guide tool to the bone screw during

insertion of the screw into bone, but allows the tool to release from the bone screw for removal of the tool at the end of the procedure by rotation of the tool about a central axis thereof or by some other mechanism, as described herein.

Objects and Advantages of the Invention

(17) Therefore, the objects of the present invention are: to provide a compact tool assembly for supporting and installing bone screws and other implants with minimal surgical invasion to the patient; to provide such an assembly wherein a tool providing support and stabilization for implant engaging members of the assembly during bone screw implantation may also be utilized for deployment of rod containment tangs and as a rod reducer; to further provide a set of tools for implanting a spinal rod for support or alignment along a human spine with minimal surgical invasion of the patient; to provide such a set of tools including a pair of end tool guides for slidably guiding opposed ends of the rod toward end bone screws attached to the end guide tools; to provide such a set of tools including intermediate guide tools for each intermediate bone screw that guide the rod in slots therethrough to respective bone screws; to provide such a set of tools including rod and closure top installation tools for assisting in securing the rod in the bone screws; to provide such a set of tools wherein the guide tools are easily attached to and disengaged from the bone screws; to provide such a set of tools wherein the guide tools, guide tool supports or stabilizers, tang containment and deployment tools, rod reduction tools, bone screw installation tools and closure top installation tools are all easily aligned, positioned, and engaged, if necessary, with respect to the bone screw and are disengaged from the bone screw and other tools in the installation assembly by manual manipulation of the surgeon; to provide a method of implanting a rod into bone screws within a patient with minimal surgical invasion of the patient; to provide such a method utilizing the previously described tools for percutaneous implantation of such a rod; and to provide such a set of tools and methods that are easy to use and especially adapted for the intended use thereof and wherein the tools are comparatively inexpensive to produce.

(18) Other objects and advantages of this invention will become apparent from the following description taken in conjunction with the accompanying drawings wherein are set forth, by way of illustration and example, certain embodiments of this invention.

(19) The drawings constitute a part of this specification and include exemplary embodiments of the present invention and illustrate various objects and features thereof.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1** is an exploded front elevational view of a tool assembly according to the present invention showing a driver tool, a multi-purpose installation tool implant engaging member stabilizer sleeve/tang container and deployer/rod pusher and reducer and an end guide tool shown with an attached polyaxial bone screw.

(2) FIG. **2** is an enlarged front elevational view of an intermediate guide tool of the invention.

(3) FIG. **3** is an enlarged side elevational view of the intermediate guide tool of FIG. **2**.

(4) FIG. **4** is an enlarged rear elevational view of the intermediate guide tool of FIG. **2**.

(5) FIG. **5** is an enlarged front elevational view of the end guide tool of FIG. **1**.

(6) FIG. **6** is an enlarged side elevational view of the end guide tool of FIG. **5**.

(7) FIG. **7** is an enlarged rear elevational view of the end guide tool of FIG. **5**.

(8) FIG. **8** is a cross-sectional view of the end guide tool, taken along the line **8-8** of FIG. **5**.

(9) FIG. **9** is an enlarged cross-sectional view of the intermediate guide tool, taken along the line **9**-**9** of FIG. **2**.

(10) FIG. **10** is an enlarged cross-sectional view of the intermediate guide tool, taken along the line **10**-**10** of FIG. **2**.

(11) FIG. **11** is an enlarged bottom plan view of the intermediate guide tool of FIG. **2**.

(12) FIG. **12** is an enlarged and fragmentary perspective view of a polyaxial bone screw of the invention.

(13) FIG. **13** is an enlarged and fragmentary front elevational view of the polyaxial bone screw of FIG. **12**.

(14) FIG. **14** is an enlarged and fragmentary side elevational view of the polyaxial bone screw of FIG. **12**.

(15) FIG. **15** is an enlarged and fragmentary side elevational view of the polyaxial bone screw of FIG. **12** disposed opposite the side shown in FIG. **14**.

(16) FIG. **16** is an enlarged top plan view of the polyaxial bone screw of FIG. **12**.

(17) FIG. **17** is an enlarged and fragmentary front elevational view of the polyaxial bone screw of FIG. **12** and the intermediate guide tool of FIG. **2**, shown at an early stage of a twist-on installation of the intermediate guide tool to the bone screw head.

(18) FIG. **18** is an enlarged and fragmentary cross-sectional view of the intermediate guide tool and polyaxial bone screw installation, taken along the line **18**-**18** of FIG. **17**.

(19) FIG. **19** is an enlarged and fragmentary cross-sectional view similar to FIG. **18**, showing a later stage of the twist-on installation of the intermediate guide tool to the bone screw head.

(20) FIG. **20** is an enlarged and fragmentary cross-sectional view similar to FIGS. **18** and **19**, showing the intermediate guide tool installed on the bone screw head.

(21) FIG. **21** is an enlarged, fragmentary and cross-sectional view, taken along the line **21**-**21** of FIG. **20**, showing the intermediate guide tool installed on the bone screw head.

(22) FIG. **22** is an enlarged front elevational view of the multi-purpose tool shown in FIG. **1**.

(23) FIG. **23** is a cross-sectional view of the multi-purpose tool taken along the line **23**-**23** of FIG. **22**.

(24) FIG. **24** is an enlarged bottom plan view of the multi-purpose tool of FIG. **22**.

(25) FIG. **25** is an enlarged and fragmentary cross-sectional view of a portion of the multi-purpose tool shown in FIG. **23**.

(26) FIG. **26** is an enlarged and fragmentary side elevational view of the driver shown in FIG. **1** having a handle, a nut fastener and a stem, with the nut fastener being shown in a first, unengaged position.

(27) FIG. **27** is an enlarged and fragmentary front elevational view of the driver tool similar to FIG. **26**, showing the nut fastener in a second or intermediate position.

(28) FIG. **28** is an enlarged and fragmentary side elevational view similar to FIG. **27** and further showing a cross-sectional view of the nut fastener, taken along the line **28**-**28** of FIG. **27**.

(29) FIG. **29** is an enlarged cross-sectional view similar to FIG. **23**, showing an early stage of the installation of the multi-purpose tool to the end guide tool (shown in side elevation as in FIG. **6**).

(30) FIG. **30** is an enlarged cross-sectional view similar to FIG. **29**, showing the multi-purpose tool installed to the end guide tool (shown in side elevation).

(31) FIG. **31** is an enlarged cross-sectional view of the multi-purpose tool, taken along the line **31**-**31** of FIG. **30**, showing the end guide tool in front elevation.

(32) FIG. **32** is an enlarged and fragmentary cross-sectional view of the multi-purpose tool similar to FIG. **31**, shown attached to the end guide tool and also showing a sliding engagement stage of attachment to the driver (shown in front elevation).

(33) FIG. **33** is an enlarged and fragmentary front elevational view similar to FIG. **32**, showing the driver nut fastener in the intermediate position shown in FIG. **27**.

(34) FIG. **34** is an enlarged and fragmentary front elevational view similar to FIG. **33**, showing the driver in fixed engagement with the guide tool.

(35) FIG. **35** is an enlarged and fragmentary view similar to FIG. **34**, showing the driver in fixed engagement with the guide tool and with the driver nut fastener shown in cross-section as in FIG. **28**, and the multi-purpose tool shown in cross-section as in FIG. **32**.

(36) FIG. **36** is a partial and generally schematic cross-sectional view of a patient's spine, showing a thin guide pin installed at a first side thereof and a bone screw tap tool and threaded bore made thereby at a second side thereof.

(37) FIG. **37** is a partial and generally schematic view of a patient's spine showing a tool assembly according to the invention with attached bone screw being guided toward the threaded bore in a vertebra in an early stage of a process according to the invention.

(38) FIG. **38** is a partial and generally schematic view of a patient's spine, showing an end guide tool and the multi-purpose tool of the present invention being positioned for use in a process according to the invention.

(39) FIG. **39** is a partial and generally schematic view of a patient's spine, showing a pair of end tools and a pair of intermediate tools of the present invention being positioned for use in a process according to the invention.

(40) FIG. **40** is a partial and generally schematic view of a patient's spine, showing a pair of end tools with the flexible tangs containing a rod which has now been inserted and a pair of intermediate tools of the present invention with one of the intermediate tools shown with an attached multi-purpose tool in a rod reduction application and one of the end guide tools shown partially cut-away, illustrating a closure top installation tool disposed within the end tool and cooperating with a bone screw closure member, the tools being utilized in an early stage of rod implantation to guide the rod toward the bone screws.

(41) FIG. **41** is a partial and generally schematic cross-sectional view of the spine, taken along the line **41**-**41** of FIG. **40**, showing an early stage of implanting a rod according to a process of the invention.

(42) FIG. **42** is a partial and generally schematic view of a patient's spine similar to FIG. **40**, showing cut-away portions of all four tool assemblies, illustrating an intermediate stage of implanting a rod.

(43) FIG. **43** is a partial and generally schematic view of a patient's spine similar to FIG. **42**, showing cut-away portions of three of the tool assemblies and one assembly without an end tool, illustrating the rod fully installed in all the bone screws.

(44) FIG. **44** is an exploded front elevational view of an anti-torque tool assembly according to the present invention showing an antitorque tool and a closure top installation tool cooperating with a break-away bone screw closure member.

(45) FIG. **45** is a bottom plan view of the anti-torque tool shown in FIG. **44**.

(46) FIG. **46** is a fragmentary and front elevational view of a bone screw with attached break-away closure member and installed rod, and further showing the closure top installation tool of FIG. **44** with the anti-torque tool.

(47) FIG. **47** is a fragmentary and front elevational view of a bone screw and anti-torque tool with portions broken away to show a torque driver advancing toward the break-away closure member in a process according to the invention.

(48) FIG. **48** is a fragmentary and front elevational view of the bone screw and anti-torque tool similar to FIG. **47**, with portions broken away to show a fully installed rod and closure member with the break-away head removed from the top by the torque driver.

(49) FIG. **49** is an enlarged fragmentary side elevational view of the bone screw head with the closure installed therein, the closure and bone screw head incorporating the interlocking form according to the present invention with portions broken away to show detail thereof.

(50) FIG. **50** is a view similar to FIG. **49** and illustrates details of first modified bone screw and closure showing a medial bead embodiment of an interlocking form of the present invention.

(51) FIG. **51** is view similar to FIG. **49** and illustrates details of a second modified bone screw and closure showing an axial aligned shoulder embodiment of an interlocking form of the present invention.

(52) FIG. **52** is a view similar to FIG. **49** and illustrates details of a third modified bone screw and closure showing an axial bead embodiment of an interlocking form of the present invention.

(53) FIG. **53** is a view similar to FIG. **49** and illustrates details of a fourth modified bone screw and closure showing a shallow axial bead embodiment of an interlocking form of the present invention.

(54) FIG. **54** is a view similar to FIG. **49** and illustrates details of a fifth modified bone screw and closure showing a radial bead embodiment of an interlocking form of the present invention.

(55) FIG. **55** is a view similar to FIG. **49** and illustrates details of a sixth modified bone screw and closure showing a scalloped depression or scooped embodiment of an interlocking form of the present invention.

(56) FIG. **56** is a fragmentary cross sectional view of a seventh modified bone screw and closure, similar to the embodiment in FIG. **55**, showing a pair of interlocking forms in accordance with the present invention.

(57) FIG. **57** is a fragmentary cross sectional view of an eighth modified embodiment of a bone screw and closure showing a pair of interlocking forms in accordance with the invention.

(58) FIG. **58** is a fragmentary cross sectional view of an ninth modified embodiment of a bone screw and closure showing a pair of interlocking forms in accordance with the invention.

(59) FIG. **59** is a fragmentary cross sectional view of an tenth modified embodiment of a bone screw and closure showing a pair of interlocking forms in accordance with the invention.

(60) FIG. **60** is a perspective view of an example closure for an open headed bone screw that has a helical wound gripping interlocking form in accordance with the present invention mounted thereon.

(61) FIG. **61** is a side elevational view of the closure.

(62) FIG. **62** is a side elevational view illustrating an interlocking form of the closure mated with and installed in a companion interlocking form on an open headed bone screw to capture a fixation rod within a head of the bone screw and with the head of the bone screw partially broken away to illustrate detail thereof.

