United States Patent Application Publication	20250262057
Kind Code	A1
Publication Date	August 21, 2025
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EXPANDABLE INTER-BODY DEVICE, SYSTEM, AND METHOD

Abstract

A bone pin installation system is disclosed. The bone pin installation system may include a hollow surgical tool extending in a longitudinal direction and may have a guide portion at a distal end thereof. The system may include one or more bone pins having a curved body and a support arm. The system may also include one or more connector plates having a superior surface, an inferior surface and one or more pin seats extending between the superior surface and the inferior surface. The pin seats may be configured to receive at least one of the bone pins so that the support arm is pivotally supported by the superior surface. The guide portion may include one or more channels configured to receive the support arm of the one or more bone pins and guide the corresponding bone pin during an installation procedure.

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Family ID: **1000008449694**

Appl. No.: **19/046653**

Filed: **February 06, 2025**

Related U.S. Application Data

us-provisional-application US 63555635 20240220

Publication Classification

Int. Cl.: **A61F2/30** (20060101); **A61B17/56** (20060101); **A61B17/84** (20060101); **A61F2/44** (20060101)

U.S. Cl.:

CPC **A61F2/30749** (20130101); **A61B17/846** (20130101); **A61F2/4455** (20130101); A61B2017/564 (20130101); A61F2002/30476 (20130101)

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION [0001] This application claims the benefit of and priority to U.S. Provisional Patent Application No. 63/555,635 filed Feb. 20, 2024, the entire disclosure of which is incorporated by reference herein.

FIELD

[0002] The present disclosure generally relates to medical devices for the treatment of musculoskeletal disorders, and more particularly to a surgical device that includes a bone pin anchoring system, and systems and tools for implanting and manipulating the bone pin anchoring system in conjunction with an expandable spinal implant, and a method for using the same.

BACKGROUND

[0003] Spinal disorders such as degenerative disc disease, disc herniation, osteoporosis, spondylolisthesis, stenosis, scoliosis and other curvature abnormalities, kyphosis, tumor, and fracture may result from factors including trauma, disease and degenerative conditions caused by injury and aging. Spinal disorders typically result in symptoms including pain, nerve damage, and partial or complete loss of mobility.

[0004] Non-surgical treatments, such as medication, rehabilitation and exercise can be effective, however, they may fail to relieve the symptoms associated with these disorders. Surgical treatment of these spinal disorders includes fusion, fixation, correction, discectomy, laminectomy and implantable prosthetics. As part of these surgical treatments, spinal constructs, such as, for example, bone fasteners, spinal rods and interbody devices can be used to provide stability to a treated region. For example, during surgical treatment, interbody devices may be introduced to a space between adjacent vertebral bodies (the interbody space) to properly space the vertebral bodies and provide a receptacle for bone growth promoting materials, e.g., grafting. Bone fasteners such as screws and pins may be used to anchor these interbody devices in the interbody space.

[0005] An existing problem is that bone fasteners must often be positioned by the surgeon at a particular orientation and angle relative to other components of the surgical treatment prior to deployment. The surgeon must also often make a determination on the depth at which to deploy the bone fasteners into the vertebral bodies. These determinations on the part of the surgeon leave room for error and can increase deployment time of the bone fasteners.

[0006] In addition, screw type bone fasteners generally cannot have a curved body because it is not possible to drill curved pilot holes to receive the screws. Curved bone pins pose an advantage over screws in that curved bone pins are less prone to backing out of the vertebral bodies than screws. In addition, the footprint required by the surgeon to deploy screws is greater than for impacting pins. Pin impaction is also faster than screw fastening because multiple pins can be impacted at substantially the same time, whereas, it is not practical to fasten multiple screws at once.

[0007] A further problem is instability of existing expandable interbody devices as they are inserted and expanded. Often, the load-bearing surfaces move relative to one another, as well as relative to an inserter, as the interbody device is expanded such that there is a risk of undesired shifts in the positioning of the interbody device within the interverterbral space. Additionally, and depending at least partly on the particular insertion technique employed, anatomical features such as the iliac crest and rib cage pose challenges to the adjustment of inter-body designs in situ.

[0008] The present disclosure seeks to address these and other shortcomings in the existing relevant arts.

SUMMARY

[0009] One aspect of the disclosure relates to an anchoring system for use in a surgical procedure. The system includes one or more bone pins having a curved body extending from a proximal end to a distal end, and the proximal end comprising a support arm. The system also includes a connector plate having a superior surface, an inferior surface, and one or more pin seats extending between the superior surface and the inferior surface, wherein each of the one or more pin seats are configured to receive a corresponding one of the one or more bone pins such that the support arm of the corresponding one or more bone pins is pivotally supported. The curved body of the one or more bone pins is configured to facilitate anchoring of the one or more bone pins in bony anatomy.
[0010] Another aspect of the disclosure relates to a bone pin installation system. In one aspect, the system includes a hollow surgical tool extending in a longitudinal direction and having a guide portion at a distal end thereof. The system also includes one or more bone pins having a curved body extending from a proximal end to a distal end and a support arm. The system still further includes one or more connector plates having a superior surface, an inferior surface and one or more pin seats extending between the superior surface and the inferior surface, wherein the one or more pin seats are configured to receive a corresponding one of the one or more bone pins so that the support arm of the corresponding bone pin is pivotally supported by the superior surface. The guide portion includes one or more channels configured to receive the support arm of a corresponding one of the one or more bone pins and guide the corresponding bone pin during an installation procedure. The curved body of the one or more bone pins is configured to facilitate anchoring of the one or more bone pins in bony anatomy.
[0011] Another aspect of the disclosure relates to a method of inserting an expandable spinal implant. The method includes preparing a spinal implant for insertion in a patient, removing a degenerative portion of patient anatomy, inserting the spinal implant between one or more bony structures of the patient, preparing one or more anchoring systems, as disclosed herein, for insertion into the patient, wherein each of the one or more bone pins of the anchoring system is pre-loaded into one or more anchor apertures of a guide portion. The method further includes an aligning step including aligning a guide rod of the guide portion with a central aperture of an endplate of the spinal implant and an impacting step including impacting the one or more anchoring systems into bony anatomy using a pusher. The method still further includes locking one or more locking mechanisms of the spinal implant.
[0012] The details of one or more aspects of the disclosure are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the techniques described in this disclosure will be apparent from the description and drawings, and from the claims.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0013] FIG. **1** is a perspective view of an embodiment of an expandable spinal implant including a lateral endplate in accordance with the principles of the present disclosure;
[0014] FIG. **2** is an exploded parts view diagram of the embodiment of FIG. **1** in accordance with the principles of the present disclosure;
[0015] FIG. **3** is a perspective view of the embodiment of FIG. **1** including an anchoring system comprising a plurality of bone pins in accordance with the principles of the present disclosure;
[0016] FIG. **4** is an embodiment of an endplate in accordance with the principles of the present disclosure;
[0017] FIG. **5** is an alternative embodiment of a spinal implant including a lateral endplate in accordance with the principles of the present disclosure;
[0018] FIG. **6** is an embodiment of a surgical tool for adjusting and inserting various implants in

