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Straight and curved femoral broach impactor adapters

Abstract

An orthopaedic surgical instrument may include an elongated body with a broach end and an impactor end. The body may be straight or curved. A latch lever may be pivotally coupled to the elongated body. The latch lever may be moveable between an open position and a latched position in which the latch lever is retained within the body. A surgical broach may be rigidly attached to the broach end of the elongated body. An automated surgical impactor may be attached to the impactor end.

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Background/Summary

TECHNICAL FIELD

(1) The present disclosure relates generally to orthopaedic instruments for use in the performance of an orthopaedic joint replacement procedure, and more particularly to orthopaedic surgical instruments for use in the performance of a hip replacement procedure.

BACKGROUND

(2) Joint arthroplasty is a well-known surgical procedure by which a diseased and/or damaged natural joint is replaced by a prosthetic joint. For example, in a hip arthroplasty surgical procedure, a patient's natural hip ball and socket joint is partially or totally replaced by a prosthetic hip joint. A typical prosthetic hip joint includes an acetabular prosthetic component and a femoral head prosthetic component. An acetabular prosthetic component generally includes an outer shell configured to engage the acetabulum of the patient and an inner bearing or liner coupled to the shell and configured to engage the femoral head. The femoral head prosthetic component and inner liner of the acetabular component form a ball and socket joint that approximates the natural hip joint.

(3) Typical joint arthroplasty surgical procedures include impacting surgical instruments (e.g., broaches, chisels, or other cutting tools) and/or prosthetic implants into the patient's bone. Historically, impaction has been performed by an orthopaedic surgeon manually striking a surgical instrument using a surgical mallet or hammer. Such manual impaction can be unpredictable and imprecise. Additionally, typical manual impaction instruments may require the surgeon to hold the instrument with one hand and strike the instrument with a mallet held in the surgeon's other hand.

(4) Certain automated surgical impactors are capable of performing a series of percussive impacts that each provide a controlled amount of impaction energy. An automated surgical impactor may be used with one or more adapters to connect to various surgical instruments and/or implants. Typical adaptors connect to the surgical instrument and/or implant using a rigid drive train including one or more drive shafts, gear trains, or other rigid mechanical connections.

SUMMARY

(5) According to one aspect, an orthopaedic surgical instrument includes an elongated body, a first lever and a second lever, a leaf spring, and a pushbutton catch coupled to the elongated body. The elongated body extends from a first end to a second end. The first end is configured to be received by an automated surgical impactor. The first lever extends from a pivot end to a latch end. The pivot end is pivotally coupled to the elongated body. The second lever is pivotally coupled to the elongated body, and includes a hook extending toward a top surface of the elongated body. The leaf spring has a first end that is pivotally coupled to the first lever and a second end that is pivotally

coupled to the second lever such that movement of the first lever causes movement of the second lever. The first lever is movable between a first position in which the latch end is spaced apart from the elongated body and a second position in which the latch end is captured by the pushbutton catch. When the first lever is in the second position the leaf spring urges the second lever to pivot the hook toward the top surface. In an embodiment, the elongated body comprises a curved segment between the pivot end of the first lever and the second end of the elongated body.

(6) In an embodiment, the elongated body includes the top surface having an elongated opening defined therein, a bottom surface opposite the top surface and having an elongated opening defined therein, one or more inner walls extending between the elongated opening defined in the top surface and the elongated opening defined in the bottom surface, and a first cavity defined by the one or more inner walls. The second lever is positioned within the first cavity and the pivot end of the first lever is pivotally coupled to the elongated body within the first cavity. The latch end of the elongated lever extends out of the first cavity through the elongated opening defined in the top surface. The leaf spring is positioned within the first cavity.

(7) In an embodiment, the elongated body includes a planar front surface positioned on the second end of the elongated body, and a circular aperture is defined in the planar front surface. The circular aperture opens into the first cavity. In an embodiment, the circular aperture defines a passageway into the internal cavity that is sized to receive a mounting post of the surgical broach. When the first lever is in the second position the hook of the second lever is positioned in the passageway. In an embodiment, a guide post extends outward from the planar front surface of the elongated body. The guide post is positioned between the circular aperture and the bottom surface.

(8) In an embodiment, the orthopaedic surgical instrument further includes a stop pin coupled to the elongated body and positioned within the first cavity. When the first lever is in the first position a bottom surface of the pivot end of the first lever contacts the stop pin.

(9) In an embodiment, the elongated body includes a first side wall and a second side wall opposite the first side wall, an opening defined in the first side wall, one or more inner walls extending inwardly from the opening in the first side wall, wherein the one or more inner walls define a second cavity, and a second opening defined in the top surface between the first end and the elongated opening, wherein the second opening opens into the second cavity. The pushbutton catch is positioned in the second cavity. When the first lever is in the second position, a latch extending downward from the latch ending is positioned in the second cavity and retained by the pushbutton catch. In an embodiment, the pushbutton catch is moveable between a first position in which the pushbutton catch engages the latch positioned within the second cavity and a second position in which the pushbutton catch does not engage the latch. In an embodiment, the orthopaedic surgical instrument further includes a second spring positioned in the second cavity. The second spring is configured to bias the pushbutton catch in the first position.