DETAILED DESCRIPTION OF THE INVENTION

(63) As required, detailed embodiments of the present invention are disclosed herein; however, it is to be understood that the disclosed embodiments are merely exemplary of the invention, which may be embodied in various forms. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a basis for the claims and as a representative basis for teaching one skilled in the art to variously employ the present invention in virtually any appropriately detailed structure.

(64) With reference to FIG. **1**, and for example, also FIGS. **37** and **40**, reference numeral **1** generally designates a tool assembly according to the present invention and reference numeral **2** generally designates a tool set according to the invention, made up of a number and variety of tool assemblies **1** for use in installing a set of bone screws **4** into a patient's spine **6**, followed by the installation of an orthopedic spinal rod or longitudinal member **8** into the bone screws **4** in a process according to the present invention.

(65) The tool assembly **1** includes an end guide tool **9** or an intermediate guide tool **10** mated with a multi-purpose installation tool **12** configured to function as a guide tool stabilizer and supporter, a tang container and deployer and a rod pusher and reducer. The tool assembly **1** may further include a driver **14**. A set **2** of the illustrated embodiment includes a pair of end guide tools **9** and a plurality of intermediate guide tools **10**, which in the illustrated embodiment includes a pair of intermediate guide tools **10** on each side of a patient's spine **6**, but which can include none, one or many intermediate guide tools **10** depending upon the particular application, so that one intermediate guide tool **10** is used for each intermediate bone screw **4** to which the rod **8** is to be attached.

(66) The driver **14** is used in conjunction with the guide tool **9** and the guide tool **10** to implant bone screws **4** in the patient's spine **6** and, in particular, in vertebrae **16** along the spine **6** as shown in FIG. **37**. Each end guide tool **9** and intermediate guide tool **10** is configured to cooperate with the multi-purpose installation tool **12** to install the rod **8**. However, it may be sufficient according to a process of the invention to utilize only one multi-purpose installation tool **12** in a particular tool set **2**, as shown in FIG. **40**. Rods **8** or other longitudinal members are often installed on both sides of the spine **6** during the same procedure.

(67) It is noted that any reference to the words top, bottom, up and down, and the like, in this application refers to the alignment shown in the various drawing figures, as well as the normal connotations applied to such devices, and is not intended to restrict positioning of the assembly **1** or the tool set **2** in actual use.

(68) The end guide tool **9** is illustrated in FIG. **1** and FIGS. **5** through **8**. In particular, each end guide tool **9** has an elongate body **18** that is sized and shaped to be sufficiently long to extend from implanted bone screws **4** through an exterior of a patient's skin **20** so as to provide an outwardly extending and upper handle portion **22** that allows and provides for gripping by a surgeon during procedures utilizing the tool set **2**, with or without an attached multi-purpose installation tool **12** and/or driver **14**.

(69) Each of the end guide tools **9** further includes an intermediate portion **24** and a lower implant engaging portion **26** which includes opposed implant engaging members for securing one the implants there between. Each end guide tool **9** has a substantially flat back wall **28** joining a pair of substantially cylindrically shaped side walls **32** and **33**. The back wall **28** provides a flexible holding structure that includes a pair of parallel slits **34** extending from near the lower handle portion **22** to an end **36** of the tool **9**. When pressed upon by a rod **8**, a flap or flexible tang **38** disposed between the slits **34** in the back wall portion is configured to flex or spring radially outwardly from the bottom and about the top thereof in a deployed position, as is shown in FIG. **6**. The back wall portion flap or tang **38** provides a surgeon with some additional working space and flexibility when working with the rod **8** during surgery, so the rod **8** can extend beyond the bone screws **4** while remaining under resilient tension produced by outward biasing of the flexible back wall portion so that the rod **8** remains in a desired position and

under control. Further, the tang or flap **38** also functions to urge the rod **8** toward the other tools in the tool set **2**, as shown in FIG. **40** and as will be discussed more fully below.

(70) The upper portion **22** of each end guide tool **9** includes a laterally or sideways opening channel **39**, forming a U-shaped cross-section, a C-shaped cross-section, a crescent shaped cross-section or the like having a generally elongate and axially extending opening **40** with a side-to-side width **42**. Preferably, the channel **39** mates with other channel structure described below so as to extend the entire length of the end guide tool **9**. The opening **40** communicates with and forms part of the channel **39** that opens at an upper end **43** of the guide tool **9** and also opens perpendicularly with respect to a central axis of the guide tool **9** or laterally to one side of the end guide tool **9**, thus defining the opening **40**. The opening **40** narrows near the upper end **43** providing a slot **44** having a side-to-side width **45** that is smaller than the side-to-side width **42**. The slot **44** is configured for sliding engagement with a rotational locking pin **46** disposed on the driver **14** and discussed more fully below. Disposed on either side of the slot **44** are co-planar surfaces **47** and **48** that are parallel with the back wall **28**. The surfaces **47** and **48**, as well as the back wall **28**, provide alignment surfaces when the multi-purpose tool **12** is inserted onto the guide tool **9** discussed more fully below.

(71) The opening **40** is of substantially constant width through a mid-section **48** of the handle portion **22**, sufficiently wide to receive additional tools and/or a closure top for sideways loading into the channel **39**, as will be discussed below.

(72) The upper portion **22** also includes an outer helically wound discontinuous guide and advancement structure **50** disposed on outer surfaces of both of the substantially cylindrically shaped side walls **32** and **33**, which may include conventional helically wound V type threads, buttress threads, helically wound square threads, or other guide and advancement structure to cooperate with equivalent or mateable structure within the multi-purpose installation tool **12** and the driver **14**, as described more fully below. The advancement structure **50** extends from near the intermediate portion **24** to the open end **43**. The back wall **28** extending between the threaded sides **32** and **33** has an outer substantially planar and smooth surface finish.

(73) Extending from the upper portion **22** and into the intermediate portion **24** of each end guide tool **9** is an outward facing channel **51** that has an opening **52** with a side-to-side width **53** that is somewhat smaller than the width **42** of the upper handle portion **22**, such that the channel **51** and opening **52** are sized and shaped to receive and allow passage of certain tools and implants, as described below.

(74) Furthermore, a remaining portion of the end guide tool intermediate portion **24** and the lower portion **26** includes a groove or channel **55**, with an elongate, axially extending and radially outward opening **57**, having a side-to-side width **58** that is slightly smaller than the width **42** of the opening **40**, but larger than the slot width **45** and the opening width **53**. The channel opening **57** is disposed opposite the flexible tang or flap **38**. All of the channels **39**, **51** and **55** communicate with one another and are aligned with one another so as to provide a continuous elongate interior and sideways open passageway with an open side from near the top end **43** to near the bottom **36** thereof. This passageway provides a continuous open path of non-uniform cross-sectional radius throughout from the top **43** to the bottom **36** thereof that is parallel to an elongate axis A of each end guide tool **9**. As will be discussed more fully below, each end guide tool channel opening **57** is sized and shaped to slidingly receive a respective end **59** of the rod **8** therein. It is foreseen that one or all of the channel openings forming the open side that extends from near the top end **43** to near the bottom **36** of the guide tool **9** may be sized and shaped to receive the end **59** of the rod **8**. It is also foreseen that the rod **8** may be of uniform or non-uniform diameter, regular or uneven surface construction, or smooth or roughened surface finish, and that the channel openings may in turn be sized and shaped to receive such a rod end that may exhibit a greater or smaller width or diameter than at other locations along the rod.

(75) The slits **34** are spaced in order to have a back wall or flap flex region having a size and shape to allow at least partial passage of a respective end **59** of the rod **8** between the side walls **32** and **33**. Also located near the end guide bottom **36** is a rod abutment recess **61** that is sized and shaped for the purpose of bridging the rod **8** when the end guide tool **9** is rotated for removal, as described below.

However, it is foreseen that other removal means could be used. The end guide tool **9** also receives a closure top **62**, as will be described below. Still further, near the bottom **36** of each of the end guides **9** on inner surfaces of the side walls **32** and **33**, is a helical wound, discontinuous guide and advancement structure **64** which may include conventional helically wound V-shaped threads, buttress threads, reverse angle threads, helically wound square threads, or other guide and advancement structure to cooperate with equivalent or mateable structure within the bone screw heads **4** and on the closure top **62**, as also described below.

(76) At the lower portion **26**, the substantially cylindrical side walls **32** and **33** include an outer radially extending bevel **66** and substantially cylindrical outer side walls **68** and **69**, respectively. The walls **68** and **69** uniformly increase the thickness of the respective side walls **32** and **33**, resulting in a substantially cylindrical cross-section of greater diameter than a diameter created by an outer surface of the side walls **32** and **33** at the intermediate portion **24**.

(77) As will be discussed more fully below, in addition to increasing the diameter, the walls **68** and **69** are configured with co-planar front walls or facets **70** and co-planar back walls or facets **71** with the facets **70** being disposed parallel to the facets **71**, providing for alignment and mating with an interior of the multi-purpose installation tool **12** to ensure that the end guide tool **9** is retained in a selected, non-rotatable position with respect to the multi-purpose installation tool **12** when installed therein. Each of the walls **68** and **69** can include an abutment pin **67** located at an outer surface thereof and near the bottom or end **36**. The pin **67** may serve as a stop for the multi-purpose installation tool **12** as will be described more fully below; however, such a pin stop is not always needed.

(78) Near the end or bottom **36** of each end guide tool **9**, disposed on an inner surface of each of the side walls **32** and **33**, is a radially inward facing attachment structure, generally **72**, that will be described below in conjunction with a similar structure on the intermediate guide tool **10** and the bone screw **4**.

(79) Each of the intermediate guide tools **10**, specifically illustrated in FIGS. **2** to **4**, have a somewhat similar overall shape when compared to the end guide tools **9** in that both are preferably of the same axial length and width and also have much structure in common; however with certain differences as noted. Each intermediate guide tool **10** has an overall elongate body **74** with an upper handle portion **76**, an intermediate portion **77** and a lower implant engaging portion **78** which includes opposed implant engaging members for securing one of the implants there between. In the upper portion **76**, the body **74** is generally C-shaped defining a radially outward opening **79** communicating with an elongate and axially extending channel **80** defined by a rear wall **81** having a lower web edge **96** and side walls **82** and **83**. With reference to FIG. **2**, the channel **80** front opening **79** extends parallel to an axis B of the body **74** and has a side-to-side width **85** configured to receive tools and elements described below.

(80) Similar to the end guide tool **9**, the opening **85** narrows near an upper end **87** providing an elongate slot **88** having a side-to-side width **89** that is smaller than the width **85**. The slot **88** is configured for sliding engagement with the pin **46** disposed on the driver **14** and discussed more fully below. Disposed on either side of the slot **88** are co-planar surfaces **91** and **92** that are parallel with the rear wall **81**. The surfaces **91** and **92**, as well as the rear wall **81**, provide alignment surfaces when the multi-purpose tool **12** is inserted onto the guide tool **10**, discussed more fully below. Below the slot **88**, the side-to-side opening width **85** is substantially constant through a mid-section **90** of the handle portion **76**, sufficient to receive additional tools and/or a closure top, as will be discussed below.

(81) The upper or handle portion **76** also includes an outer helically wound discontinuous guide and advancement structure **93** disposed on outer sides of both of the substantially cylindrically shaped side walls **82** and **83**, which may include conventional helically wound V-threads, helically wound square threads, buttress threads or other guide and advancement structure to cooperate with equivalent or mateable structure within the multi-purpose installation tool **12** and the driver **14** as described more fully below. The advancement structure **93** extends from near the intermediate portion **77** to the open end **87.** An outer surface of the rear wall **81** extending between the threaded sides **32** and **33** is substantially planar and smooth.

(82) The upper or handle portion **76** further includes an outward facing channel **94** communicating with the channel **80**. The channel **94** is defined in part by a rear wall or web **95** having a lower end with the web edge **96**, the wall **95** being integral with the wall **81**. Communicating with the channel **94** is an elongate and axially extending opening **98** having a side-to-side width **99** that is somewhat smaller than the width **85** of the opening **79**. The opening **98** is further defined by the walls **82** and **83**. The channel **94** and opening **98** are configured to receive, contain and allow translational movement therealong or rotational relative movement of certain tools, as described more fully below. Although not shown in the drawings, it is foreseen that the channel **94**, channel opening **98** and rear wall or web **95** may extend into the intermediate portion **77** to provide greater strength and stability to the lower portion **78** of the intermediate tool **10**, with the opening **98** also extending into the lower portion **78** providing greater retention of small tools or parts being inserted through the channel **94**.