accordance with the principles of the present disclosure;
[0019] FIG. **7** is an embodiment of another surgical tool for inserting and installing a bone pin anchoring system in accordance with the principles of the present disclosure;
[0020] FIG. **8** is an exploded view of the embodiment of FIG. **7** in accordance with the principles of the present disclosure;
[0021] FIG. **9** is a top-down view of a handle of the surgical tool of FIG. **7** in accordance with the principles of the present disclosure;
[0022] FIG. **10** is a side view of the surgical tool of FIG. **7** in accordance with the principles of the present disclosure;
[0023] FIG. **11** is a side perspective view of an embodiment of a guide in accordance with the principles of the present disclosure;
[0024] FIG. **12** is a top-down view of an embodiment of a guide in accordance with the principles of the present disclosure;
[0025] FIG. **13** is a section view of a portion of an embodiment of a guide in accordance with the principles of the present disclosure.
[0026] FIG. **14** is a zoomed in view of the distal end of the surgical tool of FIG. **7** in accordance with the principles of the present disclosure;
[0027] FIG. **15** is an alternative perspective view of an embodiment of another surgical tool in accordance with the principles of the present disclosure;
[0028] FIG. **16** is a zoomed in view of a portion of an embodiment of another surgical tool in accordance with the principles of the present disclosure;
[0029] FIG. **17**A is a side perspective view of an example bone pin in accordance with the principles of the present disclosure;
[0030] FIG. **17**B is a bottom perspective view of an example bone pin in accordance with the principles of the present disclosure;
[0031] FIG. **18** is a perspective view of an embodiment of a bone pin connector plate in accordance with the principles of the present disclosure;
[0032] FIG. **19** is an alternative perspective view of an embodiment of a bone pin connector plate in accordance with the principles of the present disclosure; and
[0033] FIG. **20** is a flow chart of a method of operation of various systems and surgical tools in accordance with the principles of the present disclosure;

DETAILED DESCRIPTION

[0034] The various bone pin anchoring and installation systems disclosed herein may be configured for use with and/or include an expandable spinal implant. FIG. **1** is a perspective view of an embodiment of an expandable spinal implant **800**. Other embodiments of spinal implants are contemplated such as those described in U.S. patent application Ser. No.17/887,957, herein incorporated by reference in its entirety. Expandable spinal implant **800** includes an endplate **810**. In some embodiments, endplate **810** may be configured for use as a medial, anterior, posterior or front endplate depending upon orientation or approach employed and the specific configuration and shape of the implant and the location, side or end to which the endplate is affixed or located with respect to the expandable spinal implant. Expandable spinal implant **800** may also include a top endplate **820** (superior endplate) and a bottom endplate **830** (inferior endplate) as will be explained in further detail below.
[0035] Implant **800** may include an anterior side **800***a*, a posterior side **800***p* and two opposing lateral sides **8001**, for example. Additionally, the outside contours of implant **800** may include a top endplate **820** (superior endplate), bottom endplate **830** (inferior endplate) and a lateral endplate **810** (front endplate), for example. In various embodiments, the top endplate **820** and bottom endplate **830** may collectively define the posterior side **800***p* (rear side) of implant **800**. Lateral endplate **810** may include a plurality of circular bone pin apertures **801**, for example. In the example embodiment, four circular bone pin apertures **801** are disclosed although in other embodiments the

number of bone pin apertures **801** may be more or less. For example, in some embodiments there may be an additional **5**th and **6**th bone pin aperture in the medial location of lateral endplate **810**. In other embodiments, there may be a total of two bone pin apertures **801** including a left bone pin aperture **801** diagonally projecting over the top endplate **820** and a right bone pin aperture **801** diagonally projecting over the bottom endplate **820**.

[0036] Lateral endplate **810** may include at least one bone pin lock **803** for preventing one or more bone pins from backing out of endplate **810**. For example, bone pin lock **803** may be a rotatable lock that may rotate about **90**° between an open position and a closed position. In various embodiments, lateral endplate **810** may include at least one attachment point **805** for connecting implant **800** with a surgical tool. In the disclosed embodiment, a plurality of attachment points **805** are distributed around pin guide aperture **807**. In the disclosed embodiment, six attachment points **805** are radially distributed around pin guide aperture **807** although other embodiments may have more or less, e.g., 2, 3, 4, 5, 7 or 8.

[0037] Lateral endplate **810** also includes a central aperture **840**. In the illustrated embodiment, the central aperture **804** extends through the endplate **810** and provides access to the spinal implant **800** through the endplate **810**. The central aperture **840** can be configured to facilitate alignment of a surgical tool with the spinal implant **800**. For example the central aperture **840** can be aligned with a component of the spinal implant **800** so that access through the central aperture **840** positions a surgical tool properly in relation to the spinal implant **800**.

[0038] FIG. **2** is an exploded parts view diagram of the embodiment of FIG. **1** in accordance with the principles of the present disclosure.

[0039] As understood best with reference to FIG. **2**, lateral endplate **810**, top endplate **820**, and bottom endplate **830** may be operably coupled to moving mechanism **250**. For example, moving mechanism **250** serves as a central attachment location for each of the endplates **810**, **820**, **830** and each of the endplates **810**, **820**, **830** may interact independently with moving mechanism **250**, for example. In the disclosed embodiment, lateral endplate **810** may be operably coupled to moving mechanism **250** by inserting posts **855** into a corresponding post retaining aperture **255** having a size and shape configured to securely couple the two together. In various embodiments, posts **855** may extend from an inside surface of lateral endplate **810** in a direction towards the posterior side **800***p* of implant **800** and towards moving mechanism **250**. In this way, lateral endplate **810** is independently secured to moving mechanism **250** from top endplate **820** and bottom endplate **830**, for example.

[0040] In the example illustration, bottom endplate **830** may include a bone pin relief **832** for each corresponding bone pin aperture **801**. For example, bone pin relief **832** comprises an arcuate channel and/or conical channel defining a portion of the outside surface of endplate **830**. In some embodiments, the number of bone pin reliefs **832** may be more or less. For example, a single bone pin relief **832** or three bone pin reliefs **832**. In some embodiments, the top endplate **820** may include a first bone pin relief **822** and the bottom endplate **830** may include a second bone screw relief **832** that project oppositely from one another in a diametrically opposed direction.

[0041] FIG. **3** shows a perspective view of an embodiment of an expandable spinal implant **600**. The expandable spinal implant **600** includes an endplate **604** having a first side **601***a* and a second side **601***b*. On first side **601***a*, a connector plate **608**, described in further detail herein, is seated in a recess of the endplate **604**. The connector plate **608** on first side **601***a* supports a superior bone pin **602***a* and an inferior bone pin **602***b*. A bone pin lock **610** is also located on side **601***a*. The bone pin lock **610** is configured to be rotated in the endplate **604**, for example the bone pin lock can be rotated about an attachment point that affixes the bone pin lock **610** to the endplate **604**, such as a pin, and can be rotated to at least partially cover the connector plate **608**. In this configuration, the bone pin lock **610** can secure the connector plate **608** and the associated bone pins in the endplate **604**. As shown in FIG. **3**, a complementary connector plate, bone pins and pin lock may be located on side **601***b* and have substantially the same arrangement as those on side **601***a*.