(10) In an embodiment, the pushbutton catch includes a button surface positioned toward the first side wall of the elongated body, a pair of side walls extending from the button surface into the second cavity, a back wall that connects the pair of side walls, and a catch that extends from the back wall into the second cavity. In an embodiment, the latch of the elongated lever includes a first cam surface and the catch of the pushbutton catch includes a second cam surface. When the first lever is moved from the first position to the second position, the first cam surface engages the second cam surface, and when the first cam surface engages the second cam surface the pushbutton catch is urged from the first position to the second position.

(11) According to another aspect, a method for performing an orthopaedic surgical procedure includes inserting a mounting post of a surgical broach into a circular aperture defined in a planar surface positioned at a first end of an orthopaedic surgical instrument; moving a first lever of the orthopaedic surgical instrument from a first position to a second position in response to inserting the mounting post into the circular aperture, wherein moving the first lever from the first position to the second position comprises latching the first lever in the second position, applying

compression with a compliant member of the orthopaedic surgical instrument on a second lever of the orthopaedic surgical instrument, and clamping a hook of the second lever against the mounting post of the surgical broach; and coupling a second end of the orthopaedic surgical instrument to an automated surgical impactor in response to moving the lever.

(12) In an embodiment, clamping the hook of the second lever against the mounting post comprises engaging a notch defined in the mounting post with a first side of a curved outer surface of the hook. In an embodiment, inserting the mounting post comprises engaging a second side of the curved outer surface of the hook with a chamfer defined in a tip of the mounting post, wherein engaging the second side comprises pivoting the hook away from a centerline of the circular aperture.

(13) In an embodiment, the method further comprises impacting the surgical broach with the automated surgical impactor into a surgically prepared bone of a patient in response to coupling the second end to the automated surgical impactor; depressing a pushbutton catch of the orthopaedic surgical instrument in response to impacting the broach, wherein depressing the pushbutton catch comprises unlatching the second lever from the second position and releasing compression with the compliant member; and releasing the surgical broach from the first end of the orthopaedic surgical instrument in response to depressing the pushbutton catch.

(14) In an embodiment, the method further comprises extracting the surgical broach with the automated surgical impactor from the surgically prepared bone in response to impacting the surgical broach; wherein depressing the pushbutton catch comprises depressing the pushbutton catch in response to extracting the surgical broach. In an embodiment, the method further comprises inserting a mounting post of second surgical broach into the circular aperture defined in the planar surface positioned at the first end of the orthopaedic surgical instrument in response to releasing the surgical broach.

(15) According to another aspect, a surgical instrument assembly includes an orthopaedic surgical instrument and a surgical broach. The orthopaedic surgical instrument includes an elongated body, a first lever and a second lever, a leaf spring, and a pushbutton catch coupled to the elongated body. The elongated body extends from a first end to a second end. The first end is configured to be received by an automated surgical impactor. T first lever extends from a pivot end to a latch end. The pivot end is pivotally coupled to the elongated body, and the second lever is also pivotally coupled to the elongated body. The second lever includes a hook extending toward a top surface of the elongated body. The leaf spring has a first end that is pivotally coupled to the first lever and a second end that is pivotally coupled to the second lever such that movement of the first lever causes movement of the second lever. The surgical broach includes a mounting post extending from a first end of the surgical broach, and the surgical broach is coupled to the second end of the orthopaedic surgical instrument. The first lever of the orthopaedic surgical instrument is movable between a first position in which the latch end is spaced apart from the elongated body and a second position in which the latch end is captured by the pushbutton catch. When the first lever is in the second position the leaf spring urges the second lever to pivot the hook into engagement with the mounting post of the surgical broach.

(16) In an embodiment, the elongated body includes the top surface having an elongated opening defined therein, a bottom surface opposite the top surface and having an elongated opening defined therein, one or more inner walls extending between the elongated opening defined in the top surface and the elongated opening defined in the bottom surface, and a first cavity defined by the one or more inner walls. The second lever is positioned within the first cavity. The pivot end of the first lever is pivotally coupled to the elongated body within the first cavity. The latch end of the elongated lever extends out of the first cavity through the elongated opening defined in the top surface. The leaf spring is positioned within the first cavity.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) The detailed description particularly refers to the following figures, in which:

(2) FIG. **1** is a perspective view of straight broach impactor adapter in an open configuration;

(3) FIG. **2** is a cross-sectional elevation view of the straight broach impactor adapter of FIG. **1**;

(4) FIG. **3** is a perspective view of the straight broach impactor adapter of FIG. **1** in a latched configuration;

(5) FIG. **4** is a cross-sectional elevation view of the straight broach impactor adapter of FIG. **3**;

(6) FIG. **5** is a cross-sectional rear elevation view of the straight broach adapter of FIG. **3**;

(7) FIG. **6** is an elevation view of the straight broach impactor adapter of FIGS. **1-5** coupled to a femoral broach and in the open configuration;

(8) FIG. **7** is a fragmentary cross-sectional elevation view of the straight broach impactor adapter and the femoral broach of FIG. **6**;

(9) FIG. **8** is an elevation view of the straight broach impactor adapter of FIGS. **1-5** attached to the femoral broach and in the latched configuration;

(10) FIG. **9** is a fragmentary cross-sectional elevation view of the straight broach impactor and the femoral broach of FIG. **8**;