(83) The intermediate portion **77** of the intermediate tool **10** includes two spaced side walls or legs **102** and **103**, extending from and integral with the side walls **82** and **83**, respectively. The legs **102** and **103** have outer surfaces that are partially cylindrical.

(84) Similar to the end tool **9**, at the juncture of the intermediate portion **77** and the lower portion **78**, each of the legs **102** and **103** include an outwardly facing radially extending bevel **106** integral with substantially cylindrical outer side walls **107** and **108**, respectively. The outer walls **107** and **108** extend along the length of the lower portion **78** and uniformly increase the thickness of the respective legs **102** and **103**, resulting in a substantially cylindrical cross-section of greater outer diameter at the lower portion **78** than an outer diameter created by the outer surfaces of the legs **102** and **103** along the intermediate portion **77**. As will be discussed more fully below, in addition to increasing the diameter, the walls **107** and **108** are configured with co-planar front facets or walls with flat surfaces **109** and co-planar rear facets or walls with flat surfaces **110**, the facets **109** disposed parallel to the facets **110**, providing for alignment with an interior of the multi-purpose installation tool **12** to ensure that the intermediate guide tool **10** is properly mated with and retained in a selected, non-rotatable position with respect to the multi-purpose installation tool **12** when installed therein.

(85) Along both the intermediate and lower portions **77** and **78** of the intermediate tool **10**, the legs **102** and **103** define an elongate and axially extending passthrough slot **111** sized and shaped to slidingly receive the rod **8**. The slot or opening extends from the lower edge of the web end **96** of the rear wall **95** to an open end or bottom **112** of the tool **10** configured to secure an open ended spinal surgery implant there between.

(86) Near the bottom **112** of each implant engaging leg member **102** and **103** of the intermediate guide tool **10** is a helically wound but discontinuous square thread **114** and it is foreseen that other type of guide and advancement structure may be utilized such as helically wound flange forms, reverse angle threads, buttress threads, etc. The thread form **114** cooperates with the closure top **62**, as described below. The lower end of each leg **102** and **103** of the intermediate guide tool **10** also includes a cutout or rod-abutment recess **116** similar to the recess **61** described with respect to the end tool **9**. Each of the walls **107** and **108** can include an abutment pin **118** located at an outer surface thereof and near the bottom or end **112**. The pin **118** may serve as a stop for the multi-purpose installation tool **12** as will be described more fully below.

(87) Also near the end or bottom **112** of each leg **102** and **103** of the intermediate guide tool **10**, disposed on inner substantially cylindrical surfaces **120** and **121**, respectively, is a radially inward facing attachment structure, generally **124**, substantially similar to the structure **72** disposed on the end guide tool **9**. The structure **124** will be described herein in conjunction with the bone screw **4**.

(88) With reference to FIGS. **9**-**11**, the embodiment shown includes an attachment structure **124** having a first projection, stop or pin **126** in spaced relation with a second smaller projection, stop or pin **127**, both pins being disposed on the surface **120**. In the embodiment shown, the structure **123** further includes a cooperating third projection, stop or pin **130** in spaced relation with a fourth smaller projection, stop or pin **131**, the pins **130** and **131** being disposed on the surface **121**.

(89) The larger pins **126** and **130** are substantially configured the same, both being substantially rounded, radially inward projecting nodules, each having a ridge or lip **132** and **133**, respectively, projecting upwardly toward the guide and advancement structure **114** and that preferably follows the curvature of the respective leg inner surface **120** and **121**.

(90) The lips **132** and **133** with respective surfaces **120** and **121** define slots **134** and **135**, respectively, for receiving the bone screw **4** as will be discussed more fully below. The pin **126** is configured slightly larger than the pin **130**, requiring similar modification in the bone screw **4**, resulting in a method of operation wherein the bone screw **4** may only be mated with the guide **9** or **10** from a single direction, ensuring appropriate alignment between the bone screw **4** and guide tool advancement structure **114** with respect to the installment of the closure top **62**.

(91) Each of the larger pins **126** and **130** is also disposed at substantially the same distance from respective bottom surfaces **138** and **139**, at the end **112** of the guide tool **10** and adjacent a rod-abutment recess **116**. Furthermore, each of the larger pins **126** and **130** is also disposed at substantially the same distance from respective parallel seating surfaces **140** and **141**, that form a base of the guide and advancement structure **114**. Additionally, in this embodiment the pins **126** and **130** are disposed in diametrically opposed relation when viewed in cross-section as shown in FIG. **10**.

(92) The smaller pins **127** and **131** are also substantially configured the same, the pin **131** being slightly larger than the pin **127**, but otherwise both pins **127** and **131** being substantially rounded, radially inwardly projecting nubs, each disposed at substantially the same distance from the respective bottom surfaces **138** and **139** and the respective seating surfaces **140** and **141**. Furthermore, the pins **127** and **131** are disposed in diametrically opposed relation when viewed in cross-section as shown in FIG. **10**. Each of the pins **127** and **131** are disposed closer to the respective end surfaces **138** and **139** than are the larger pins **126** and **130**. It is noted that other orientations and pin sizes may be utilized according to the invention, with the pin sizes and locations cooperating with respective features on the bone screws **4**. Preferably, the pins are of different sizes to provide for mating of the guide tool **9** or **10** with the bone screw **4** from a single direction, resulting in a desired alignment between the bone screw **4** guide and advancement structure **114** and the closure top **62** guide and advancement structure.

(93) The pins **126**, **127**, **130** and **131** cooperate and mate with the bone screw **4**, at a receiver portion, generally identified by the reference numeral **145**, of a head **146** thereof. With reference to FIGS. **12-15**, each of the bone screws **4** further includes a threaded shank **148** attached to the head **146**, the shank **148** for screwing into and seating in a vertebra **16** that is part of the human spine **6**. The head **146** includes first and second arms **150** and **151** that define a rod receiving channel **153** passing therethrough. Each of the bone screw shanks **148** includes an upper portion **154** that extends into the head **146** and is operationally secured therein, so that the head **146** is rotatable on the shank **148** until locked in position through engagement with the rod **8** under pressure.

(94) The receiver portion **145** is disposed on outer surfaces of the arms **150** and **151**. The receiver portion **145** of arm **150** includes a slot or groove **158** communicating with a recess **159** defined in part by a flange **160**. The groove **158** and recess **159** open at a front surface **162** of the arm **150** and extend across a facet **163** and into a side surface **164** thereof. With reference to FIG. **21**, the groove **158** is configured to mate with the large pin **126** with the lip **132** extending into the recess **159** and the flange **160** disposed in the slot **134** when the guide tool **10** is attached to the bone screw head **146**. The width of the slot **134** is sized to prevent passage therethrough of the pin **126** except by twisting or rotational relative movement therebetween. The receiver portion **145** of the arm **150** further includes a rounded aperture **165** disposed substantially centrally on a face or facet **167** of the arm **150**, the facet **167** disposed adjacent to the side surface **163**. The aperture **165** is configured to mate with the small pin **127**.

(95) Similar to the arm **150**, the receiver portion **145** of the arm **151** defines a groove **168** communicating with a recess **169** defined in part by a flange **170**. The groove **168** and recess **169** open at a back surface **172** of the arm **151** and extend across a facet **173** into a side surface **174** thereof.

(96) Similar to what is shown in FIG. **21** with respect to the arm **150**, the groove **168** is configured to mate with the large pin **130** with the lip **133** extending into the recess **169** and the flange **170** disposed in the slot **135** when the guide tool **10** is attached to the bone screw head **146**. The receiver portion **145** of the arm **151** further includes a rounded aperture **175** disposed substantially centrally on a face or facet **177** of the arm **151**, the facet **177** disposed adjacent to the side surface **173**. The aperture **175** is configured to mate with the small pin **131**.

(97) In the embodiment shown, to attach the bone screw head **146** to the guide tool **10**, the guide tool **10** is rotated about its axis B such that the legs **102** and **103** are lowered into place as shown in FIGS. **17** and **18**, with the facets **167** and **177** of the head **146** disposed between the guide tool legs **102** and **103**, with the facet **167** adjacent the leg **102** and the facet **177** adjacent the leg **103**, thereby aligning the groove **158** with the large pin **126** and the groove **168** with the large pin **130**. The head **146** may then be twisted into place as shown by the arrow T in FIGS. **18**, **19** and **20**. The legs **102** and **103** may splay slightly as the head is twisted into place, but come to rest in a generally non-splayed configuration and held in place by the structure of the attachment mechanism to resist splaying.

(98) In order to disengage the guide tool **9** or the guide tool **10** from the bone screw **4**, the guide tool **9**, **10** is rotated counterclockwise from an attaching configuration (opposite to the arrow T), when viewing from the top so as to disengage the lips **132** and **133** from the recesses **159** and **169**, respectively. In this manner, end guide tools **9** and intermediate guide tools **10** that have previously twisted on, now twist off of respective bone screws **4**.

(99) While a preferred embodiment of the invention has the respective pins of the attachment structure on the guide tools and the grooves on the bone screw heads, it is foreseen that these elements could be reversed in total or part in accordance with the invention. Also, other suitable attachment structure could be used, such as sloped or tapered undercut surfaces on the screw heads that overlap, mate and interlock with radially or linearly projecting structure on or near the ends of the guide tools. Such projecting structure can be snapped on or clipped on and translated up to provide for anti-splay overlapping surfaces.

(100) In the embodiment shown, the recesses **61** and **116** disposed on the respective guide tools **9** and **10** are sized, shaped and positioned so that when the rod **8** is located in the bone screws **4**, the guide tools **9** and **10** can rotate about respective axes A and B, with the recess **61** and **116** allowing the respective guide tool **9** and **10** to straddle over the rod **8**, thereby allowing the guide tool **9** and **10** to twist relative to the bone screw **4** and free the attachment structures **72** and **124** from the receiver portion **145** of the bone screw **4** and thereafter be removed after all procedures are complete, as described below.

(101) The closure top **62** closes between the spaced bone screw arms **150** and **151** to secure the rod **8** in the channel **153**. The closure top **62** can be any of many different plug type closures. With reference to FIGS. **46-48**, preferably the closure top **62** has a cylindrical body **180** that has a helically wound mating guide and advancement structure **181**. The guide and advancement structure **181** can be of any type, including V-type threads, buttress threads, reverse angle threads, or square threads. Preferably the guide and advancement structure **181** is a helically wound flange form that interlocks with a reciprocal flange form as part of a guide and advancement structure **183** on the interior of the bone screw arms **150** and **151**.

(102) A suitable locking guide and advancement structure of this type is disclosed in U.S. Pat. No. 6,726,689 from Ser. No. 10/236,123 which is incorporated herein by reference. Referring to FIGS. **49** to **59**, the reference numeral **400** generally designates a gripping interlocking form arrangement incorporating a non-linear or compound surface which embodies the present invention. The interlocking form arrangement **400** includes an external interlocking form **402** and internal interlocking form **404** which have respective thrust surfaces **406** and **408** (FIG. **4**) and which are used as pairs. The interlocking form arrangement **400** may be used on any of a number of interlocking formed devices, such as an implanted bone fixation system, including a receiver or open headed implant member which receives a closure or closure member to secure a fixation member therein. In the interlocking form arrangement **400**, the thrust surfaces **406** and **408** are non-linear or compound in

such a manner as to resist tendencies of arms **432**, for example, to splay or expand when the closure member **410** is rotated therein.

(103) The interlocking forms **402** and **404** are helical and are intended to advance the closure member **410** linearly along the axis of rotation **412** of the closure member **410** and the interlocking forms **402** and **404** relative to another member as the closure member **410** is rotated relative to a bone screw **4**. A spatial reference for such rotation and linear movement is along the axis **412** (FIG. **49**). The axis **412** locates the coincident axes of the external or radially outward interlocking form **402** of a base **410** (e.g., a closure member **410**) and the internal or radially inward interlocking form **404** of a head **414**, when the base **410** is inserted into the head **414** by starting at the top of the interlocking form **404** (top is up in FIG. **49**) and rotated. The base **410** has a basic cylindrical shape, and the external interlocking form **402** includes a root **416** and a crest **418** formed by cutting a helical wound channel of the desired cross section into the original surface of the base **410**. The crest **418** of the external interlocking form **402** has a greater radius than the root **416**. In a like manner, the internal interlocking form **404** of the head **414** of a screw **4** has a helical channel under cut thereinto, forming a root **420** and crest **422**. The root **420** of the internal interlocking form **404** has a greater radius than the crest **422**.