[0042] Referring now to FIG. **4**, an embodiment of a lateral endplate of a spinal implant is shown. Lateral endplate **700**, has a first side **701***a* and a second side **701***b*. First side **701***a* of the lateral endplate **700** includes two bone pin apertures **702** (although other arrangements are contemplated). Each bone pin aperture **702** is configured to receive a bone pin as described herein. A connector plate seat **704** is located between the two bone pin apertures **702** and is configured to receive a connector plate (see **901** in FIG. **18**). The connector plate seat **704** can be a cutout, aperture, seat, groove or other feature of the endplate and can facilitate centering and/or alignment of a connector plate relative to or inside of an indentation of the lateral endplate **700**. For example, the connector plate seat **704** can have a geometric configuration corresponding to a feature of a connector plate such as bottom protrusion **914** of connector plate **901**, as shown in FIG. **18**. Such a geometric configuration can allow the bottom protrusion **914** to be received in the connector plate seat **704**. Additionally, each of the bone pin apertures **702** may have a ring-shaped perimeter, that may, collectively with the connector plate seat **704**, form a receiving region **712** configured to receive a connector plate. For example, the receiving region **712** can have a geometric configuration similar to that of inferior surface **912**, shown in FIG. **19**. Second side **701***b* of the lateral endplate **700** may include a substantially similar arrangement of bone pin apertures and/or connector plate seat as first side **701***a*. Lateral endplate **700** also includes one or more bone pin lock seats **708** having a geometric configuration configured for receiving a bone pin lock (see **610** in FIG. **3**). Additionally, a central alignment aperture **710**, discussed in more detail later, is included in the lateral endplate **700** and may be configured to facilitate aligning a spinal implant with a surgical tool.

[0043] FIG. **5** shows an alternative embodiment of a lateral endplate **501** coupled to an embodiment of an expandable spinal implant. Implant **500** may have the same, similar, and/or substantially the same features and functionality as the various spinal implants disclosed herein. Accordingly, duplicative description will be omitted or only briefly described. The illustrated embodiment of FIG. **5** has an inferior bone pin aperture **551** and a superior bone pin aperture **552** that is vertically aligned with inferior bone pin aperture **551**. There is a bone pin relief **522** in top end plate **110** located behind superior bone pin aperture **522**. A similar bone pin relief may be located behind inferior bone pin aperture **551** in bottom endplate **120**. Proximal plate **550** is coupled to implant **500** either rigidly or pivotally to allow for lateral movement, vertical and/or rotational movement. In addition, bone pin apertures **551** and **552** are oriented to one lateral side of proximal plate **550**. In other embodiments bone pin apertures **551** and **552** can be vertically aligned with proximal plate **550**. For example, bone pin aperture **551** can be located vertically below proximal plate **550** and bone pin aperture **552** can be located vertically above proximal plate **550**. FIG. **5** also shows a plurality of attachment points **505** on proximal plate **550** for attachment of spinal implant **500** to a surgical tool.

[0044] In other embodiments proximal plate **550** may be omitted in favor of an alternate connection between lateral endplate **501** and spinal implant **500**. For example, a threaded connection between one or more surfaces on the lateral endplate **501** and the spinal implant **550** may connect the two components. Alternatively, the attachment points **505**, discussed above, can be located on a surface of spinal plant **500** instead of on the proximal plate **550** in embodiments in which proximal plate **550** is omitted.

[0045] A bone pin lock **503** is shown in the illustrated embodiment and can be rotated to lock one or more bone pins in place. In some embodiments bone pin aperture **551** and **552** may each have a corresponding bone pin lock. In alternative embodiments there may be one bone pin lock corresponding to each bone pin aperture and/or each bone pin. In some embodiments, each bone pin aperture may be configured to accommodate one bone pin. In alternative embodiments, each bone pin aperture may be able to accommodate two or more bone pins. In some embodiments, each bone pin aperture may be configured to accommodate two or more bone pins connected by a bone pin connector plate, as disclosed herein.

[0046] The various bone pin installation systems disclosed herein may include one or more surgical tools for implant component insertion, deployment and manipulation of various system components into an interbody space of a patient. Various surgical tools for insertion of a spinal implant are contemplated, such as those in U.S. patent application Ser. No. 17/,307,706 incorporated herein by reference in its entirety.

[0047] FIG. **6** shows an embodiment of a first surgical tool **400** for inserting and/or positioning a spinal implant **100** e.g., between vertebral bodies during surgery or another procedure. The first surgical tool **400** includes a handle **402** and a shaft **404**. The shaft **404** includes a tip **406** having a threaded portion **412**. The threaded portion **412** may be configured to separably connect to a spinal implant such that spinal implant may be securely attached to first surgical tool **400** during insertion of the spinal implant in situ and then detached from the spinal implant following insertion.

[0048] FIGS. **7** and **8** show an embodiment of a second surgical tool **100**. Other embodiments of a second surgical tool are contemplated. The first surgical tool **400** can be used in conjunction with a second surgical tool **100**. For example, the first surgical tool **400** may be used for inserting of a spinal implant and the second surgical tool may be used for deploying bone pins and/or bone pin anchor systems, into the spinal implant via surgical tool **100**. The illustrated embodiment includes a shaft **104** having a proximal end **116** relatively near handle **108** and a distal end **114** downstream of proximal end **116**. In the illustrated embodiment, a guide **102** is located on the distal end **114** of the shaft **104**. The guide **102** may be separably connected to the shaft **104**. For example, in some embodiments, the distal end **114** of the shaft **104** may include a threaded portion configured to connect with a threaded surface on the guide **102**. In alternative embodiments the guide **102** may be connected to the shaft **104** by way of other fasteners such as pins or screws.

[0049] In addition, the illustrated embodiment includes a pushing element **122** having a longitudinal stem **126** and a forked end **118**. The forked end **118** is configured to be received in an anchor aperture **1514** (shown best in FIG. **15**) during impaction of bone pins and/or bone anchors. The guide **102** also includes a guide rod **106** for facilitating in lining up the bone pin anchor systems properly with a spinal implant in order to facilitate proper impaction. For example, such that when impacting the bone pins these pins will extend through the corresponding apertures of the spinal implant as will be explained in further detail below. The guide **102**, pushing element **122**, and fork **112** are discussed in more detail below.

[0050] The illustrated embodiment in FIG. **8** also includes a stop axis **124**. The stop axis **124** includes a threaded portion **140** for attaching another component of a second surgical tool, such as guide **102**. The stop axis **124** may be housed by the shaft **104** and be used to manipulate a stop (discussed in more detail below) on the second surgical tool **100**.

[0051] The handle **108** encloses a volume and at least a portion of the shaft **104** may be received in the handle volume. In some embodiments the handle **108** may enclose a portion of the shaft such as proximal end (**116**) while another portion of the shaft remains unenclosed such as distal end (**114**). In the illustrated embodiment, the handle **108** includes a removable end cap **154**. A fork **112** is separably insertable within and/or connectable to the handle **108**. The fork includes a fork axis **153**. A first adjustment knob **110** is located upstream of the fork **112** adjacent to the proximal end. The first adjustment knob **110** may be separably connected to the fork **112** such as by way of a threaded connection to fork axis **153**. The separable connection of the fork **112** and the first adjustment knob **110** allows for access to a handle aperture (see **1904** in FIG. **9**) on the handle **108** and/or handle end cap **154** i.e., the first adjustment knob **110** and fork **112** may be removed so that a pushing element **122** or other component of the second surgical tool **100** may be fed through a handle aperture.

[0052] Referring now to FIG. **9**, a top-down view of a second surgical tool **1900**, like that shown in FIG. **7** is shown. In FIG. **9** the fork **112** and first adjustment knob **110** from the second surgical tool **100** of FIG. **7** have been removed for ease of understanding the remaining components. The second surgical tool **1900**, includes a handle **1901**, having a top surface **1902** with a handle aperture **1904**. In the illustrated embodiment, the handle aperture **1904**, has a T-bone, dog bone or other similar shape in order to allow the forked end of a pushing element to be fed through apertures shown in the handle **1901** of FIG. **9**. For example, the illustrated embodiment shows the handle aperture **1904** with two bulbous ends **1912** linked by a linear middle portion **1910**. The bulbous ends **1912** have a different shape than the linear middle portion **1910** to accommodate a forked end of a pushing element e.g. forked end **118** in FIG. **8**. The handle **1901** also includes a stop axis aperture **1908** so that a stop axis (not shown) may be fed through the handle to a distal end of the second surgical tool **1900** proximal to a guide (e.g., guide **102** in FIG. **8**). The stop axis can be a rod with a threaded end for receiving a stop. The stop axis and the stop may be used to position a stop configured to control impaction depth of the guide during impaction of a bone pin anchoring system.