(11) FIG. **10** is a perspective view of the straight broach impactor adapter and the femoral broach of FIGS. **8-9** during the performance of an orthopaedic surgical procedure using an automated surgical impactor;

(12) FIG. **11** is a perspective view of curved broach impactor adapter in an open configuration;

(13) FIG. **12** is a cross-sectional elevation view of the curved broach impactor adapter of FIG. **11**;

(14) FIG. **13** is a perspective view of the curved broach impactor adapter of FIG. **11** in a latched configuration;

(15) FIG. **14** is a cross-sectional elevation view of the curved broach impactor adapter of FIG. **13**;

(16) FIG. **15** is a cross-sectional rear elevation view of the curved broach adapter of FIG. **13**;

(17) FIG. **16** is an elevation view of the curved broach impactor adapter of FIGS. **11-15** coupled to a femoral broach and in the open configuration;

(18) FIG. **17** is a fragmentary cross-sectional elevation view of the curved broach impactor adapter and the femoral broach of FIG. **16**;

(19) FIG. **18** is an elevation view of the curved broach impactor adapter of FIGS. **11-15** attached to the femoral broach and in the latched configuration;

(20) FIG. **19** is a fragmentary cross-sectional elevation view of the curved broach impactor and the femoral broach of FIG. **18**; and

(21) FIG. **20** is a perspective view of the curved broach impactor adapter and the femoral broach of FIGS. **18-19** during the performance of an orthopaedic surgical procedure using an automated surgical impactor.

DETAILED DESCRIPTION OF THE DRAWINGS

(22) While the concepts of the present disclosure are susceptible to various modifications and alternative forms, specific exemplary embodiments thereof have been shown by way of example in the drawings and will herein be described in detail. It should be understood, however, that there is no intent to limit the concepts of the present disclosure to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

(23) Terms representing anatomical references, such as anterior, posterior, medial, lateral, superior, inferior, etcetera, may be used throughout the specification in reference to the orthopaedic implants and orthopaedic surgical instruments described herein as well as in reference to the patient's natural anatomy. Such terms have well-understood meanings in both the study of anatomy and the field of

orthopaedics. Use of such anatomical reference terms in the written description and claims is intended to be consistent with their well-understood meanings unless noted otherwise. Additionally, it is to be understood that terms such as top, bottom, front, rear, side, height, length, width, upper, lower, and the like that may be used herein merely describe points of reference and do not necessarily limit embodiments of the present disclosure to any particular orientation or configuration.

(24) Referring now to FIGS. **1**-**5**, a straight femoral broach impactor adapter **10** (hereinafter impactor adapter **10**) is shown. The impactor adapter **10** is an orthopaedic surgical instrument; that is, a surgical tool used by a surgeon in performing an orthopaedic surgical procedure. As such, it should be appreciated that, as used herein, the terms "orthopaedic surgical instrument" and "orthopaedic surgical instruments" are distinct from orthopaedic implants or prostheses that are surgically implanted in the body of the patient. As described further below, the impactor adapter **10** may be used with an automated surgical impactor to drive a femoral broach into a patient's surgically prepared femur.

(25) As shown in FIGS. **1**-**4**, the impactor adapter **10** includes an elongated body **12** extending from an angled impactor attachment end **14** to a broach end **16**. In the illustrative embodiment, the body **12** is formed from metallic material, such as, for example, stainless steel or cobalt chromium. The body **12** is generally linear and defines a longitudinal tool axis **18**. As described further below, in use the impactor end **14**, also called the rear end or the proximal end, may be attached to an automated surgical impactor tool. Similarly, in use the broach end **16**, also called the tip end, the front end, or the distal end, may be attached to a surgical broach, chisel, or other surgical cutting tool.

(26) The elongated body **12** is generally rectangular in cross section and thus has a top surface **20** and a bottom surface **22** opposite the top surface **20**, as well as a pair of side surfaces **24**, **26**. A pair of elongated openings **28**, **30** are defined in each of the top surface **20** and the bottom surface **22**, respectively. One or more inner walls **32** extend between the openings **28**, **30** through the body **12** and define a cavity **34** inside the body **12**.

(27) The broach end **16** includes a planar surface **36** having a circular aperture **38** defined thereon. A passageway **40** extends inward from the circular aperture **38** into the cavity **34**. A guide pin **42** positioned on the planar surface **36** between the circular aperture **38** and the bottom surface **32** extends outward from the planar surface **36**. As described further below, when the impactor adaptor **10** is coupled to a femoral surgical broach, the aperture **38** receives a mounting post of the broach.

(28) The impactor adapter **10** further includes an elongated latch lever **44** that extends outward from the cavity **34** through the opening **28** defined in the top surface **20**. The latch lever **44** includes a pivot end **46** that is pivotally mounted to the body **12** within the cavity **34**. Illustratively, a bore **48** is defined through the pivot end **46**, and a pair of circular openings **50** are defined through the side surfaces **24**, **26** of the body **12**. The bore **48** encompasses the pivot point of the latch lever **44**. A pin **52** is positioned in the bore **48** and the openings **50** such that the latch lever **44** is joined with the body **12** and is allowed to rotate about the pin **52**. In the illustrative embodiment, the pin **52** is press-fit into the openings **50**; however, any suitable method of securing the pin **52** may be used.