(104) The thrust surfaces **406** and **408** respectively of the external and internal interlocking forms **402** and **404** engage frictionally when the base **410** is rotated into the head **414**. The thrust surfaces **406** and **408** are located on the trailing sides respectively of the crests **418** and **422**, as referenced to the tightening direction movement of the base **410** into the head **414**. In general, there is minimal contact between the clearance surfaces **424** and **426** when the base **410** is rotated in a tightening direction into the screw head **4** to allow rotation. The clearance surfaces **424** and **426** may frictionally engage when the base **410** is rotated in a reverse direction to remove it from the screw head **414**.

(105) Frictional engagement of the thrust surfaces **406** and **408** due to rotation causes the base **410** to be advanced linearly along the axis **412** into the screw head **414**. However, once the base **410** “bottoms out” by contact of a lower surface **428** or a set point **430** with a rod **432** and the rod **432** is unbent and pushed downwardly as far as it will go into a channel or seat of the head **414**, further rotation of the base **410** cannot result in further linear movement of the base **410** within the head **414**. The interlocking forms **402** and **404** thereafter are radially locked together and each turn or pass of the forms **402** and **404** is preferably sufficiently snug with respect to turns of the opposite interlocking form to prevent either form **402** or **404** from slipping or sliding radially past one another upon application of additional torque or with application of forces due to usage by the patient.

(106) The various compound, complex, or non-linear interlocking form arrangements of the present invention are intended to resist splaying tendencies of the arms **432**. In particular, each thrust surface **406** and **408** of the interlocking forms **402** and **404** have a gripping, blocking or splay resisting surface **434** or **436** respectively which is oriented in such a direction as to resist splaying of the arms **432** of the screw head **414** when the base **410** is rotated to a high degree of torque. On the external interlocking form **402**, the splay resisting surface **434** is directed generally toward or faces the axis **412**. Conversely, on the internal interlocking form **404**, the splay resisting surface **436** is directed generally away from or faces away from the axis **412**. Each of the surfaces **434** and **436** in this manner wrap over or around the opposite and block substantial radially relative movement there between. It is especially noted that the surfaces **434** and **436** are extensions of the interlocking forms **402** and **404** in an axial direction (that is parallel to the axis **412** or up and down as seen in FIG. **49**). This axial extension is spaced away from the juncture of the interlocking forms **402** and **404** with the base **410** and screw **4**. It is foreseen that such an extension can take many shapes and configurations (some of which are shown herein) and may also functionally be depressions or grooves. In each case the paired interlocking forms, such as forms **402** and **404**, overlap each other and are snug about each other so as to prevent substantial relative radial slippage or movement between them during and after assembly of the base **410** into the bone screw **4**.

(107) FIG. **50** illustrate a non-linear or compound thrust surface interlocking form arrangement **438** which is of a medial bead interlocking form type. The interlocking form arrangement **438** is a thrust surface **406** located on a plug **410** and internal interlocking form **404** with thrust surfaces **408** within a head **414** of a bone screw **4**. The thrust surfaces **406** and **408** are contoured to provide

complementary, interacting, splay resisting surfaces **434** and **436** on the external and internal interlocking forms **402** and **404** respectively. The external interlocking form **402** is provided with a bead **440** on the thrust surface **406**, and the internal interlocking form **404** is provided with a complementary channel or groove **442** formed into the thrust surface **408**. The illustrated thrust surfaces **406** and **408** are substantially perpendicular to the axis **412**; however, such surfaces may alternatively be angled somewhat with respect to the axis **412** so as to slope downward or upward as the surface extends radially outward.

(108) The bead **440** is located at a radius which is between or medial with respect to the root **416** and crest **418** of the external interlocking form **402**. Similarly, the groove **442** is located at a radius which is medial to the root **420** and crest **422** of the internal interlocking form **404**. The illustrated bead **440** and groove **442** are rounded and somewhat triangular in cross section. Alternatively, the bead and groove **440** and **442** could be pointed and triangular, squared off, or semicircular. It should also be noted that the bead and groove **440** and **442** could be replaced by a medial groove formed in the external interlocking form **402** on the thrust surface **406** and a medial bead formed on the thrust surface **408** of the internal interlocking form **404**. An inwardly facing surface **444** of the bead **440** forms the splay resisting surface **434** thereof, while an outwardly facing surface **446** of the groove **442** forms the splay resisting surface **436** of the groove **442**. Engagement of the splay resisting surfaces **444** and **446**, respectively of the bead **440** and groove **442**, resists tendencies of the arms **432** of the screw head **414** to splay when the closure base **410** is rotated into the head **414**.

(109) FIGS. **51** to **59** illustrate further variations in the paired interlocking forms of the present invention. In each case the base closure and bone screw, except as noted with respect to the interlocking forms, of the variations shown in FIGS. **51** to **59** are essentially the same as those shown in FIG. **49**, so only differing detail of the interlocking form structure will be described in detail and reference is made to the description given for FIG. **49** for the remaining detail.

(110) In FIG. **51**, a guide and advancement structure **448** includes the external interlocking form **450** having an axially aligned shoulder or flange-like shaped configuration when view in cross section in a plane passing through an axis of rotation **452**. The interlocking form **450** has a thrust surface **454** on a base **456**. The structure **448** also has an internal interlocking form **458** with a thrust surface **460** within the head **462** of a bone screw **464**. The internal interlocking form **458** has a root **466** and a crest **468**, while the external interlocking form **450** includes a root **470** and crest **472**. The thrust surface **454** of the external interlocking form **450** includes an axially oriented or cylindrical shoulder **474** which forms a splay resisting surface **476** thereof.

(111) Similarly, the thrust surface **460** of the internal interlocking form **458** includes a mating or complementary axially oriented or cylindrical shoulder **478** which forms a splay resisting surface **480**. Engagement of the splay resisting surfaces **476** and **480** resists tendencies of the arms **482** of the head **462** to splay when the plug or base **456** is rotated into the head **462** and torqued tightly or at later times during usage. It is foreseen that a variation of the axial shoulder interlocking form would provide shoulders at inclined angles (not shown) to the axis **412**. The illustrated splay resisting shoulder **474** is formed by a rectangular cross section bead **484** formed on the thrust surface **454** of the external interlocking form **450**. Similarly, splay resisting shoulder **478** is formed by a somewhat rectangularly cross section shaped bead or foot portion **486** adjacent a groove **488** for receiving bead **484** and formed in the thrust surface **460** of the internal interlocking form **458**. The interlocking forms **450** and **458** have a general flange-like shape configuration when viewed in cross section that is also some what L-shaped with the beads **484** and **486** forming feet of the flange shape that overlap and lock so as to prevent substantial radial movement of the arms **482** of the bone screw **464** relative to the closure plug base **456**. FIGS. **52** and **53** illustrate further variations of the axial shoulder interlocking structure **490** and **508** respectively in the form of a rounded axial bead interlocking form **492** shown in FIG. **52** and a shallow rounded axial bead interlocking form **510** in FIG. **53**. The rounded axial bead interlocking form **492** includes a rounded bead **493** projecting in a direction parallel to an axis **495**. The bead **493** is formed on a thrust surface **494** of an external interlocking form **496** and a rounded groove **498** is formed on a thrust surface **500** of an internal interlocking form **502**. The bead **493** includes a splay resisting surface **504**, while the groove **498** also includes a splay resisting surface **506**.

(112) In a similar manner, the shallow rounded axial bead interlocking form **508** includes a shallow rounded bead **510** formed on a thrust surface **512** of an external interlocking form **516** and a shallow rounded groove **514** formed on a thrust surface **517** of an internal interlocking form **518**. The bead **510** includes a splay resisting surface **520**, and the groove **514** includes a splay resisting surface **522**. The surfaces **520** and **522** engage and abut to resist splaying or significant radial separation movement therebetween.

(113) FIG. **54** illustrates a radial bead embodiment of an implant **524** having a guide and advancement structure **526**. The structure **526** includes a rounded external and bead interlocking form **528** projecting radially from a base **530** and forming a crest **532**. The bead interlocking form **528** has a pair of splay resisting surfaces **536** facing generally toward an axis **534** of rotation of the base **530**. A complementary groove internal interlocking form **538** is part of a screw head **540**. The head interlocking form **538** has a pair of splay resisting surfaces **542** facing generally away from the axis **534**. The structure **526** has the splay resisting surfaces **536** and **542** on thrust surfaces **544** and **546** respectively of the interlocking forms **528** and **538**, as well as on clearance surfaces **548** and **550** thereof. The illustrated radial bead interlocking form **524** is, in some ways, a double sided variation of the rounded axial bead interlocking form of an earlier embodiment.

(114) FIGS. **55** and **56** illustrate a scalloped or scooped embodiment structure **572** including a pair of compound interlocking forms **552** and **554** according to the present invention. The interlocking form **552** is scalloped and, in effect, an inversion of the shallow rounded bead interlocking form similar to that of an earlier embodiment. The interlocking form **554** includes a shallow groove **556** formed in a thrust surface **558** of the external interlocking form **552** of a base **560** and a shallow bead **562** formed on a thrust surface **564** of the interlocking form **554** of a screw head **566**. The groove **556** has a splay resisting surface **568** which cooperates with a complementary splay resisting surface **570** of the bead **562**.

(115) Illustrated in FIG. **57** is another guide and advancement structure **600** associated with a receiver member **601** and a closure member, such as a plug, **602** that is rotated into the receiver member **601**. The structure **200** includes a first interlocking form **605** and a second interlocking form **606** attached to the closure member **602** and receiver member **601** respectively.

(116) The first interlocking form **605** includes an arcuate upper surface **607** with a gripping or locking section **608**. The second interlocking form **606** includes an arcuate lower surface **609** with a gripping or locking section **610**. The interlocking forms **605** and **606** also have respective lower or leading surfaces **614** and **615** respectively that are sufficiently spaced to allow rotation about the axis thereof, but sufficiently close to be snug and not allow substantial movement of the forms **605** and **606** relative to each other in an axial direction without rotation.

(117) FIG. **58** shows an alternative flange shaped embodiment of a guide and advancement structure **630** in accordance with the invention. The structure **630** is mounted on a closure **631** and a receiver **632** so that interlocking forms **633** and **634**, which are seen in cross section, are helically mounted on the closure **631** and receiver **632** respectively.

(118) The first interlocking form **633** is L or flange-shaped in cross section with a vertically or axially extending foot portion **640** with a gripping surface **641**. The second interlocking form **634** generally complements the first and is also L or flange shaped except that a foot **643** thereof is much wider than the foot portion **640**. The foot **643** has a gripping or wraparound surface **645** that abuts the surface **641** during assembly and resist radial movement between the receiver **632** and the closure **631**.

(119) Shown in FIG. **59** is another embodiment of a guide and advancement structure **660** in accordance with the invention. The structure **660** is utilized with a receiver **661** and a closure or plug **662**. The structure **660** has first and second interlocking forms **663** and **664**. The first interlocking form has an elongate wall **668** with a circular bead **669** attached to an end thereof opposite the closure **662**. The bead **669** has opposed gripping surfaces **670** and **671**. The second interlocking form **664** is shaped to mate with and generally surround the first interlocking form **663** except sufficient clearance is provided to allow the closure **662** to be rotated and advanced into the receiver **663** by sliding

tangentially, but not radially. The second interlocking form **664** has a circular cross section channel **672** that receives the bead **669** and a pair of gripping surfaces **673** and **674** that engage and abut against the bead surfaces **670** and **671**.

(120) It is foreseen in accordance with the invention that certain regions of the interlocking forms may be eased or removed to allow for easier use which still maintaining the primary objective of resisting radial movement between the closure plug and the opposed arms of the bone screw to prevent splaying of such arms.

(121) It is also seen in accordance with the invention that the axial aligned extension or depression on the described interlocking forms could in some cases be multiple in nature or formed by an undulating pattern.