[0053] Referring now to FIG. **10**, a second surgical tool **100** includes a shaft **104** having a first wall **105***a* and a second wall **105***b* opposite first wall **105***a*. The spacing between first wall **105***a* and second wall **105***b* forms a shaft aperture **130** extending along the longitudinal axis, λ, of the shaft **104** between a proximal end **116** and distal end **114** of the shaft **104**. The shaft aperture **130** may be configured to at least partially receive a component of the second surgical tool **100** such as a pushing element **122** and/or a stop axis (not shown). In the illustrated embodiment, the pushing element **122** can be seen between first wall **105***a* and second wall **105***b*. For example, the pushing element **122** and/or stop axis can be fed through one of the handle apertures discussed previously and received in the shaft aperture **130**. The shaft aperture **130** guides the pushing element **122** and/or stop axis by allowing movement along the longitudinal axis of the shaft **104** while limiting horizontal movement in the transverse direction of the shaft **104**.

[0054] FIG. **11** shows an embodiment of a guide **300**. The guide **300** may be attached to a second surgical tool such as that shown in FIG. **10** (see guide **102** attached to second surgical tool **100**). The guide **300** includes a second face **322** opposite a first face **312** having a guide rod **324**. The guide rod **324** may be configured to be received in a portion of a spinal implant in order to facilitate alignment of the guide **200** with the spinal implant. For example, the guide rod **324** may be received in a central aperture of a spinal implant. This further facilitates alignment of the guide **200** with the spinal implant and aids in proper bone pin placement in the implant. A bone pin anchor system **900** including a bone pin **902** and a connector plate **901** is shown seated in the guide **300**. In some embodiments, the guide may include a window **320**, providing access to the interior of the guide **300**. The window **320** can be seen on elongated side **314***a* of the illustrated embodiment.

[0055] Referring to FIG. **12**, a top-down view of a guide **300** is shown. In some embodiments, the guide **300** may include a threaded surface **301**, which may utilize threads in order to attach the guide **300** to a threaded portion of a second surgical tool. For example, the threaded surface **301** may be configured to connect the guide **300** to a threaded portion of a stop axis on a second surgical tool. The guide **300** includes a first face **312** having one or more anchor apertures **306** configured to receive one or more embodiments of an anchoring system **308**. The location of the anchor apertures **306** on the first face **312** may correspond to the location of regions (e.g., regions formed collectively by the bone pin apertures **702** and connector plate seat **704** in FIG. **4**) on an endplate and be of a similar geometry to such regions. This correspondence in size and shape facilitates the deployment of one or more bone pins and/or bone pin anchoring systems into the apertures of the endplate of a spinal implant using the second surgical tool. In the embodiment illustrated in FIG. **12**, the guide **300** also includes a central alignment aperture **318** on first face **312**. Nested inside of central alignment aperture **318** is a surface **342** having a shaft aperture **310**. The central alignment aperture **318** may have a diameter large enough to accommodate at least one prong (e.g., prong **119** in FIG. **8**) on a pushing element (e.g., pushing **122** in FIG. **8**). The shaft opening **310** may have a diameter large enough to receive a portion of a shaft of a second surgical tool.

[0056] FIG. **13** shows a section view of an embodiment of a guide **500**. In the illustrated embodiment, one or more channels **502** are shown on an interior surface located inside the one or more anchor apertures (see **306** in FIG. **12**) on the guide **500**. The channels **502** are configured so that when the bone pins (and connector plate) (as shown in FIG. **11**) are inserted in the one or more anchor apertures a support arm (e.g., **504** in FIG. **17**A) of each bone pin is aligned within a corresponding channel **502**. The one or more channels **502** run between a first face **504** and second face **506** of the guide. In some embodiments, there is a channel **502** corresponding to each bone pin seated within the connector plate i.e., if a connector plate (e.g. **901** in FIG. **11**) contains two bone pins there may be two channels **502** in the corresponding anchor aperture, e.g., an upper channel **502** and a lower channel **502** that diverge in different directions as shown in the cross section drawing of FIG. **13**. In alternative embodiments, the number of channels and corresponding bone pins can differ. In many embodiments each bone pin may have a corresponding channel **502**, e.g., three bone pins and three corresponding channels, four bone pins and four corresponding channels.

[0057] The channels **502** define a trajectory, denoted by t configured to allow the support arm (**504** in FIG. **17**A) of the bone pins to rotate therein. For example, FIG. **13** has two channels **502**, each channel **502** may be configured to receive the support arm **504** of one corresponding bone pin. The trajectory of each of the channels **502** is relatively straight along a first portion thereof that is close to the anchor aperture (**306** in FIG. **12**) and then gradually converges inwardly along a second portion thereof that is toward the other channel **502** so that the space between the two channels decreases between the first face **504** and second face **506**. In various embodiments, this configuration of the support arm **504** of a first bone pin to rotate in a first channel **502***a* in a clockwise direction relative to the medial axis **518** of the bone pin (see FIG. **17**A and **17**B). Likewise, the second bone pin rotates in a second channel **502***b* in a counter-clockwise direction relative to the medial axis **518** causing the distal ends of the first and second bone pins to diverge relative to a central axis of a connector plate. For example, during impaction the channels cause the corresponding bone pins to splay outwards relative to the central axis of the connector plate. In the illustrated embodiment, the trajectories of the two channels **502***a* and **502***b* are substantially symmetrical so that each of the two bone pins diverges in the same manner (or a similar manner) as the other bone pin but in an opposite direction (or a different direction). In various embodiments the two bone pins may diverge an equal amount, and in other embodiments the two bone pins may diverge a different amount, e.g., depending on the particular needs of the patient's anatomy and the orientation of the bone pin apertures of the endplate of the implant. In various embodiments, the channels **502**, **504** allow for precise manipulation of the pins divergence and rotation thereof during an installation procedure and such divergence and rotation may facilitate anchoring of the bone pins into a bony structure. The control the guide **500** imparts over the bone pins via the channels **502** facilitates a surgeon in installing the bone pins in a manner that promotes stability of an associated spinal implant. Additionally, the curved nature of the bone pins and the divergence of the bone pins during an installation procedure may also increase the retention of the bone pins in patient anatomy relative to straight bone pins and/or bone pins that do not diverge during impaction. In this way, embodiments in accordance with the principles of this disclosure improve upon systems of the prior art.

[0058] The guide **500** may be outfitted with a deflector tab **508** adjacent to each of the anchor apertures. The deflector tab **508** may be configured to temporarily retain and orient the connector plate relate to the guide **500** immediately prior to impaction. For example, the deflector tab **508** may temporarily retain the connector plate and bone pins during an insertion and alignment process prior to impaction of the bone pins. In addition, each deflector tab **508** has a corresponding groove **507** on an inner surface of each of the connector plate apertures configured to position the connector plate within the connector plate aperture. When the bone pins and connector plate are loaded into the guide **500** the deflector tab **508** extends in a direction, e.g., outwardly from a longitudinal axis of a second surgical tool, so as to allow the connector plate (with bone pins) to pass through the connector plate aperture and align with the groove **507** so that the bone pins and connector plate sit within the guide **500** securely and with the proper orientation for impaction. In this way, the deflector tab **508** deflects outwardly and then snaps back into place. The unique geometrical arrangement shown in the example embodiment then allows the forward motion of the connector plate and bone pins during an impaction process.