(29) Another pair of circular openings **54** is defined through the side surfaces **24**, **26** of the body **12**. A stop pin **56** is positioned in the openings **54**. In the illustrative embodiment, the stop pin **56** is press-fit into the openings **54**; however, any suitable method of securing the stop pin **56** may be used. As shown in FIG. **2**, as the lever **44** reaches an open position, a lower surface **58** of the pivot end **46** engages the stop pin **56**. Thus, the stop pin **56** operates as a stop that limits range of motion for the lever **44**.

(30) A body **60** of the latch lever **44** extends from the pivot end **46** outward from the opening **28** defined in the top surface **20**. A wing **62** extends laterally from the body **60**. The body **60** extends further toward a latch end **64**. The latch end **64** includes a latch **66** extending downward from the lever body **60**. As shown in the cross-sectional view of FIG. **5**, the latch **66** includes a lower cam

surface **68** and an upper surface **70** that extend inward toward the interior of the body **12**. As described further below, when the lever **44** is in a latched position as shown in FIGS. **3-5**, the latch **66** of the latch lever **44** may be captured within the body **12** by a catch mechanism.

(31) In the latched position, the body **60** of the lever **44** may contact the top surface **20** of the body **12**, operating as a stop that limits range of motion of the lever **44**. In the latched position, the wing **62** of the lever **44** extends outward past the side surface **24**, allowing the surgeon or other user to grip the lever **44**. As described above, the latch lever **44** is moveable between the open position shown in FIGS. **1-2** and the latched position shown in FIGS. **3-5**. The throw of the lever **44**, that is, the angle between the body **60** of the lever **44** and the body **12** when the lever **44** is in the fully open position may be limited to less than about 40-45 degrees.

(32) The impactor adapter **10** further includes a clamp lever **72** positioned within the cavity **34**. The clamp lever **72** includes a body **74** having a roughly triangular, non-linear shape. The clamp lever **72** is pivotally mounted to the body **12** within the cavity **34**. Illustratively, a bore **76** is defined through lever body **74**, and a pair of circular openings **78** are defined through the side surfaces **24**, **26** of the body **12**. The bore **76** encompasses the pivot point of the clamp lever **72**. A pin **80** is positioned in the bore **76** and the openings **78** such that the clamp lever **72** is joined with the body **12** and is allowed to rotate about the pin **80**. In the illustrative embodiment, the pin **80** is press-fit into the openings **78**; however, any suitable method of securing the pin **80** may be used.

(33) The clamp lever **72** extends to a bullnose hook **82** having a convex, rounded outer surface **84**. As the clamp lever **72** rotates about the pin **80**, the hook **82** pivots toward and away from the top surface **20** within the cavity **34**. As described further below, the hook **82** of the clamp lever **72** is operable to securely attach a surgical broach to the impactor adapter **10**.

(34) The impactor adapter **10** further includes a leaf spring **86** or other compliant connecting member that connects the latch lever **44** and the clamp lever **72**. The leaf spring **86** includes a flexible body **88** that extends between ends **90**, **92**. The end **90** is pivotally coupled to pivot end **46** of the latch lever **44**, and the end **92** is pivotally coupled to the body **74** of the clamp lever **72**. Illustratively, each end **90**, **92** includes a fork **94** that extends to a pair of mounting plates **96**. A circular opening **98** is defined through each mounting plate **96**. The mounting plates **96** of the end **90** surround a bore **100** defined through the pivot end **46** of the lever **44**. A pin **102** is positioned in the openings **98** and the bore **100** to pivotally couple the end **90** to the lever **44**. Similarly, the mounting plates **96** of the end **92** surround a bore **104** defined through the clamp lever **72**, and a pin **106** is positioned in the openings **98** and the bore **104** to pivotally couple the end **92** to the clamp lever **72**.

(35) When the lever **44** is in the open position (shown in FIGS. **1-2**), the leaf spring **86** has a relaxed, arcuate shape. When the lever **44** is moved to the latched position (shown in FIGS. **3-5**), the leaf spring **86** has a relatively shortened and compressed shape, causing the leaf spring **86** to be in compression. When in compression, the leaf spring **86** urges the clamp lever **72** to pivot about the pin **80**, rotating the hook **82** toward the top surface **20** of the body **12**. Compression on the leaf spring **86** may be released by moving the lever **44** from the latched position to the open position as described further below. As described above, the wing **62** extending from the lever body **60** may assist the surgeon or other user in moving the lever **44** from the latched position to the open position.

(36) As shown in FIGS. **1** and **3**, each of the side surfaces **24**, **26** has a waist **108** positioned between the cavity **34** and the impactor end **14**. At the waist **108**, the distance between the side surfaces **24**, **26** increases toward the impactor end **14**. As shown in FIG. **3**, in the closed position, the wing **62** is positioned between the waist **108** and the broach end **14** and extends past the side surface **24**, allowing the surgeon to grip the wing **62**.