(122) Turning back to FIGS. **46-48**, the helically wound guide and advancement structures **64** and **114** in the respective guide tools **9** and **10** are sized and shaped to receive the mating guide and advancement structure **181** of the closure top **62** and align with the guide and advancement structure **183** of the bone screw **4** to form a generally continuous helically wound pathway, but does not require locking between the closure top **62** and the tools **9** and **10**, even when an interlocking flange form is utilized on the closure top **62**.

(123) The guides **64** and **114** allow the closure top **62** to be rotated and the surgeon to develop mechanical advantage to urge or drive the rod **8**, while still outside or partially outside the bone screw **4**, toward and into the bone screw head **146**. This is especially helpful where the rod **8** is bent relative to the location of the vertebra **16** (which is sometimes the case) to which the rod **8** is to attach and is not easily placed in the bone screw head **146** without force and the mechanical advantage provided by the guides **64** and **114**. In particular, the guide and advancement structures **64** and **114** on the respective tools **9** and **10** are located and positioned to align with the guide and advancement structure **183** on the insides of the bone screw arms **150** and **151**, as shown in FIG. **42** and pass the closure top **62** therebetween while allowing the closure top **62** to continue to rotate and to continuously apply force to the rod **8**, so as to aid in seating the rod **8** in the bone screw head **146**.

(124) Each closure top **62** also preferably includes a break-off head **186** that breaks from the cylindrical body **180** in a break-off region **187** upon the application of a preselected torque, such as 95 to 120 inch-pounds. The break-off head **186** preferably has a hexagonal cross section faceted exterior that is configured to mate with a similarly shaped socket of a final closure driving or torquing tool **190** described below. It is foreseen that different driving heads or other methods of driving the closure top **62** can be utilized with certain embodiments of the invention, such as non-break-off closure top designs.

(125) Turning to FIGS. **60-62**, another example closure member **600** is illustrated. The closure member **600** includes a plug, base section or base **602** and a break off head section **604** that breaks from the base **602** at a preselected torque. It is foreseen that such a closure could be made without a breakoff head and other structure could be added for torquing or removing the base section. Furthermore, it is foreseen that such a base both captures the rod and locks the rod as in the embodiment illustrated in FIG. **60** to **62** or, alternatively, that the base could just capture the rod and a set screw could be used in a threaded bore in the base to lock the rod in place. The base section **602** is provided with the external interlocking form **402**, as described above, which is compatible with the internal interlocking form **404** of the bone screw head **606**. Both interlocking forms **402** and **404** are helically wound and rotatably mateable together through rotation or turning of the closure member **600** about the central axis **412** thereof. The head **608** includes structure for positive engagement by an installation tool (not shown) to install the closure member **600** in the bone screw member **610**. The structure that allows for installation of the illustrated break off head **604** includes faces **612** forming a hexagonal shape or “hex” head to receive a complementary hexagonally shaped installation driver or tool. The head **604** also includes a central bore **614** and a cross bore slot **616**. The outer end of the head **604** is chamfered at **618**, and the bore **614** is provided with an interior conical countersink at **620**. The region where the head **604** meets the base **602** is reduced in cross sectional thickness to form a weakened breakaway or fracture region **622**. The breakaway region **622** is designed so that the head

604 separates from the base **602** when a selected torque is applied by the installation tool, as is diagrammatically illustrated by breaking away of the head **604** in FIG. **62**. The base **602** is preferably provided with structure to facilitate removal of the base **602** from the implant head **606**, such as the illustrated removal bores **624**. The bores **624** may be formed by drilling from a lower end surface **626** of the plug **602**, since an upper end surface **628** of the plug **602** is normally not accessible for drilling the bores **624** prior to break-off of the head **604**. It is foreseen that many different types of removal devices or structures can be utilized with the base such as: axially aligned bores with hex, torx or other multifaceted cross-section, step down bores for engagement by an easy out, bores at the periphery or non axially aligned on the face of the base, bores with a left handed thread or the like. Further, the same structure used to torque the base on installation may be used to remove the base.

(126) The base **602** is rotated into the receiving member of the bone screw head **606** to clamp the fixation rod **608** therein for any of a variety of surgical purposes. In general, the rod **608** is used to fix the position of a bone or portion of a bone, such as a plurality of vertebrae. The rod **608** may be anchored relative to some vertebrae and, in turn, used to secure other vertebrae in desired positions or orientations or used to properly align a series of vertebrae. It is generally required that the union formed between the bone screw **610**, closure **600** and the rod **608** be very tight or snug to avoid relative movement therebetween. The fixation system **630** preferably employs structure that positively engages and seats the head **606** and/or the base **602** with respect to the rod **608**, such as a conical set point **632** formed on the bottom surface **626** of the base **602** which engages the rod **608**. The point **632** positively “bites” into the surface of the rod **608** to help prevent rotational or axial movement of the rod **608** relative to the screw **610**. Alternatively or in combination with a point **632**, other structures may be used to positively engage the closure plug **602** with the rod **608**, such as a sharp edged coaxial ring (not shown) having a V-shaped cross section formed on the lower surface **626** of the base **602** or point extending upwardly from the channel.

(127) The present invention is not intended to be restricted to a particular type of bone screw or bone screw closure mechanism. In the present embodiment, a polyaxial type bone screw **4** is utilized wherein the shank **148** is locked in position by direct contact with the rod **8**. It is foreseen that the tool set **2** of the present invention can be used with virtually any type of bone screw, including fixed monoaxial and polyaxial bone screws of many different types wherein the head is locked relative to the shank by structure other than in the manner described in the illustrated embodiment.

(128) With reference to FIGS. **22-25**, the multi-purpose installation tool **12** of the tool assembly **1** of the invention includes an upper translation nut **202** rotatably and free wheeling ably attached to a lower guide tool stabilizer or support sleeve **204**. The sleeve **204** has an inner substantially cylindrical surface **205** defining a substantially hollow passageway **206** sized and shaped to slidingly receive an end tool **9** or an intermediate tool **10** therein. Alternatively, is foreseen that the sleeve could have an inner and outer planar surface. The sleeve **204** is elongate and includes a receiving end **207**, a substantially cylindrical outer body **208** and a translation nut attachment end portion **210** disposed opposite the receiving end **207**. The receiving end **207** not only functions to receive the guide tool **9** or **10** into the sleeve **204**, but also as a pressing block **218** for contacting the flexible flap or spring tang **38** and as a pressing end **207** for contacting the rod **8** and translating the rod **8** toward the bone screw head **146** when the multi-purpose installation tool **12** is installed on the guide tool **9** or **10**, as will be discussed more fully below.

(129) The cylindrical body **208** further defines a slotted U-shaped or C-shaped channel **212** that opens radially at an opening **213** and also opens at the receiving end **207** and extends substantially along a length of the body **208** to a location **214** spaced from the nut attachment end portion **210**. The channel opening has a side-to-side width **216** sized to receive the back wall tang portion or flexible flap **38** of the end guide tool **9** therethrough, when aligned therewith. For example, with reference to FIG. **38**, the multi-purpose installation tool **12** is shown partially removed from an end guide tool **9** and deploying the tang **38** after the bone screw has been inserted. Because of the substantial length of the channel **212** as defined by the location **214** and because of the channel width **216**, the multi-purpose installation tool **12** can be removed, turned 180? and reattached to the end guide tool **9** thereby providing access through the channel opening **213** for protrusion of the back wall tang portion or flap **38** of the end guide tool **9**. The flap **38** is thus not encumbered or restricted by the tool **12** during the

rod pushing application and the flap **38** can be flexed outwardly by a rod **8** (not shown) or other forces, when the devices are assembled in this configuration.

(130) Disposed flush to the lower sleeve end **207** and rigidly attached to the inner cylindrical surface **205** is the solid guide tool alignment and tang/rod pressing block **218**. The block **218** has a substantially smooth, planar and rectangular surface **220** facing inwardly radially from the inner surface **205**. The block **218** also follows the curve of the cylindrical surface **220** at a surface **222** thereof. Thus, as shown in FIG. **24**, the block **218** has a segment shape when observed from a bottom plan view. The term segment used herein is defined as the part of a circular area bounded by a chord and an arc of a circle cut off by the chord. This segment shape of the block **218** provides a mechanical advantage for compressing the flexible flap **38** flush with the end guide tool **9** and for advancing the rod **8** into the bone screw **4** with the multi-purpose installation tool **12** which will be discussed more fully below.

(131) The flat, rectangular surface **220** provides structure for installing the guide tool **9** or **10** in a mating and desired alignment with respect to the multi-purpose installation tool **12**. For example, with respect to the guide tool **10**, a preferred alignment is that the rear wall **81** of the tool **10** be disposed adjacent to the surface **220** when inserting the tool **10** into the multi-purpose installation tool **12**. Then, the tool **10** is slid into the multi-purpose tool sleeve **204**, with the block **218** preventing axial rotation of the tool **10** with respect to the sleeve **204**, and resulting in the preferred alignment of the opening **79** and the pass-through slot **11** of the tool **10** and the U-shaped channel **212** of the multi-purpose tool in this application.

(132) With respect to the end guide tool **9**, the block **218** with the planar surface **220** provides for the insertion of the tool **9** in a first, installation tang containing position or a second, rod pushing position. When utilizing the assembly **1** of the invention to install a bone screw **4**, it is advantageous for the flexible back wall portion or tang **38** of the tool **9** to be fully restrained by the multi-purpose installation tool **12** and for the walls **68** and **69** to be locked in a non-splayable or anti-splay position. Therefore, in the first, bone screw installation tang containing position, the multi-purpose installation tool **12** is inserted onto the tool **9** with the back wall **28** of the tool **9** disposed adjacent to the sleeve surface **220**. Then, the tool **9** and the sleeve **204** are attached with the block **218** preventing axial rotation of the tool **9** with respect to the multi-purpose installation tool **12**. This results in the preferred alignment wherein the flexible back wall portion or tang **38** is disposed adjacent to the multi-purpose tool sleeve **204** and contained and disposed opposite the U-shaped channel **212**. After the bone screw **4** is installed and it is desired to install the rod **8** in two or more bone screws **4**, the multi-purpose installation tool **12** is removed from the end guide tool **9** and replaced thereon with the slot **44** and channel openings **40** and **94** adjacent to and facing the alignment block **218**.

(133) The translation nut **202** of the multi-purpose installation tool **12** is substantially cylindrical in shape and is shown with outer grooves **223** to aid a surgeon in handling the multi-purpose installation tool **12** and rotating the nut **202**. The nut **202** further includes an inner cylindrical surface **224** defining an inner substantially cylindrical passage **226** communicating with the passage **206** of the sleeve **204**. The inner surface **224** further includes a helical guide and advancement structure as shown by a V-shaped thread **228** that is configured to mate with the guide and advancement structure **50** of the end guide tool **9** or the guide and advancement structure **93** of the intermediate guide tool **10**.

(134) With reference to FIG. **25**, the inner cylindrical surface **224** extends from an upper open end **230** of the translation nut **202** to an annular seating surface **232** extending radially outwardly and perpendicular to the cylindrical surface **224**. As will be discussed more fully below, the surface **224** with associated thread **228** is of a length that provides an equivalent translation distance of the multi-purpose installation tool **12**, and in particular the tang/rod pressing block **218**, with respect to the guide tool **9** or **10** such that the pressing block **218** can be used to gradually push the rod **8** toward the bone screw **4** for the entire translation distance by rotating the nut **202** which can be continued until the rod is fully seated in the head of the bone screw.

(135) Also with reference to FIG. **25**, at the annular seating surface **232**, the sleeve **204** is in sliding contact with the nut **202**. A lower portion **234** of the nut **202** further defines a second inner cylindrical

surface **236** of greater diameter than the surface **224**. The surface **236** has a diameter slightly greater than a diameter of the sleeve **204** and is configured to slidingly receive the sleeve **204** into the nut **202** along the surface **236**. The nut **202** further defines an annular recess or groove **238** configured to receive a pin **240** rigidly fixed to the sleeve **204**. The pin **240** may be accessed for attachment and removal from the sleeve **204** through an aperture **242** disposed in the translation nut **202**. The pin **240** slidingly mates with the nut **202** within the recess **238**, keeping the nut **202** and sleeve **204** in an attached but freely rotatable relation.