[0059] Referring back to FIG. **8** an embodiment of a pushing element **122** is shown. In the illustrated embodiment the pushing element **122** includes a first prong **119** and a second prong **120** connected by a bridge **121** therebetween. In this embodiment, the first prong **119** is formed from the tip of the stem **126** of the pushing element **122**. That is to say that the first prong **119** is coaxially aligned with the longitudinal axis of the stem of the pushing element **122** and the second prong **120** is offset to the side of the longitudinal axis of the stem. The second prong **120** extends off of the bridge **121** in a direction, **8**, and is substantially parallel to the first prong **119**. In some instances, such as during impaction, the first prong **119** may partially extend within a central alignment aperture such as central alignment aperture **318**, shown in FIG. **12**. Likewise, the second prong **120** may extend partially within a connection plate aperture such as connection plate aperture **308**, also shown in FIG. **12** so that the bridge straddles a portion of connection plate **300** between the central alignment aperture **318** and connection plate aperture **308**.

[0060] Referring now to FIG. **14**, a guide **300** includes a first elongated side **314*a*** and a second elongated side (not shown) opposite first elongated side **314*a***. A first face **312** and a second face **322** opposite the first face **312** are shown. First face **312** abuts the shaft **104** of a second surgical tool. The shaft has a forked end **118** located near enough to first face **312** so as to extend at least partially within an aperture on first face **312**. Second face **322** includes a guide rod **324**.

[0061] In the illustrated embodiment a stop **326** is located on the first elongated side **314*a*** of guide **300** and is connected to a stop shaft **327**. The stop shaft **327** may extend alongside a shaft or within a shaft aperture of a second surgical tool and be connected to a first adjustment knob upstream of the guide **300** e.g., near a handle of a second surgical tool. The stop **326** may be connected to the stop shaft **327** by a threaded connection. For example, the stop **326** can be threadably connected to an end of stop shaft **327** which may extend partially within the guide. In various embodiments, a user can use a second adjustment knob to extend and retract the stop **326** between a first position and a second position. For example, a user can press a button on a second surgical tool to release the second adjustment knob (see **1614** in FIG. **16**). The user can then turn the second adjustment knob in a clockwise or counterclockwise direction to extend the stop shaft **327** to a first position.

[0062] The stop may include a planar surface, which may be configured to provide close fit contact between the planar surface and a fixed structure e.g., a vertebrae or other bony structure. When the guide is positioned in situ, the user can extend the stop so that the planar surface is in contact with a nearby bony structure, and in turn, the nearby bony structure provides a stabilizing surface for the guide to rest on, e.g., during impaction of the bone pins. Additionally, the contact between the stop and the nearby bony structure limits the depth of insertion of the second surgical tool into an interbody space.

[0063] FIG. **15** shows an embodiment of a pushing element **1542** on an embodiment of a second surgical tool **1500**. The pushing element **1542** includes a stem **1526** having a proximal end and a distal end. One or more prongs **1516** are located on the distal end of the stem **1526**. A knob **1524**, e.g., a substantially flat headed knob **1524** is located on the proximal end of the stem **1526** and is configured to sustain an impaction force from a striking tool such as a hammer, piston, or other blunt instrument. The stem **1526** of the pushing element **1542** may be at least partially disposed inside a shaft aperture. A guide **1512** is connected to an end of the second surgical tool **1500**. The guide **1512** may contain one or more bone pin anchoring systems **1544** received in one or more anchor apertures **1514** on a first surface **1510** of the guide **1512**. FIG. **15** shows one of the anchor apertures **1514** void of an anchoring system **1544**. This is merely for case of understanding and both anchor apertures **1514** in FIG. **15** are configured to receive an anchoring system **1544**. Additionally or alternatively, the one or more prongs **1516** can extend at least partially into the one or more anchor apertures **1514** of the guide **1512** so that the tip of one or more of the prongs **1516** are in contact with a portion of the one or more bone pin anchor systems **1544**.

[0064] During impaction of the one or more bone pin anchor systems **1544**, a user can apply a force to the substantially flat head **1524** of the pushing element **1542** and this force may be transferred by contact of the pushing clement **1542** by way of the prongs **1516** with the one or more bone pin anchor systems **1544** thereby creating a successive chain of forces driving impaction of the one or more bone pin anchor systems **1544**.

[0065] FIG. **15** also shows an embodiment of a wedge **1528**. The wedge **1528** has a height h and a substantially semi-circular cross section **1540**. The wedge **1528** also includes a first surface **1536**. The first surface **1536** forms a groove configured to be received around the stem **1526** of the pushing element **1542** so that the wedge **1528** may be securely attached to the stem **1526**. In some embodiments, the wedge **1528** is placed around an end of the stem **1526** located upstream of a handle **1546**. The wedge **1528** limits the extension of the pushing element **1542** by height h during impaction and thereby limits the depth at which the bone pin anchor systems **1544** are impacted. This configuration also allows removal of the wedge **1528** and utilization of wedges **1528** having different heights or thicknesses so that a user may alter the impaction depth.

[0066] FIG. **16** shows a portion of a proximal end of an embodiment of a second surgical tool **1600** utilizing a different end for impaction of bone pins. The illustrated embodiment includes a fork **1612** that is connected to a handle **1616** of the second surgical tool **1600**. In the example embodiment, fork **1612** is a C-shaped fork. The fork **1612** may be separably connected to the handle **1616** via a threaded connection **1608** or other suitable means. A rotatable adjustment knob **1602** is located upstream of the fork and defines the proximal end of the tool. The adjustment knob may be connected via a threaded connection to the fork **1612** and may be removable from the fork **1612** as discussed previously. The separability of the fork **1612** and adjustment knob **1602** may allow for replacement by another tool such as a pushing element to one or more handle apertures. A user may turn the adjustment knob **1602** in order to gradually impact one or more bone pin anchor systems or to finish the impaction thereof after usage of a hammer applying a blunt force as explained above. In some embodiments the adjustment knob **1602** may compress a spring **1604**, which applies a force to a pushing element in order to impact one or more bone pin anchor systems. Additionally, or in the alternative, the adjustment knob **1602** may tighten a threaded connection between a pushing element and the fork **1612** and cause the pushing element to extend so as to impact the one or more bone pin anchor systems. In various embodiments, the adjustment knob **1602** and fork **1612** can also be used to complete the final portion of impaction of the bone pin anchor systems following an initial partial impaction completed with a pushing element.

[0067] Referring now to FIGS. **17**A and **17**B, an embodiment of a bone pin **500** is shown. The bone pin **500** includes a curved body **512**. The curved body **512** includes a convex outer surface **516** and a concave inner surface **514**. In some embodiments, the surface of the curved body **512** can include two or more faces that meet at an angular juncture and/or two or more faces that meet at a curved juncture resulting in the surface of the body **512** being smooth at some locations and textured at other locations. The curved body **512** extends between a proximal end **508** and a distal end **510** of the bone pin for a pre-determined length. In some embodiments, the body **512** may be curved from end to end and in others the body **512** may be curved from an intermediate point to one end and straight from the intermediate point to the other end. The bone pin **500** also includes a planar surface **506** that converges into distal end **510** at a point. The distal end **510** and/or planar surface **506** may be sufficiently sharp and hard to cut through a substrate so that the bone pin **500** may be driven or impacted into a substrate, such as bone. One or more protrusions (not shown) e.g., barbs, teeth, hooks, spikes, etc. may be disposed along the curved body **512** at various locations and may prevent and/or otherwise facilitate the bone pin **500** from backing out of a substrate. In addition to the protrusions, the curved nature of the body **512** may facilitate anchoring of the bone pin **500** in a substrate e.g., a bony substrate such as a portion of vertebrae. In this way, the curved bone pin **500** may be less prone to back out of a substrate than a similar pin without a curved body **512** and therefore promote better fixation of a spinal implant in a patient's disc space.