(37) As shown in FIGS. **1-5**, an opening **110** is defined in the side surface **24** of the body **12** between the waist **108** and the impactor end **14** of the body **12**. One or more inner walls **112** extend inwardly from the opening **110**, defining a cavity **114**. An additional opening **116** is defined in the

top surface **20**. A passageway **118** extends through the opening **116** into the cavity **114**.
(38) A pushbutton catch **120**, also referred to as a button **120**, is positioned within the cavity **114**. As described further below, the pushbutton catch **120** may be used to selectively retain the latch lever **44** in the latched position shown in FIGS. **3-5**. The pushbutton catch **120** includes a button surface **122** positioned toward the side surface **24** of the body **12**. The button surface **122** is configured to be pressed by a surgeon and thus may be textured or otherwise configured to provide additional grip. Additionally, as shown in FIG. **5**, in ordinary operation the button surface **122** may be flush with the side surface **24** and/or recessed within the cavity **114** in order to prevent accidental operation.
(39) The pushbutton catch **120** further includes a pair of side walls **124** that extend inward from the button surface **122** into the cavity **114**. The side walls are connected by a back wall **126**. Together, the button surface **122**, the side walls **124**, and the back wall **126** surround a button cavity **128**. A catch **130** extends upward from the back wall **126**. The catch **130** includes an upper cam surface **132** and a lower surface **134** that extend inward into the button cavity **128**. A guide pin **136** extends from a back surface **138** of the catch **130** toward the other side surface **26**. A helical spring **140** is retained between the body **12** and the back surface **138** of the catch **130**, and the guide pin **136** is captured within the spring **140**. The spring **140** urges against the body **12** and the back surface **138** to bias the pushbutton catch **120** toward the opening **110** in the side surface **24**. A stop pin **142** positioned in a hole defined through the bottom surface **22** of the body **12** extends into the latch cavity **114**. When the pushbutton catch **120** is positioned in the cavity **114**, the stop pin **142** also extends into the button cavity **128**. The stop pin **142** engages the back wall **126** of the pushbutton catch **120** and thus retains the pushbutton catch **120** within the cavity **114** of the body **12**.
(40) As shown in FIG. **5**, when the lever **44** is in the latched position, the latch **66** extends into the cavity **114** and into the button cavity **128**. The upper surface **70** of the latch **66** engages the lower surface **134** of the catch **130**, thereby retaining the latch **66** within the button cavity **128**. When the surgeon or other user depresses the button surface **162**, the pushbutton catch **120** slides toward the side surface **26**, and the lower surface **134** of the catch **130** slides off the upper surface **70**, releasing the latch **66**. When the latch **66** is released, the leaf spring **86** causes the latch end **64** of the lever **44** to swing out of the cavity **114** toward the open position, which releases compression of the leaf spring **86**.
(41) When a surgeon or other user moves the lever **44** from the open position to the latched position without depressing the pushbutton catch **120**, the lower cam surface **68** of the latch **66** engages the upper cam surface **132** of the catch **130**. This engagement of the cam surfaces **68**, **132** forces the pushbutton catch **120** to slide toward the side surface **26**, allowing the latch **66** to enter the button cavity **128**. When the latch **66** passes the catch **120** and the cam surfaces **68**, **132** disengage, the spring **140** forces the pushbutton catch **120** to slide back toward the side surface **24**, which causes the lower surface **134** of the catch **130** to retain the upper surface **70** of the latch **66**. Accordingly, the latch lever **44** may be operated with a single hand.
(42) As shown in FIGS. **1-4**, the impactor end **14** includes a shank **144**, which is configured to be received by an automated surgical impactor. As shown in FIGS. **1** and **3**, the shank **144** extends at a nonzero angle away from the tool axis **18**. This nonzero angle may improve ergonomics for the surgeon when used with an automated surgical impactor. The illustrative shank **144** includes a pin **146** and a flange **148**. The shank **144** is configured to be impacted by the automated surgical impactor in either a forward direction (i.e., to advance the impactor adaptor **10** toward the patient's bone) or a reverse direction (i.e., to back the impactor adaptor **10** out of the patient's bone). In other embodiments, it should be understood that the shank **144** may include any other configuration of pins, flanges, flats, and/or other features configured to captured and/or impacted by the automated surgical impactor. The illustrative shank **144** further includes a groove **150**, which marks a depth at which the shank **144** is fully seated within the automated surgical impactor.
(43) The impactor adapter **10** may be utilized during the performance of an orthopaedic surgical

procedure similar to that shown in FIGS. **6-10**. Initially, the surgeon surgically prepares the patient's bone to receive a surgical broach. To do so, the surgeon or other member of the surgical team may resect the patient's femur to remove the natural femoral head and create a substantially planar proximal surface on the patient's femur. The surgeon may use an osteotome to create an opening into the femoral canal.

(44) After preparing the patient's bone, and as shown in FIGS. **6-7**, the surgeon attaches a femoral broach **152** to the impactor adapter **10**. The surgeon may select the broach **152** from a collection of broaches **152** that each have a different size. As described further below, the surgeon may sequentially broach the patient's femur with a series of broaches **152** of increasing size.

(45) The illustrative femoral broach **152** includes an elongated body **154** that extends from a proximal end **156** to a distal tip **158**. In the illustrative embodiment, the femoral broach **152** is formed as a single monolithic component from a metallic material such as stainless steel. A tapered outer surface **160** extends from the proximal end **156** to the distal tip **158**, and in some embodiments is covered with a plurality of cutting teeth **162**. Each tooth **162** may be shaped and sized to surgically prepare the femoral canal of the patient's femur to receive a femoral component and/or another surgical instrument (e.g., another femoral broach and/or a femoral trial component).