(136) With reference to FIGS. **26-28**, the driver **14** of an assembly **1** according to the invention includes a handle **250**, a guide tool fastener or nut **252**, and an elongate cylindrical stem or shaft **254** having a lower cylindrical portion **255** integral with a bone screw engager shown as a socket **256**. The socket **256** is configured to mate with the upper part of the bone screw shank **154**. The shaft **254** with attached socket **256** is receivable in and passes through the interior of the guides **9** and **10**, such as the channel **80** of the guide tool **10**. The lower portion **255** has a slightly smaller diameter than a diameter of the remainder of the shaft **254**, this smaller diameter provides for adequate clearance of the portion **254** from the guide and advancement structures **64** and **114** when the shaft **254** is installed within the interior of the respective guide tools **9** and **10**. The stem or shaft **254** is rigidly attached to the handle **250** and coaxial therewith. Both the handle **250** and the guide tool fastener **252** include outer grooves **258** and **259** respectively, about outer cylindrical surfaces thereof to aid in gripping and rotating the respective components.

(137) The guide tool fastener **252** is a substantially hollow cylinder disposed in coaxial relationship with the handle **250** and the shaft **254**. The fastener has a threaded inner cylindrical surface **262** disposed at a lower portion **263** thereof, the threaded surface **262** configured to mate with the guide and advancement structure **50** of the end guide tool **9** or the guide and advancement structure **93** of the intermediate guide tool **10**. The fastener **252** is disposed on the driver **14** between an annular surface **264** of the handle **250** and the pin **46** that is fixed to the shaft **254** and extends laterally therefrom.

(138) The driver **12** further includes a lateral pin **266** projecting radially outwardly from a cylindrical surface **268** adjacent the handle **250**. In the embodiment shown, the cylindrical surface **268** is integral with the handle **250** and fixedly attached to the shaft **254**. The pin **266** is disposed within an annular recess **270** defined by the cylindrical surface **268**, and surfaces of the fastener **252**, including an upper seating surface **272**, a lower seating surface **274** and an inner cylindrical surface **276**. The pin **266** disposed in the recess **270** allows for both rotational and axial or vertical translational movements of the fastener **252** with respect to the shaft **254**. Thus, as shown in FIG. **26**, the fastener **252** is rotatable about an axis C. Furthermore, the fastener is slidable along the axis C between the annular surface **264** and the pin **46**, with FIG. **26** showing a first or unattached position with the fastener **252** in contact with the annular surface **264** and FIGS. **27** and **28** showing a second, engagement position, with the fastener **252** partially covering, but not contacting the pin **46**, with the pin **266** abutting the upper seating surface **272** prohibiting further downward or vertical (axial) translational movement of the fastener **252** with respect to the shaft **254**.

(139) As stated previously herein, the pin **46** is configured for sliding engagement with both the slot **44** of the guide tool **9** and the slot **88** of the guide tool **10** when the driver shaft **254** is disposed in an interior of the guide tool **9** or **10**. When the pin **46** is received in the slot **44** or the slot **88**, any relative rotational movement between the guide tool **9** or **10** and the driver **14** is prevented, but the driver is free to slide axially with respect to the guide tool **9** or **10**. When the fastener or nut **252** is slid into the second position shown in FIGS. **27** and **28** and the fastener is mated with the guide and advancement structure **50** of the end guide tool **9** or the guide and advancement structure **93** of the intermediate guide tool **10** by rotating the fastener **252** to a location adjacent to the pin **46**, with the pin **266** in contact with the upper seating surface **272**, relative axial movement between the driver **14** and the guide tool **9** or **10** is also prevented.

(140) With reference to FIGS. **1** and **29-35**, a three-component assembly **1** according to the invention including the guide tool **9**, the multi-purpose installation tool **12** and the driver **14** may be assembled as follows: The guide tool **9** shown with attached bone screw **4** is inserted into the multi-purpose

installation tool **12** with the upper end **43** being inserted into the receiving end **207** of the multi-purpose installation tool **12**. With respect to the assembly shown in FIGS. **29**-**31**, illustrated is a particular assembly wherein the multi-purpose installation tool **12** is being utilized as a support or stabilizer for the end guide tool **9** during installation of the bone screw **4** into the vertebra **16**, specifically, to contain and compress the tang **38** and to provide extra support to the walls, such as walls **68** and **69** of tool **9**. Thus, the guide tool **9** is received into the multi-purpose installation tool **12** with the rear wall **28** facing the alignment block **218** as shown in FIG. **29**.

(141) As the guide tool **9** is received into the multi-purpose installation tool **12**, rotational movement is prevented by the alignment block **218** in sliding contact with the flat surfaces **28** of the guide tool **9**. The translation nut **202** is then rotated clock-wise as viewed from the top end **230** and shown by the arrow X, with the thread **50** of the guide tool **9** mating with the thread **228** disposed on the inner surface **224** of the translation nut **202**. The translation nut **202** is preferably rotated until the upper end **43** of the guide tool **9** is positioned outside of the body of the nut **202** with a few of the threads **50** exposed as shown in FIGS. **30** and **31**. Furthermore, the sleeve **204** cannot be translated beyond the pin **67** that stops the sleeve near the rod abutment recess **61** disposed near the end of the guide tool **9**. During rotation of the translation nut **202**, the guide tool **9** is held in a preferred bone screw installation position and any rotational movement of the tool **9** is prevented by the alignment block **218** in contact with the co-planar back walls or facets **71** of the guide tool **9** as well as the planar back surface of the tang **38**. As illustrated in FIGS. **30** and **31**, when the guide tool **9** is fully installed in the multi-purpose installation tool **12** in this first or bone screw installation position, the flexible back wall portion or flap **38** is compressed and retained in place between the side walls **32** and **33** by the alignment block **218**.

(142) When the multi-purpose installation tool **12** is used as a rod pusher with the guide tool **9** as shown in FIGS. **38** and **41**, the multi-purpose installation tool **12** is preferably used first as an end guide tool stabilizer and tang **38** container, as already described herein, and thus must first be removed by rotating the translation nut **202** counter-clockwise until the multi-purpose installation tool **12** is disengaged from the end tool guide **9** thereby deploying the tang **38**. Thereafter, the multi-purpose installation tool **12** is removed and replaced on the guide tool **9** with the slot **44** and channel openings **40** and **94** adjacent to and facing the alignment block **218**. As the multi-purpose installation tool **12** reinserted onto the guide tool **9**, rotational movement is prevented by the alignment block **218** in sliding contact with the flat surfaces **47** and **48** of the guide tool **9**. The translation nut **202** is then rotated clock-wise as shown by the arrow X (FIG. **29**), with the thread **50** of the guide tool **9** mating with the thread **228** disposed on the inner surface **224** of the translation nut **202**. Similar to what is shown in FIGS. **30** and **31**, the translation nut **202** is rotated clockwise as shown by the arrow X, until the upper end **43** of the guide tool **9** is positioned outside of the body of the nut **202** with some of the threads **50** exposed. During rotation of the translation nut **202**, the guide tool **9** is held in position and any rotational movement of the tool **9** is prevented by the alignment block **218** in contact with the co-planar front walls or facets **70** of the guide tool **9**. When the multi-purpose installation tool **12** is used in this second or rod pushing position, the flexible back wall tang portion or flap **38** is not obstructed by the sleeve **204** of the multi-purpose installation tool **12** and may spring out or be further pushed out through the opening **213** of the U-shaped channel **212**.

(143) An assembly **1** according to the invention may also include the intermediate guide tool **10** in the place of the guide tool **9** as shown in FIGS. **40**-**42**. Because the intermediate guide tool **10** includes a pass-through slot **111** rather than a flexible back wall tang portion **38**, the alignment between the multi-purpose installation tool **12** and the guide tool **10** may be the same during bone screw installation as for the pushing of the rod **8**. Therefore, the tool guide **10** may be inserted into the multi-purpose installation tool **12** with either the rear wall **81** or the slot **88** adjacent to and facing the alignment block **218**.

(144) Similar to the discussion herein with respect to the guide tool **9**, as the guide tool **10** is inserted into the multi-purpose installation tool **12**, rotational movement is prohibited by the alignment block **218** in sliding contact with either the rear wall **81** or the coplanar surfaces **91** and **92** of the guide tool **10**. The translation nut **202** is then rotated clock-wise as viewed looking toward the top **87** of the tool **10**, with the thread **93** of the guide tool **10** mating with the thread **228** disposed on the inner surface **224** of

the translation nut. Similar to what is shown in FIGS. **30** and **31**, the translation nut **202** is rotated until the upper end **87** of the guide tool **10** is positioned outside of the body of the nut **202** with some of the threads **93** exposed. During rotation of the translation nut **202**, the guide tool **10** is held in position, with rotational movement of the tool **10** being prevented by the alignment block **218** in contact with the co-planar front walls or facets **109** or the co-planar rear walls or facets **110** of the guide tool **10**.

(145) Further discussion of the assembly **1** in this application will be directed toward the end guide tool **9** shown in the drawings. Unless specifically stated otherwise, the intermediate guide tool **10** can be utilized in similar fashion to what is being described herein with respect to the end guide tool **9**.

(146) With reference to FIGS. **1** and **32-35**, after installation of the multi-purpose installation tool **12** to the guide tool **9**, the driver **14** is inserted into the guide tool **9**/multi-purpose installation tool **12** combination by inserting the socket end **256** into the end **43** of the guide tool **9** and sliding the shaft **254** into the interior of the guide tool **9** until the socket end **256** contacts and surrounds the upper part of the shank **154** of the bone screw **4** as shown in FIG. **35**. As the shaft **254** is being inserted into the guide tool **9**, the pin **46** on the shaft **254** of the driver **14** is aligned with and slid into the slot **44** of the guide tool **9**. In order to more easily view the pin alignment process, the guide tool fastener **252** is placed in the first or unattached position with the fastener **252** in contact with the annular surface **264** as shown in FIG. **32**. Also as shown in FIG. **32**, preferably, the pin **46** is slid to a position disposed substantially within the slot **44** when the socket end **256** engages the shank **154** of the bone screw **4**. The guide tool fastener or nut **252** is then rotated clockwise as viewed from the handle and illustrated by the arrow Y in FIG. **33**, from the first unattached position toward the second engaged position, mating the thread **50** located near the end **43** of the guide tool **9** with the inner threaded surface **262** of the nut **252** of the driver **14**. If, after the fastener **252** is rotated to a hand-tightened position, and a gap or space remains between the fastener **252** and the translation nut **202**, as shown in FIG. **33**, the translation nut **202** may then be rotated counter-clockwise as shown by an arrow Z in FIG. **33**, and hand-tightened until the translation nut **202** abuts against the fastener **252**, as shown in FIG. **34**. The assembly **1** is then fully assembled and may be used to install the bone screw **4** into the vertebra **16** as will be described more fully below. Thereafter, the driver **14** may be removed by rotating the fastener **252** in a counter-clockwise direction (arrow Z) and sliding the shaft **254** out of the multi-purpose installation tool **12** through the open end **230**.

(147) Another tool used in implanting a spinal rod **8** is an antitorque tool **300** illustrated in FIGS. **44** and **45** and further shown in FIG. **44** with a closure top installation tool **302** engaging the break-away portion **186** of the closure top **62**. The closure top installation tool **302** includes an upper handle portion **303** and a lower, closure top engagement portion **304** configured to mate with and rotate the closure top **62**.

(148) The antitorque tool **300** is also preferably used with a closure top torquing tool **305**, shown in FIGS. **47** and **48**. The tool **305** is used to torque and set the closure top **62**, so it is snug against the rod **8**, and thereafter break away the break-off head **186** in the manner shown in FIG. **48**. The torquing tool **305** is preferably in the form of a socket as shown in the drawings to allow for adequate tightening of the closure top **62** and also ease in removal of the break-off head **186** as shown in FIG. **48**.

(149) The antitorque tool **300** includes a tubular hollow shaft **306** that is sized and shaped to be slidably received over the installation tool **302** and also the torquing tool **305**. The shaft **306** has a lower end portion **308** that has a pair of diametrically spaced, curved bridges **310**. Each of the bridges **310** is sized and shaped to fit over the rod **8**, shown in FIGS. **47** and **48**. When in place, as illustrated in FIG. **47**, the antitorque tool **300** allows a surgeon to counter torque applied by the torquing tool **305**, when applying torque to and breaking away the break-off head **186**. The antitorque tool **300** also has an upper handle **316** disposed perpendicular to the shaft **306** and having an opening **318** through which the installation tool **302** and the torquing tool **305** passes in the manner suggested by FIGS. **46-48**.