[0068] Proximal end **508** of bone pin **500** includes a stem **502**. In the example embodiment, an arm **504** extends outwardly from the stem **502**. The arm **504** may be oriented substantially perpendicular to the stem **502** as shown in FIGS. **17**A and **17**B. Alternatively, the arm **504** may be oriented at an angle relative to stem **502** and/or arm **504** and it may be hingedly connected. FIG. **17**A and **17**B show a medial axis **518** of the stem **502** that runs through the center of the stem **502** and in the lengthwise direction.

[0069] Referring now to FIGS. **18** and **19**, an embodiment of a bone pin anchoring system **900** is shown. In the example illustration, one bone pin is not illustrated for case of understanding. The bone pin anchoring system **900** includes a bone pin connector plate **901** including one or more pin seats **908** that are configured to receive a corresponding bone pin **902**. In the illustrated embodiment, the bone pin connector plate **901** includes two pin seats **908** where each pin seat **908** is configured to support a corresponding one bone pin **902**. One of the pin seats **908** is located on a first side **920***a* of the bone pin connector plate **901** and another pin seat **908** is located on a second side **920***b* of the bone pin connector plate **901**. The bone pin seats **908** can be arranged symmetrically about a central axis **922** of the bone pin connector plate **901** or they may be asymmetrical.

[0070] A bone pin **902** is inserted into one of the pin seat **908** so that a stem **904** of the bone pin **902** extends through a superior surface **910** and an inferior surface **912** of the bone pin connector plate **900** and the arm **906** extends outside the plane defined by the superior surface **910**. The superior surface **910** may at least partially support the arm **906** as shown in FIG. **18**. The stem **904** may have a cylindrical body having a circumference or an ovoid body that facilitates rotation of the stem **904** during an installation procedure. The pin seat **908** may include a first interior surface **918** having a circumference slightly larger than the circumference of the cylindrical body of stem **904** and be configured to receive the stem **904**. The pin seats **908** may also include a second interior surface **916** having a perimeter that is sufficiently sized to receive the stem **904**.

[0071] The connector plate **901** also includes a bottom protrusion **914** on the inferior surface **912** that aligns with a corresponding seat on an endplate of a spinal implant so that the connector plate **914** can be aligned in the endplate. The connector plate **901** can reduce excess movement of the bone pins during impaction and while deployed in vertebral bodies. By connecting multiple bone pins the connector plate **901** facilitates stability of the bone pins during impaction during a surgical procedure and reduces the likelihood of the bone pins backing out of vertebral bodies. In various embodiments the bone pins may be pre-loaded to the connector plate **901** to facilitate installation thereof. For example, a surgeon may take a pre-assembled bone pin anchoring system **900** and quickly couple it to a surgical tool for impaction of the bone pins as will be explained in further detail below. The connection of the bone pins by connector plate **901** also allows for simultaneous impaction of multiple bone pins reducing the time required for installation of the pins and the time required for a related surgical procedure.

[0072] In some embodiments, various components of the bone pin installation system may be coated or treated with a variety of additives or coatings to improve biocompatibility, bone growth promotion materials such as BMP or other features. For example, bone pin **902** may be selectively coated with bone growth promoting or bone on growth promoting surface treatments that may include, but are not limited to: titanium coatings (solid, porous or textured), hydroxyapatite coatings, or titanium plates (solid, porous or textured), and/or may have various nano-coated or nano-sized features for enhanced bone ingrowth surfaces.

[0073] FIG. **20** is a flow chart method of operation and/or a surgical procedure **2000** for installing an expandable spinal implant and bone pins in and around the vertebrae of a patient. The various method steps below may be explained in the context of the various disclosed spinal implants, e.g., like those shown in FIGS. **1-3**. Although the various spinal implants and bone pins disclosed herein may be used to perform the method of operation **2000** the method of operation is not limited to the embodiments disclosed herein. Furthermore, the following steps need not be performed in sequence

and can be performed in any alternate sequence with or without all of the disclosed method steps.
[0074] At step **2002**, an expandable spinal implant may be provided for use in a surgical procedure including, without limitation, corpectomy, discectomy, fusion and/or fixation treatments that employ spinal implants, anterior lumbar interbody fusions (ALIF), posterior lumbar interbody fusion (PLIF), oblique lumbar interbody fusion, transforaminal lumbar interbody fusion (TLIF), various types of anterior fusion procedures, and any fusion procedure in any portion of the spinal column (sacral, lumbar, thoracic, and cervical, for example), open surgery, mini-open surgery, minimally invasive surgery and percutaneous surgical implantation. For example, a surgeon or their staff may prepare the spinal implant for use in a surgical procedure by making it available for use in an operating room, removing the spinal implant from its manufacturing and/or shipping packaging, inspecting the spinal implant or placing the spinal implant on a tray or adjacent to a patient's body. In accordance with various embodiments described herein, the spinal implant may include an endplate, including but not limited to, a lateral endplate, anterior endplate and/or be configured to be connected to one or more surgical tools.
[0075] At step **2004**, an end user may prepare a space between adjacent boney structures by removal and/or cleaning of the disc space. For example, an end user may remove a degenerative disc between a superior vertebrae and an inferior vertebrae.
[0076] At step **2006**, an end user may insert the spinal implant in the interbody space between the disc space between the superior vertebrae and the inferior vertebrae. The end user may use a first surgical tool to insert the spinal implant. For example, the user may align the first surgical tool with the lateral endplate of the spinal implant and insert the implant.
[0077] At step **2008** an end user may expand the spinal implant to adjust the spacing and angle of inclination of the adjacent vertebrae. For example, the end user may use the first surgical tool to expand and/or angulate the spinal implant. The user may then use the first surgical tool to adjust the positioning of the spinal implant in the interbody space and the angulation of one or more endplates of the spinal implant.
[0078] At step **2010** one or more bone pins may be provided. For example, a surgeon or their staff may prepare the one or more bone pins for use in a surgical procedure by making the one or more bone pins available for use in the operating room, removing the bone pins from their manufacturing and/or shipping packaging, inspecting the bone pins or placing the bone pins on a tray or adjacent to a patient's body. The one or more bone pin may be part of an anchoring system, in accordance with various embodiments described herein, which may be prepared for use in a surgical procedure in a similar manner to the bone pins described above. For example, one or more anchoring systems having a connector plate with one or more bone pins received with the connector plate may be provided. One or more connector plate apertures of a guide can be loaded with the one or more anchoring systems. In some embodiments, the guide is loaded with an anchoring system in each anchor aperture. The guide may be pre-loaded, that is loaded in advance of this method **2000** and/or step **2010**, with one or more anchoring systems and/or bone pins. For example, the anchoring system and bone pins may be preassembled such that the bone pins are attached to the anchoring system as a single unit that allows far rapid installation of the bone pins. Alternatively, an end user may insert, manually or by any other means, the one or more anchoring systems and/or bone pins into the guide at this step **2010**. The bone pins and/or anchoring systems may, for example, be used in any surgical procedures or techniques discussed herein.
[0079] At step **2012**, an end user e.g., a surgeon, may deploy or impact the one or more bone pins into a bony structure. The user may insert a guide rod on the end of the guide into a central alignment aperture of an end plate of the spinal implant previously inserted between vertebral bodies in step **2006**. The insertion of the rod in the central alignment aperture aligns the guide, anchoring systems and bone pins properly with the implant e.g., in an orientation so that the bone pins may be impacted into the area surrounding the implant so that the pins are correctly positioned relative to one or more bone pin apertures, or other component of the implant.