(46) The femoral broach **152** includes a planar proximal surface **164** at the proximal end **156** of the elongated body **154**. As shown in FIG. **7**, a slot **166** is defined in the proximal surface **164**, which is sized to receive the guide pin **42** that extends from the broach end **16** of the impactor adapter **10**. The broach **152** further includes a proximal mounting post **168** that extends outward from the surface **164** to a tip **170**. The post **168** further defines a chamfer **172** positioned on the tip **170**. An inner wall **174** defines a notch **176**, which may be used to secure the femoral broach **152** to the impactor adaptor **10** as discussed further below.

(47) As shown in FIG. **6**, the lever **44** of the impactor adapter **10** is initially in the open position. The surgeon or other user attaches the proximal end **156** of the femoral broach **152** to the broach end **16** of the impactor adapter **10**. As shown in FIG. **7**, as the broach **152** and the impactor adaptor **10** are attached, the mounting post **168** of broach **152** passes through the aperture **38** of the impactor adapter **10** into the passageway **40**, and the guide pin **42** of the impactor adapter **10** passes through the slot **166** of the broach **152**. As the mounting post **168** enters the passageway **40**, depending on the position of the clamp lever **72**, the mounting post **168** may contact the bullnose hook **82** of the clamp lever **72**. If so, the chamfer **172** on the tip **170** of mounting post **168** engages the convex outer surface **84** of the hook **82**. As the chamfer **172** and the outer surface **84** are in engagement, the hook **82** is urged to rotate downward away from the passageway **40**, allowing the mounting post **168** to continue entering the passageway. When the broach **152** is fully inserted into the impactor adaptor **10**, the proximal surface **164** of the broach **152** contacts the planar surface **36** of the impactor adaptor. When fully inserted, the notch **176** defined in the mounting post **168** faces the bullnose hook **82** of the clamp lever **72**.

(48) After securing the femoral broach **152** to the impactor adaptor **10**, the surgeon moves the latch lever **44** from the open position to the latched position, as shown in FIGS. **8-9**. As the latch lever **44** is moved to the latched position, the leaf spring **86** is compressed. As the leaf spring **86** is placed in compression, the leaf spring **86** exerts a force on the clamp lever **72**, causing the hook **82** of the clamp lever **72** to pivot toward the mounting post **168**. The clamp lever **72** pivots until the outer surface **84** of the hook **82** engages the inner wall **174** within the notch **176**. When in engagement, the leaf spring **86** and the clamp lever **72** exert a clamping force on the mounting post **168** that retains the femoral broach **152** against the surface **36** of the impactor adapter **10**. The femoral broach **152** is thus held rigid and immobile against the implant adapter **10**. As described above, when the latch lever **44** is in the latched position, the pushbutton catch **120** retains the latch **66**, ensuring that the latch lever **44** remains in the latched position and that the femoral broach **152** remains rigidly attached to the impactor adaptor **10**. Additionally, as the latch lever **44** is retained by the pushbutton catch **120**, the leaf spring **86** is not extended to an over-center position in order

to retain the latch lever **44**. Thus, the impactor adapter **10** may have reduced wear and increased longevity as compared to impaction tools that use an over-center clamp function.

(49) After latching the impactor adapter **10**, the surgeon attaches the impactor end **14** of the impactor adapter **10** to an automated surgical impactor **178** as shown in FIG. **10**. Additionally or alternatively, in some embodiments the impactor adapter **10** may be attached to the automated surgical impactor **178** before being attached to the femoral broach **152**.

(50) The automated surgical impactor **178** may be embodied as a Kincise™ surgical automated system component commercially available from DePuy Synthes of Warsaw, Indiana. In the illustrative embodiment, the automated surgical impactor **178** includes an impactor body **180** having a twist-lock collar **182** and a battery pack **184**. Electrical drive components **186** are housed within the impactor body **180**. The impactor body **180** further includes a primary hand grip **188**, a secondary hand grip **190**, and a trigger **192**.

(51) In use, the surgeon inserts the shank **144** of the impactor adapter **10** into the twist-lock collar **182** and then locks the collar **182** on to the shank **144**. Holding the primary hand grip **188** and/or the secondary hand grip **190**, the surgeon inserts the femoral broach **152** into the surgically prepared femur **194** of the patient as shown in FIG. **10**. After positioning the femoral broach **152**, the surgeon depresses the trigger **192**, which causes the electrical drive components **186** to generate a series of controlled percussive impacts on the impactor adapter **10** using electrical energy provided by the battery pack **184**. The impactor adaptor **10** communicates impaction force from the percussive impacts to the femoral broach **152**, thereby driving the femoral broach **152** into the medullary canal of the patient's femur **194**. During impaction, the surgeon's hands may remain on the automated surgical impactor **178**, and the latch lever **44** remains in the latched position. Additionally, the leaf spring **86** retains the femoral broach **152** rigidly against the impactor adaptor **10** during impaction. Unlike adapters using a typical rigid drive train attachment mechanism, the compliant, flexible leaf spring **86** of the impactor adapter **10** may not back out or otherwise loosen during impaction, even when subject to frequent, lower-amplitude impactions generated by the automated surgical impactor **178**.