(150) In use, the previously described tools are utilized to attach one or more rods **8** to the human spinal column **6**. The procedure is begun by selection of a bone screw **4** in accordance with the size of the patient's vertebra **16** and the requirements of the spinal support needed. Bone screws **4** having a

rotatable or polyaxial head **146** are preferred but not required for the procedure, as such allow relatively easy adjustment of the rod **8** in the tools **9** and **10** during placement and for movement of the tools **9** and **10**, as described below. The bone screw **4** is also preferably cannulated so as to be receivable over and guided by a guide pin **355** as discussed more fully below.

(151) A relatively small incision, such as an incision **350** in the skin **20** is then made for each bone screw **4** to be used. Preferably, the incisions are sized so as to snugly receive the tools of the invention. The incisions **350** are stretched into a round shape with a circumference equal to or just slightly larger than the multi-purpose installation tool **12**. The skin **20** is relatively flexible and allows the surgeon to move the incision **350** around relative to the spine **6** to manipulate the various tools and implants, as required. In some cases, two screws can be inserted through one or the same incision.

(152) With reference to FIG. **36**, a drill (not shown) is utilized to form a first guide bore **366** in a vertebra **16** under guidance of non invasive imaging techniques, which procedure is well known and established. The thin pin or guide wire **355** is then inserted in the first guide bore **366**. This first guide bore **366** and associated thin pin **355** function to minimize stressing the vertebra **16** and provide an eventual guide for the placement and angle of the bone screw shank **148** with respect to the vertebra **16**.

(153) The guide bore **366** is enlarged utilizing a cannulated drilling tool or tap **360** having an integral or otherwise attached cannulated and threaded bit **362** with an outer surface sized and shaped to correspond to the size and shape of the chosen threaded bone screw **4**. The drilling tool **360** cooperates with a cylindrical holder or sleeve **368** having an inner surface in slidable mating arrangement with the tool **360** and being held in a position substantially co-axial therewith. The holder **368** is sized and shaped to fit within the incision **350** and prevents soft tissues from being rolled up in the threaded bit **362** as it is rotated. The tool **360** further includes a handle **370** fixedly attached to the tool **360** located at an end portion **372** thereof and of a size and shape for rotating the bit **362** along the pin **355** and into the first bore **366**.

(154) With the pin **355** still in place, the enlargement of the guide bore **366** begins by threading the thin pin **355** through the end of the tap and inserting the holder **368** into the incision until the holder comes into contact with the vertebra **16**. The drill bit **362** is advanced downward along the pin **355** until the drill bit **362** comes into contact with the vertebra **16**. The tool **360** is then rotated within the holder **368** using the handle **370**, driving the bit **362** along the pin **355** until a full sized bore **380** is drilled to a depth desired by the surgeon. During drilling, the holder **368** remains stationary, shielding the surrounding tissue from the rotational movement of the bit **362** and tool **360**.

(155) The tool **360** is then removed by rotating the bit **362** in reverse until the bit **362** is outside the bore **380**. The tool **360** is then removed from the holder **368**, followed by the removal of the holder **368** through the incision **350**.

(156) Before placing the bone screw **4** in the vertebra **16**, the bone screw **4** is preferably joined to an associated guide tool **9** or **10**, an associated multi-purpose installation tool **12**, and an associated driver **14**. It is possible, but typically not desirable, to join a guide tool **9** or **10** to the bone screw **4** after the installation of the bone screw **4** to the vertebra **16**. There also may be instances wherein it is desirable to join the bone screw **4** to an associated guide tool **9** or **10**, but not to the multi-purpose installation tool support **12** or the driver **14** until after the bone screw **4** is installed in the vertebra **16**, if at all. Furthermore, the driver **14** may be used with a guide tool **9** or **10** without the multi-purpose installation tool **12**. However, it is preferable to utilize the multi-purpose installation tool **12** during installation of a bone screw **4** into the vertebra **16** as the tool **12** provides mechanical advantage and aids in preventing inadvertent splaying of side walls **32** and **33** of the end guide tool **9** and legs **102** and **103** of the intermediate guide tool **10**.

(157) The attachment structure **124** of the intermediate guide tool **10** is joined to a bone screw **4** by first rotating the tool **10** relative to the bone screw **4** so that the legs **102** and **103** are positioned as shown in FIGS. **17** and **18**, with the facets **167** and **177** of the head **146** disposed between the guide tool legs **102** and **103**, and with the facet **167** adjacent the leg **102** and the facet **177** adjacent the leg

103, thereby aligning the groove **158** with the large pin **126** and the groove **168** with the large pin **130**. A slight splaying of the legs **102** and **103** is possible during alignment with the head arms **150** and **151**.

(158) The head **146** is then twisted into place by rotating the tool **10** axially in a clockwise direction as shown by the arrow T in FIGS. **18** and **19**.

(159) The twist-on procedure described herein with respect to the attachment structure **124** of the intermediate tool **10** is also followed with respect to the end guide tool **9** attachment structure **72.** As previously stated herein, the attachment structure **72** is substantially similar to the attachment structure **124** of the intermediate tool **10**, with the only difference being that the end guide tool **9** includes a flexible back wall tang portion **38** rather than the pass-through slot **111** of the intermediate guide tool **10**.

(160) After the bone screws **4** have been attached to the guide tools **9** and **10**, a multi-purpose installation tool **12** is preferably attached to each of the guide tools **9** and **10**. With respect to each of the intermediate guide tools **10**, the multi-purpose installation tool **12** is preferably installed as follows: The rear wall **81** of the tool **10** is positioned adjacent to the surface **220** and the tool **10** is inserted into the hollow passage **206** and slid into the rod pusher sleeve **204** until the end **87** contacts the translation nut **210**, with the block **218** preventing axial rotation of the guide tool **10** with respect to the multi-purpose installation tool **12**, and resulting in the preferred alignment of the sleeve slot **11** and the opening **79** of the tool **10** with the U-shaped channel **212** of the multi-purpose installation tool **12.** However, because the slot **11** is a pass-through slot, the alignment of the guide tool **10** with respect to the multi-purpose installation tool **12** is not critical to processes according to the invention. Therefore, in most instances the rear wall **81** of the tool **10** may also be positioned opposite the surface **220** upon entry into the multi-purpose installation tool **12**.

(161) The translation nut **202** is then rotated with the thread **228** of the nut **202** mating with the thread **93** of the tool **10**. The nut **202** is rotated in a clockwise direction as illustrated by the arrow X in FIG. **29** until the end **87** is disposed outside of the nut **202** and positioned similar to what is shown with respect to the multi-purpose installation tool **12** and end guide tool **9** assembly shown in FIGS. **30** and **31**. The abutment pin **118** prevents further rotation of the nut **202** and advancement of the sleeve **204** beyond the pin **118.**

(162) As shown in FIGS. **29-31**, the end guide tools **9** are similarly equipped with multi-purpose installation tools **12**. In order to compress the tang **38** during installation of a bone screw **4** into a vertebra **16**, the tool **9** is received into the multi-purpose installation tool **12** with the back wall **28** of the tool **9** disposed adjacent to the surface **220**. Then the multi-purpose installation tool **12** is slid onto the tool **9** until the end **43** contacts the translation nut **202**, with the block **218** preventing axial rotation of the tool **9** with respect to the multi-purpose installation tool **12**, and resulting in the preferred alignment wherein the flexible back wall tang portion or flap **38** is disposed adjacent to the guide tool sleeve **204** disposed opposite the U-shaped channel **212.** The translation nut **202** is then rotated with the thread **228** of the nut **202** mating with the thread **50** of the end guide tool **9**. The nut **202** is rotated in a clockwise direction as illustrated by the arrow X in FIG. **29** until the end **43** is disposed outside of the nut **202** and positioned as shown in FIGS. **30** and **31**, but not beyond the pin **67**.

(163) The driver **14** is then installed into the guide tool **9** as shown in FIGS. **32-35** and as follows: The driver **14** is first prepared for ease of insertion by placing the guide tool fastener **252** in the first or unattached position with the fastener **252** in contact with the annular surface **264** of the driver **14** as shown in FIG. **32**. Then, the driver end **256** is inserted into the guide tool **9** at the end **43** with the stem **254** being slid into the guide tool **9** with the pin **46** aligned with the channel **39** until coming to a stop with the pin **46** disposed in the slot **44** and the bone screw engager **256** in contact with the bone screw upper shank **154**. A slight rotation or jiggling of the bone screw shank **148** may be required for the hex socket of the bone screw engager **256** to become positioned in operational engagement with the hex shaped upper shank **154**. The guide tool fastener or nut **252** is then moved downward and toward the end **43** and then rotated clockwise as viewed from the handle **250** and illustrated by the arrow Y in FIG. **33**, mating the thread **50** disposed near the end **43** of the guide tool **9** with the inner threaded surface **262** of the nut **252** of the driver **14**. The nut **252** is rotated in this clock-wise fashion and hand-

tightened until further translation of the nut **252** along the guide tool **9** is prevented by the pin **266** abutting the upper seating surface **272**.

(164) If, after the fastener **252** is rotated to a hand-tightened position, and a gap or space remains between the fastener **252** and the translation nut **202** as shown in FIG. **33**, the translation nut **202** is rotated counter-clockwise as shown by the arrow Z in FIG. **33**, and hand-tightened until the translation nut **202** abuts against the fastener **252** as shown in FIG. **34**. The assembly **1** is now ready for bone screw installation into the vertebra **16**.

(165) The driver **14** is installed into the intermediate guide tool **10** and multi-purpose installation tool **12** assembly in steps similar to that described above with respect to the end guide tool **9**.

(166) A series of bone screws **4** are installed in each vertebra **16** to be attached to the rod **8** by inserting each of the assemblies **1** through the skin incision **350** as shown in FIG. **37**. The screw **4** is then rotated and driven into the tapped bore **380** with the surgeon holding and rotating the assembly **1** with the driver handle **250**, thereby rotating the entire assembly **1** as one unit until the shank **148** is disposed at a desired depth in the tapped bore **380** of the respective vertebra **16**. Preferably, the shank **148** is also cannulated to receive the pin **355**, providing additional guidance for installation of the bone screw **4** into the vertebra **16**.

(167) After a specific bone screw **4** is installed, the driver **14** is removed from either the guide tool **9** or **10** by rotating the fastener **252** in a counter-clockwise direction (illustrated by the arrow Z in FIG. **33**) and sliding the shaft **254** towards the open end **230** of the multi-purpose installation tool **12** and pulling the driver **14** out of the assembly **1** by the handle **250**.

(168) With respect to the end guide tools **9**, the multi-purpose installation tool **12** is then removed by rotating the translation nut **202** counter-clockwise until the thread **228** disposed on the inner surface **224** of the translation nut **202** is disengaged from the thread **50** of the tool **9**. The multi-purpose installation tool **12** is then slid off of the tool **9** deploying the flexible flap **38**, as shown in FIG. **38**. If desired at this junction of a process according to the invention, the multi-purpose installation tool **12** many then be rotated 180 degrees and replaced on the tool **9** with the slot **44** and the channel openings **40** and **94** aligned adjacent to and facing the alignment block **218** of the multi-purpose installation tool **12** for a rod pushing application. The translation nut **202** is then rotated clockwise as illustrated by the arrow X in FIG. **29**. In this rod pushing position, the flexible tang **38** is extendible into the U-shaped channel **212** of the multi-purpose installation tool **12**.

(169) For each bone screw **4**, an associated guide tool **9** or **10** extends through the skin **14**, as illustrated in FIG. **39**. An end guide tool **9** is located at each end of the series of bone screws **4** and an intermediate guide tool **10** is located on each intermediate bone screw **4**.