[0080] Following alignment of the guide with the implant, the user may release a stop on the guide that is configured to control the depth at which the user may insert the guide into the interbody space. As described herein, the stop may be aligned with a nearby vertebral body or other bony structure while the guide is aligned with the implant. For example, the stop may be initially non-deployed and if desired by the surgeon the stop may be deployed to prevent over insertion of the surgical tool.
[0081] The user can optionally attach a wedge to a pushing element of the second surgical tool to control the impaction depth of the pushing element. The wedge can be configured to control the depth at which the pushing element impacts the bone pin anchoring systems and/or bone pins. The user may apply a force with a hammer or similar tool to a flat head or other portion of the pushing element so that the pushing element exerts an impaction force on the one or more bone pins of the anchoring system sufficient to drive the one or more bone pins into bony anatomy. In some embodiments, the pushing clement may be used to partially impact the bone pin anchoring systems up to the maximum depth allowed by the wedge. Note that different sized wedges may be available so the user can select the impaction depth allowed by the wedge. After partial impaction the one or more bone pins may be partially lodged in a vertebral body and partially lodged in the one or more anchor apertures of the guide thereby restricting removal of the second surgical tool at this step.
[0082] Following partial impaction the user can complete final impaction of the bone pins and/or anchoring systems by removing the wedge and using a hammer directly driving the bone pins and/or anchoring systems or other impaction device. Another example impaction device may comprise a rotatable driver having a threaded connection that moves a fork forward to perform a final impaction as described herein. This type of tool will allow a surgeon to continue to impact the anchoring systems so that the pins penetrate the vertebral bodies at the desired depth i.e., the depth needed to secure the implant in accordance with the relevant surgical procedure. The user may then remove the second surgical tool from the interbody space leaving the anchoring system in place. If there are one or more pin locks, cams, plates or other fastening mechanisms they may be secured to cover the bone pins following completing the impaction of the bone pins to prevent the bone pins and/or anchoring systems from backing out. For example, the user may move bone screw lock **803** in FIG. **1** from the unlocked position to the locked position to cover, or at least partially cover, the bone pins and/or anchoring systems.
[0083] It should be understood that various aspects disclosed herein may be combined in different combinations than the combinations specifically presented in the description and accompanying drawings. For example, features, functionality, and components from one embodiment may be combined with another embodiment and vice versa unless the context clearly indicates otherwise. Similarly, features, functionality, and components may be omitted unless the context clearly indicates otherwise. It should also be understood that, depending on the example, certain acts or events of any of the processes or methods described herein may be performed in a different sequence, may be added, merged, or left out altogether (e.g., all described acts or events may not be necessary to carry out the techniques).
[0084] Unless otherwise specifically defined herein, all terms are to be given their broadest possible interpretation including meanings implied from the specification as well as meanings understood by those skilled in the art and/or as defined in dictionaries, treatises, etc. It must also be noted that, as used in the specification and the appended claims, the singular forms “a,” “an” and “the” include plural referents unless otherwise specified, and that the terms “comprises” and/or “comprising,” when used in this specification, specify the presence of stated features, elements, and/or components, but do not preclude the presence or addition of one or more other features, steps, operations, elements, components, and/or groups thereof.
[0085] Without excluding further possible embodiments, certain example embodiments are summarized in the following clauses:
[0086] Clause 1: An anchoring system for use in a surgical procedure, comprising: one or more

bone pins having a curved body extending from a proximal end to a distal end, and the proximal end comprising a support arm; and a connector plate having a superior surface, an inferior surface, and one or more pin seats extending between the superior surface and the inferior surface, wherein each of the one or more pin seats are configured to receive a corresponding one of the one or more bone pins such that the support arm of the corresponding one or more bone pins is pivotally supported, and wherein the curved body of the one or more bone pins is configured to facilitate anchoring of the one or more bone pins in bony anatomy.

[0087] Clause 2: The anchoring system of clause 1, wherein the distal end of each of the one or more bone pins further comprises a planar portion terminating at a point for cutting through bony anatomy.

[0088] Clause 3: The anchoring system of any one of clauses 1-2, wherein each of the one or more bone pins further comprises one or more protrusions arranged on the curved body and configured to facilitate anchoring of the bone pin in bony anatomy.

[0089] Clause 4: The anchoring system of clause 3, wherein the connector plate further comprises at least one bulbous protrusion having a size and shape that corresponds to a size and shape of an aperture of an endplate of a spinal implant thereby facilitating stability and alignment of the anchoring system relative to the spinal implant.

[0090] Clause 5: The anchoring system of clause 4, wherein the endplate further comprises at least one rotatable bone pin lock having at least one wing, each wing comprising a surface extending in a plane that is substantially perpendicular to a corresponding bone pin trajectory and the at least one rotatable bone pin lock is configured to secure a bone pin in the endplate.

[0091] Clause 6: The anchoring system of any one of clauses 1-5, wherein each of the one or more bone pins include a hydroxyapatite coating and each of the one or more bone pins is pre-loaded to the anchoring system such that each of the one or more bone pins may be driven into patient anatomy.

[0092] Clause 7: The anchoring system of clause 4, wherein the at least one bulbous protrusion is configured to align the connector plate relative to the spinal implant without directly coupling the connector plate to the spinal implant.

[0093] Clause 8: The anchoring system of any one of clauses 1-7, wherein each of the one or more bone pins further comprises a stem and wherein, during an installation procedure, the one or more bone pins are configured to rotate relative to a medial axis of the stem and to diverge in a controlled manner from a central axis of the connector plate as the pins rotate.

[0094] Clause 9: The anchoring system of clause 8, wherein the one or more bone pins comprises a first bone pin and a second bone pin and wherein, during an installation procedure, the first bone pin is configured to rotate in a first direction while the second bone pin rotates in a second direction, the second direction being different than the first direction.

[0095] Clause 10: A bone pin installation system, the system comprising: a hollow surgical tool extending in a longitudinal direction and having a guide portion at a distal end thereof; one or more bone pins having a curved body extending from a proximal end to a distal end and a support arm; and one or more connector plates having a superior surface, an inferior surface and one or more pin seats extending between the superior surface and the inferior surface, wherein the one or more pin seats are configured to receive a corresponding one of the one or more bone pins so that the support arm of the corresponding bone pin is pivotally supported by the superior surface, wherein the guide portion includes one or more channels configured to receive the support arm of a corresponding one of the one or more bone pins and guide the corresponding bone pin during an installation procedure, wherein the curved body of the one or more bone pins is configured to facilitate anchoring of the one or more bone pins in bony anatomy.

[0096] Clause 11: The bone pin installation system of clause 10, the one or more bone pins further comprising a stem and being received in a corresponding one of the one or more connector plates, wherein the one or more bone pins are configured to rotate in the one or more channels relative to a medial axis of the stem and the distal end of the one or more bone pins diverges in a controlled manner from a central axis of the corresponding one of the one or more connector plates as the one or more bone pins rotate.

[0097] Clause 12: The bone pin installation system of clauses 10-11, wherein a distal end of the guide portion further comprises a guide rod, configured to align with a central aperture of a spinal implant.