(52) After the femoral broach **152** has been broached to a desired depth or otherwise fully impacted into the patient's femur **194**, the surgeon may remove the femoral broach **152** from the femur **194**. For example, the surgeon may remove the femoral broach **152** in order to continue broaching the femur **194** with successively larger broaches **152**. Additionally or alternatively, the surgeon may remove the femoral broach **152** in order to insert a prosthetic component, a trial component, or other femoral component into the femur **194**. To remove the femoral broach **152**, the surgeon operates the trigger **192** in a reverse mode, which generates a series of controlled percussive impacts on the impactor adapter **10** in a reverse direction, which backs the broach **152** out of the femur **194**.

(53) After removing the broach **152** from the femur **194**, the surgeon removes the impactor adaptor **10** from the femoral broach **152**. To do so, the surgeon depresses the button surface **122** of the pushbutton catch **120**, causing the pushbutton catch **120** to slide into the cavity **114** in the body **12**. As the pushbutton catch **120** slides into the cavity **114**, the lower surface **134** disengages the upper surface **70** of the latch **66**, which releases the latch end **64** of the latch lever **44**. With the latch **66** released, the leaf spring **86** may urge the latch lever **44** to swing toward the open position. The surgeon may manually open the latch lever **44** as necessary, for example using the wing **62** as a grip surface. As described above, in the fully open position, the latch lever **44** is limited to an angle of about 40 degrees. This limited open angle may have a low risk of snagging, tearing, or otherwise interfering with the patient's tissue. After moving the latch lever **44** to the open position, the clamp lever **72** is released from the mounting post **168**, and the broach **152** may be removed from the impactor adaptor **10**. After removing the broach **152**, another femoral broach **152**, for example of a larger size, may be attached to the impactor adapter **10** as described above.

(54) Although the femoral broach **152** is described as being removed from the femur **194** prior to

being removed from the impactor adapter **10**, it should be understood that in some embodiments the impactor adapter **10** may be removed from the broach **152** while the broach **152** remains positioned in the femur **194**. For example, in certain embodiments the final, largest broach **152** used by the surgeon may remain in the femur **194** for use as a femoral trial component.

(55) As described above, the elongated body **12** of the impactor adapter **10** has a generally linear shape that defines a longitudinal tool axis **18**. This linear shape of the impactor adapter **10** may be selected by surgeons who employ a direct anterior approach (DAA) surgical technique for performing hip replacements. Impactor adaptors with other shapes may be used for other surgical approaches.

(56) Referring now to FIGS. **11-15**, an illustrative embodiment of a curved broach impactor adapter **200** may be used in a posterior approach surgical technique and/or an anterolateral approach surgical technique for performing hip replacements. The illustrative curved impactor adaptor **200** shares similar components to the straight broach adapter **10**. Those similar components are shown in FIGS. **11-15** with the same reference numbers shown in FIGS. **1-5**, and the description of those components is not repeated here so as not to obscure the present disclosure.

(57) Different from the impactor adaptor **10** shown in FIGS. **1-5**, the curved adapter **200** shown in FIGS. **11-15** includes an elongated body **12** having a straight segment **202** and a curved segment **204**. The straight segment **202** extends in line with the tool axis **18**. The curved segment **204** defines a broach axis **206** extending outward from the broach end **16**. A nonzero angle is defined between the tool axis **18** and the broach axis **206**. As an additional difference with the impactor adapter **10**, the shank **144** of the curved adapter **202** extends in line with the tool axis **18**.

(58) The curved adapter **200** may be utilized during the performance of an orthopaedic surgical procedure as shown in FIGS. **16-20**. The procedure shown in FIGS. **16-20** is similar to the procedure shown in FIGS. **6-10** and described above. As described above, initially a surgeon prepares the patient's bone to receive a surgical broach. As shown in FIGS. **16-17**, the surgeon or other user attaches the femoral broach **152** to the broach end **16** of the curved adapter **200**. As shown in FIGS. **18-19**, once the femoral broach **152** is attached, the surgeon or other user moves the latch lever **44** from the open position to the latched position, in which the femoral broach **152** is held rigidly against the surface **36** of the curved adapter **200**. As shown in FIG. **20**, the surgeon attaches the impactor end **14** of the curved adapter **200** to the automated surgical impactor **178** and then impacts the broach **152** into the patient's femur **194** using the automated surgical impactor **178**. As described above, the surgeon may impact the broach **152** using a posterior approach or an anterolateral approach. After completing broaching, the surgeon may remove the broach **152** from the curved adapter **200**, for example to continue broaching with successively larger broaches **152**, or to implant a femoral component or other prosthetic component.

(59) While the disclosure has been illustrated and described in detail in the drawings and foregoing description, such an illustration and description is to be considered as exemplary and not restrictive in character, it being understood that only illustrative embodiments have been shown and described and that all changes and modifications that come within the spirit of the disclosure are desired to be protected.

(60) There are a plurality of advantages of the present disclosure arising from the various features of the method, apparatus, and system described herein. It will be noted that alternative embodiments of the method, apparatus, and system of the present disclosure may not include all of the features described yet still benefit from at least some of the advantages of such features. Those of ordinary skill in the art may readily devise their own implementations of the method, apparatus, and system that incorporate one or more of the features of the present invention and fall within the spirit and scope of the present disclosure as defined by the appended claims.