(170) In order to install a rod **8** in two or more bone screws **4**, it may not be necessary to equip each guide tool **9** or **10** with a multi-purpose installation tool **12**. For example, with reference to FIG. **40**, for a particular procedure, it may be desirable to utilize only one multi-purpose installation tool **12** with a tool set **2** according to the invention. In the process illustrated by the FIG. **40**, the multi-purpose installation tools **12** have been removed from both of the end guide tools **9** and both of the intermediate guide tools **10** after which a rod **8** has been inserted and a multi-purpose tool **12** reattached to one tool **10**. Some pushing of the rod may be accomplished by just extending a rod or tool down the central channel of the guide tools **9** and **10** when mechanical advantage is not required to move the rod **8**. As required by the surgeon, one or more multi-purpose installation tools **12** may be added or removed at any time during the course of the rod pushing or reducing procedure.

(171) With reference to FIG. **39**, prior to installation of the rod **8**, the end guide tools **9** are turned or rotated so the channels **55** therein face one another and the intermediate guide tools **10** are aligned so the pass-through slots **111** align with the channels **55**.

(172) With reference to FIG. **40**, the rod **8** has been inserted diagonally through one of the end skin incisions **350** with the adjacent end guide **9** pushed to the side, so that one of the rod ends **59** first passes through the slots **111** in the intermediate guide tools **10** and then into the channel **55** of one of

the guide tools **9**. Back muscle tissue separates easily here to allow the upper insertion of the rod **8** and can be further separated by finger separation or cutting through one of the incisions **350**, if required.

(173) After initial insertion, the remaining opposed end **59** of the rod **8** is positioned in the channel **55** of the end guide tool **9** that is located next to the insertion point of the rod **8**. Manipulation of the rod **8** in the channels **55** is aided by the back wall tang portions or flexible flaps **38** of the guide tools **9** which may also be moved like a joy-stick toward or away from each other by the surgeon. Furthermore, once the rod **8** is disposed within the channels **111** and **55**, the back wall portions or flaps **38** resiliently bias against the rod ends **59**, substantially holding and containing the rod **8** in place between the end guide tools **9** of the tool set **2**. The reason that the tangs **38** are needed is that the rod **8** extends beyond the end bone screws **4** and the end guide tool **9** are located on the end bone screws **4**. Also, the rod may tend to slip out of one end screw head. When the rod is spaced above the bone screws **4**, the guide tools **9** can be manipulated to be spaced farther apart to receive the rod **8** therebetween, but as the rod **8** nears the bone screws **4**, the guide tools **9** cannot be manipulated enough to compensate so the rod **8** must extend beyond the bodies of the guide tool **9**. Therefore, the tangs **38** allow the rod **8** to be controlled and positioned outwardly of the end bone screws **8**. Moreover, the position of the rod **8** is controlled by equal pressure applied by the tangs **38** so that the rod **8** extends past the bone screws **4** approximately an equal amount on each side.

(174) Also with reference to FIGS. **40** and **41**, once the rod **8** is positioned in the guide tools **9** and **10**, the multi-purpose installation tool **12** may be utilized to push the rod **8** toward the bone screw **4**, normally when mechanical advantage is needed to seat the rod **8** in the bone screws **4**. This is accomplished by rotating the translation nut **202** in a clockwise direction (as viewed from above the skin **20**), thereby translating the sleeve **204** in a downward direction toward the bone screw **4**, with the guide tool alignment block **218** abutting and pushing against the rod **8**.

(175) As shown in FIG. **40**, it may also be desirable to simultaneously or thereafter push the rod **8** toward the screw **4** of one or more guide tools **9** and **10** utilizing the closure top installation tool **302** pushing against a closure top **62** that in turn pushes against the rod **8**. In particular, a closure top **62** is placed in the elongate top to bottom channel associated with the guide tools **9** and **10**, preferably by entry from the side such as into the channel opening **40** of the guide tool **9** or alternatively into the channel **39** through the top end **43** of the guide tool **9**. If the guide tool **9** or **10** has the multi-purpose installation tool **12** attached, the closure top **62** can be placed into the guide tool by side insertion into the U-shaped channel **212**. The closure top installation tool **302** is then inserted into the top end **43** and through the channels disposed within the guide tool **9**, until the engagement portion **304** mates with a cooperating aperture disposed in the break-off head **186**. The closure top **62** is then driven or pushed under manual control of the surgeon by use of the installation tool **145** toward the rod **4**.

(176) With reference to FIG. **42**, near the bottom of the guide tools **9** and **10**, such as near the end **112** of the intermediate tool **10** and the bottom **36** of the back wall **28** of end guide tool **9**, the closure top **62** engages the helically wound guide and advancement structures **64** and **114** of respective guide tools **9** and **10**. The tools **302** and mated closure tops **62** are then rotated, mating the closure tops **62** with associated guide tools **9** and **10** so as to drive the closure top **62** downward against the rod **8** and to urge the rod **8** downward into the bone screw channel **153**. Preferably, the translation nut **202** of the multi-purpose installation tool **12** is rotated in a clockwise direction, translating the sleeve **204** and block **218** downwardly slightly in advance or substantially concurrent with the advancement of the closure tops **62**, providing additional mechanical advantage for the block flat surface **222** against the rod **8**.

(177) With reference to FIG. **43**, at the bottom of the guide tool **9** or **10**, the closure top mating structure **181** engages and begins to mate with the guide and advancement structure **183** on the respective bone screw **4** and continued rotation of the tool **302** drives the rod **8** downward and into engagement with the upper part of the bone screw shank **154**, so as to snug against and frictionally lock the shank **148** in position relative to the bone screw head **146**.

(178) Once all of the closure tops **62** are in final seated position in respective bone screws **4** and the surgeon is satisfied with the position of all of the elements, such as is illustrated in FIG. **43**, any and all multi-purpose installation tools **12** are removed by rotating the nut **202** counter-clockwise followed by sliding the sleeve **204** off of the guide tool **9** and **10** and out of the incision **350**. Thereafter, each of the guide tools **9** and **10** are now removed by rotating each guide tools **9** and **10** ninety degrees so that the recesses **116** straddle the rod **8** to allow the attachment structure **72** or **124** to disengage from the receiver portion **145** on the bone screw **4**. The guide tool **9** or **10** is then pulled axially upward away from the bone screw **4**, along the tool **302** and then out of the incision **350**.

(179) The antitorque tool **300** is mounted over each closure top installation tool **302**, utilizing the tool **302** as a guide for re-entry through the incision **350**. The antitorque tool **300** is slid along the tool **302** until the bridges **310** straddle the rod **8**, preventing axial rotation of the tool **300**. As shown in FIG. **46**, the closure top installation tool **302** is then pulled axially upward away from the bone screw **4** and out of the incision **350**.

(180) With reference to FIG. **47**, the closure top torquing tool **305** is then inserted into the antitorque tool **300** and engaged with the break-off head **186**. By cooperative use of the tools **300** and **305** a preselected torque is manually applied to the break-off head **186** which breaks from the closure top **62** as illustrated in FIG. **48** and is thereafter removed, followed by removal of the antitorque tool **300**, after which the incision **165** is closed.

(181) It is to be understood that while certain forms of the present invention have been illustrated and described herein, it is not to be limited to the specific forms or arrangement of parts described and shown. For example, it is foreseen that more than one tool could be used to provide the described functions for the multi-purpose installation tool **12**.

Claims

1. A receiver assembly for securing an elongate rod to a bone anchor via a threaded plug, the receiver assembly comprising: a receiver having a longitudinal axis, a base portion, and an upper portion comprising a pair of upright arms defining a channel configured to receive the elongate rod, the channel extending between a front surface and a back surface of the receiver and communicating with a top surface defining a top of the receiver, the receiver having interior surfaces with a helically wound thread form formed in at least a portion of the interior surfaces and opposite outwardly-facing side surfaces on each of the upright arms, each of the outwardly-facing side surfaces having a planar surface that is parallel with respect to the planar surface of the opposite of the outwardly-facing side surfaces, the front and back surface of the receiver each including parallel planar surfaces with respect to each other; and the threaded plug configured to be positioned within the channel to secure the elongate rod to the receiver in a locked configuration, the threaded plug comprising a cylindrical body having a central axis, an upper surface having a central drive structure, a lower surface, and an outer external surface with a mating continuous helically wound thread form formed on at least a portion of the outer external surface, the thread form of the threaded plug having a lower clearance surface and an outer crest surface forming at least a portion of an obtuse angle with respect to the lower clearance surface, the thread form of the threaded plug further including a load flank extending in at least one direction that slopes upwardly and outwardly relative to the central axis of the cylindrical body or perpendicular relative to the central axis and an inner root surface extending parallel to the central axis with a lower portion adjacent to and above a base of the thread form of the threaded plug and an upper portion adjacent to and below the base of the thread form of the threaded plug, wherein the lower surface of the cylindrical body extends continuously between an outer circumference thereof and includes a centrally located downwardly extending solid portion configured to engage and lock the elongate rod in the channel of the receiver, and wherein when the receiver assembly is in the locked configuration, the threaded plug does not extend over any part of the top surface defining the top of the receiver and the entire lower clearance surface and entire outer crest surface of the thread form of the threaded plug are spaced apart from the thread form of the receiver.

2. The receiver assembly of claim 1, wherein the load flank includes a concave shaped surface portion.

3. The receiver assembly of claim 1, wherein the lower surface of the cylindrical body includes an outer annular rim adjacent the outer circumference thereof configured to engage the elongate rod in the locked configuration.

4. The receiver assembly of claim 1, wherein each of the outwardly-facing side surfaces includes an upper tool engagement structure comprising a horizontally curvate tool engagement groove extending to at least one of the front surface or the back surface on the upper portion of the receiver, the curvate tool engagement groove further including an outwardly-facing curvate surface aligned parallel with the longitudinal axis and extending between a downwardly-facing surface and an opposed upwardly-facing surface, at least the downwardly-facing and upwardly-facing surface extending continuously along a length of the curvate tool engagement groove to open onto the at least one of the front surface or the back surface.

5. A method of securing the elongate rod to a bone anchor via the threaded plug, the method comprising: providing the receiver of claim 1; providing the threaded plug of claim 1; and positioning the threaded plug within the channel of the receiver to secure the elongate rod to the receiver in the locked configuration.

6. A receiver assembly for securing an elongate rod to a bone anchor via a threaded plug, the receiver assembly comprising: a receiver having a longitudinal axis, a base portion, and an upper portion comprising first and second upright arms defining a channel therebetween that is configured to receive the elongate rod, the channel extending between a front surface and a back surface of the receiver and communicating with a top surface defining a top of the receiver, the receiver having first and second interior surfaces with a helically wound thread form formed in at least a portion of the first and second interior surfaces, the first upright arm including a first outwardly-facing side surface opposite the first interior surface and having a first side planar surface, the second upright arm including a second outwardly-facing side surface opposite the second interior surface and having a second side planar surface, the first side planar surface and the second side planar surface being parallel with respect to each other, the front surface of the receiver including a first front planar surface defined on the first upright arm and a second front planar surface defined on the second upright arm, the first front planar surface being parallel to the second front planar surface; and the threaded plug configured to be positioned within the channel to secure the elongate rod to the receiver in a locked configuration, the threaded plug comprising a cylindrical body having a central axis, an upper surface having a central drive structure, a lower surface, and an outer external surface with a mating continuous helically wound thread form formed on at least a portion of the outer external surface, the thread form of the threaded plug having a lower clearance surface and an outer crest surface forming at least a portion of an obtuse angle with respect to the lower clearance surface, the thread form of the threaded plug further including a load flank extending in at least one direction that slopes upwardly and outwardly relative to the central axis of the cylindrical body or perpendicular relative to the central axis and an inner root surface extending parallel to the central axis with a lower portion adjacent to and above a base of the thread form of the threaded plug and an upper portion adjacent to and below the base of the thread form of the threaded plug, wherein the lower surface of the cylindrical body comprises a planar surface portion configured to engage and lock the elongate rod in the channel of the receiver, and wherein, when the receiver assembly is in the locked configuration, the threaded plug does not extend over any part of the top surface defining the top of the receiver and the entire lower clearance surface and entire outer crest surface of the thread form of the threaded plug are spaced apart from the thread form of the receiver.

7. A method of securing the elongate rod to the bone anchor via the threaded plug, the method comprising: providing the receiver of claim 6; providing the threaded plug of claim 6; and positioning the threaded plug within the channel of the receiver to secure the elongate rod to the receiver in the locked configuration.