[0098] Clause 13: The bone pin installation system of clauses 10-12, wherein the hollow surgical tool further comprises a depth stop configured to contact a bony structure of a patient, wherein the depth stop is configured to limit the depth of insertion of the surgical tool into an interbody space.

[0099] Clause 14: The bone pin installation system of clauses 10-13, wherein the guide portion further comprises one or more anchor apertures configured to receive the one or more connector plates.

[0100] Clause 15: The bone pin installation system of clause 14, wherein the guide portion further comprises a deflection tab proximate to each of the anchor apertures, wherein the deflector tab extends outward relative to the longitudinal direction of the surgical tool so as to allow the connector plate to be positioned within a groove on a surface of the guide portion and temporarily coupled in place relative to the groove.

[0101] Clause 16: The bone pin installation system of clause 14, further comprising a pusher insertable inside of the surgical tool, wherein the pusher is configured to drive the one or more connector plates by applying an impaction force to the one or more connector plates.

[0102] Clause 17: The bone pin installation system of clause 16, wherein the pusher further comprises one or more prongs at a distal end thereof configured to be received in the one or more anchor apertures.

[0103] Clause 18: The bone pin installation system of clause 17, further comprising a wedge separably attached to a proximal end of the pusher, wherein the wedge is configured to control the depth at which the one or more prongs are received in the one or more anchor apertures thereby controlling an impaction depth of the one or more bone pins.

[0104] Clause 19: A method of inserting an expandable spinal implant comprising: preparing a spinal implant for insertion in a patient; removing a degenerative portion of patient anatomy; inserting the spinal implant between one or more bony structures of a patient; preparing one or more anchoring systems according to claim **1** for insertion into the patient, wherein each of the one or more bone pins is pre-loaded into one or more anchor apertures of a guide portion; an aligning step including aligning a guide rod of the guide portion with a central aperture of an endplate of the spinal implant; an impacting step including impacting the one or more anchoring systems into bony anatomy using a pusher; and locking one or more fastening mechanisms of the spinal implant.

[0105] Clause 20: The method of clauses 19, wherein, during the impacting step, each of the one or more bone pins diverges away from a medial axis of the connector plate.

Claims

1. An anchoring system for use in a surgical procedure, comprising: one or more bone pins having a curved body extending from a proximal end to a distal end, and the proximal end comprising a support arm; and a connector plate having a superior surface, an inferior surface, and one or more pin seats extending between the superior surface and the inferior surface, wherein each of the one or more pin seats are configured to receive a corresponding one of the one or more bone pins such that the support arm of the corresponding one or more bone pins is pivotally supported, and wherein the curved body of the one or more bone pins is configured to facilitate anchoring of the one or more bone pins in bony anatomy.

2. The anchoring system of claim 1, wherein the distal end of each of the one or more bone pins further comprises a planar portion terminating at a point for cutting through bony anatomy.

3. The anchoring system of claim 1, wherein each of the one or more bone pins further comprises one or more protrusions arranged on the curved body and configured to facilitate anchoring of the bone pin in bony anatomy.

4. The anchoring system of claim 3, wherein the connector plate further comprises at least one bulbous protrusion having a size and shape that corresponds to a size and shape of an aperture of an endplate of a spinal implant thereby facilitating stability and alignment of the anchoring system relative to the spinal implant.

5. The anchoring system of claim 4, wherein the endplate further comprises at least one rotatable bone pin lock having at least one wing, each wing comprising a surface extending in a plane that is substantially perpendicular to a corresponding bone pin trajectory and the at least one rotatable bone pin lock is configured to secure a bone pin in the endplate.

6. The anchoring system of claim 1, wherein each of the one or more bone pins includes a hydroxyapatite coating and each of the one or more bone pins is pre-loaded to the anchoring system such that each of the one or more bone pins may be driven into patient anatomy.

7. The anchoring system of claim 4, wherein the at least one bulbous protrusion is configured to align the connector plate relative to the spinal implant without directly coupling the connector plate to the spinal implant.

8. The anchoring system of claim 1, wherein each of the one or more bone pins further comprises a stem and wherein the one or more bone pins are configured to relative to a medial axis of the stem and to diverge in a controlled manner from a central axis of the connector plate as the pins rotate.

9. The anchoring system of claim 8, wherein the one or more bone pins comprises a first bone pin and a second bone pin and wherein, during an installation procedure, the first bone pin is configured to rotate in a first direction while the second bone pin rotates in a second direction, the second direction being different than the first direction.

10. A bone pin installation system, the system comprising: a hollow surgical tool extending in a longitudinal direction and having a guide portion at a distal end thereof; one or more bone pins having a curved body extending from a proximal end to a distal end and a support arm; and one or more connector plates having a superior surface, an inferior surface and one or more pin seats extending between the superior surface and the inferior surface, wherein the one or more pin seats are configured to receive a corresponding one of the one or more bone pins so that the support arm of the corresponding bone pin is pivotally supported by the superior surface, wherein the guide portion includes one or more channels configured to receive the support arm of a corresponding one of the one or more bone pins and guide the corresponding bone pins during an installation procedure, wherein the curved body of the one or more bone pins is configured to facilitate anchoring of the one or more bone pins in bony anatomy.

11. The bone pin installation system of claim 10, the one or more bone pins further comprising a stem and being received in a corresponding one of the one or more connector plates, wherein the one or more bone pins are configured to rotate in the one or more channels relative to a medial axis of the stem and the distal end of the one or more bone pins diverges in a controlled manner from a central axis of the corresponding one of the one or more connector plates as the one or more bone pins rotate.

12. The bone pin installation system of claim 10, wherein a distal end of the guide portion further comprises a guide rod, configured to align with a central aperture of a spinal implant.

13. The bone pin installation system of claim 10, wherein the hollow surgical tool further comprises a depth stop configured to contact a bony structure of a patient, wherein the depth stop is configured to limit the depth of insertion of the surgical tool into an interbody space.

14. The bone pin installation system of claim 10, wherein the guide portion further comprises one or more anchor apertures configured to receive the one or more connector plates.

15. The bone pin installation system of claim 14, wherein the guide portion further comprises a deflection tab proximate to each of the anchor apertures, wherein the deflector tab extends outward relative to the longitudinal direction of the surgical tool so as to allow the connector plate to be positioned within a groove on a surface of the guide portion and temporarily coupled in place relative to the groove.

16. The bone pin installation system of claim 14, further comprising a pusher insertable inside of the surgical tool, wherein the pusher is configured to drive the one or more connector plates by applying an impaction force to the one or more connector plates.

17. The bone pin installation system of claim 16, wherein the pusher further comprises one or more prongs at a distal end thereof configured to be received in the one or more anchor apertures.

18. The bone pin installation system of claim 17, further comprising a wedge separably attached to a proximal end of the pusher, wherein the wedge is configured to control the depth at which the one or more prongs are received in the one or more anchor apertures thereby controlling an impaction depth of the one or more bone pins.

19. A method of inserting an expandable spinal implant comprising: preparing a spinal implant for insertion in a patient; removing a degenerative portion of patient anatomy; inserting the spinal implant between one or more bony structures of the patient; preparing one or more anchoring systems according to claim 1 for insertion into the patient, wherein each of the one or more bone pins is pre-loaded into one or more anchor apertures of a guide portion; an aligning step including aligning a guide rod of the guide portion with a central aperture of an endplate of the spinal implant; an impacting step including impacting the one or more anchoring systems into bony anatomy using a pusher; and locking one or more fastening mechanisms of the spinal implant.

20. The method of claim 19, wherein, during the impacting step, each of the one or more bone pins diverges away from a medial axis of the connector plate.