Claims

1. An orthopaedic surgical instrument for use with a surgical broach, the orthopaedic surgical instrument comprising: an elongated body extending from a first end to a second end, wherein the first end is configured to be received by an automated surgical impactor; a first lever that extends from a pivot end to a latch end, wherein the pivot end is pivotally coupled to the elongated body; a second lever pivotally coupled to the elongated body, the second lever comprising a hook extending toward a top surface of the elongated body; a leaf spring having a first end that is pivotally coupled to the first lever and a second end that is pivotally coupled to the second lever such that movement of the first lever causes movement of the second lever, wherein the leaf spring comprises a flexible body extending between the first end of the leaf spring and the second end of the leaf spring; a stop pin coupled to the elongated body; and a pushbutton catch coupled to the elongated body, wherein the pushbutton catch comprises a button surface positioned toward a first side wall of the elongated body; wherein the first lever is pivotally coupled to the elongated body at a first pivot point defined on the first lever and the leaf spring is pivotally coupled to the first lever at a second pivot point defined on the first lever, wherein the second pivot point is positioned between the first pivot point and the pivot end of the first lever; wherein the first lever is movable between a first position in which the latch end is spaced apart from the elongated body and a second position in which the latch end is captured by the pushbutton catch, wherein when the first lever is in the second position the leaf spring is in compression urges the second lever to pivot the hook toward the top surface, and wherein when the first lever is in the second position a force exerted by the leaf spring urges the first lever to pivot about the first pivot point, wherein the latch end of the first lever is urged against the pushbutton catch toward the first position; wherein when the first lever is in the first position a bottom surface of the pivot end of the first lever contacts the stop pin; and wherein the pushbutton catch is moveable between a first position in which the pushbutton catch engages the latch end of the first lever and a second position in which the pushbutton catch does not engage the latch end, wherein when the pushbutton catch moves from the first position to the second position the button surface moves within the elongated body in a direction transverse to a longitudinal tool axis defined by the elongated body.
2. The orthopaedic surgical instrument of claim 1, wherein the elongated body comprises a curved segment between the pivot end of the first lever and the second end of the elongated body.
3. The orthopaedic surgical instrument of claim 1, wherein: the elongated body comprises: (i) the top surface having an elongated opening defined therein, (ii) a bottom surface opposite the top surface and having an elongated opening defined therein, (iii) one or more inner walls extending between the elongated opening defined in the top surface and the elongated opening defined in the bottom surface, and (iv) a first cavity defined by the one or more inner walls; wherein the second lever is positioned within the first cavity; wherein the pivot end of the first lever is pivotally coupled to the elongated body within the first cavity and wherein the latch end of the elongated lever extends out of the first cavity through the elongated opening defined in the top surface; and wherein the leaf spring is positioned within the first cavity.
4. The orthopaedic surgical instrument of claim 3, wherein: the elongated body comprises a planar front surface positioned on the second end of the elongated body; and a circular aperture is defined in the planar front surface, wherein the circular aperture opens into the first cavity.
5. The orthopaedic surgical instrument of claim 4, wherein: the circular aperture defines a passageway into the internal cavity that is sized to receive a mounting post of the surgical broach; and when the first lever is in the second position the hook of the second lever is positioned in the passageway.
6. The orthopaedic surgical instrument of claim 5, wherein a guide post extends outward from the planar front surface of the elongated body, wherein the guide post is positioned between the circular aperture and the bottom surface.
7. The orthopaedic surgical instrument of claim 3, wherein the stop pin is positioned within the first

cavity.
8. The orthopaedic surgical instrument of claim 3, wherein: the elongated body comprises: (i) a second side wall opposite the first side wall, (ii) an opening defined in the first side wall, (iii) one or more inner walls extending inwardly from the opening in the first side wall, wherein the one or more inner walls define a second cavity, and (iv) a second opening defined in the top surface between the first end and the elongated opening, wherein the second opening opens into the second cavity; the pushbutton catch is positioned in the second cavity; and when the first lever is in the second position, a latch extending downward from the latch ending is positioned in the second cavity and retained by the pushbutton catch.
9. The orthopaedic surgical instrument of claim 8, wherein when the pushbutton catch is in the first position the pushbutton catch engages the latch positioned within the second cavity and when the pushbutton catch is in the second position the pushbutton catch does not engage the latch.
10. The orthopaedic surgical instrument of claim 9, further comprising a second spring positioned in the second cavity, wherein the second spring is configured to bias the pushbutton catch in the first position.
11. The orthopaedic surgical instrument of claim 10, wherein the pushbutton catch comprises a pair of side walls extending from the button surface into the second cavity, a back wall that connects the pair of side walls, and a catch that extends from the back wall into the second cavity.
12. The orthopaedic surgical instrument of claim 11, wherein the latch of the elongated lever comprises a first cam surface, wherein the catch of the pushbutton catch comprises a second cam surface, wherein when the first lever is moved from the first position to the second position, the first cam surface engages the second cam surface, and wherein when the first cam surface engages the second cam surface the pushbutton catch is urged from the first position to the second position.
13. An orthopaedic surgical instrument for use with a surgical broach, the orthopaedic surgical instrument comprising: an elongated body extending from a first end to a second end and comprising a first side wall, wherein the elongated body defines a longitudinal tool axis, and wherein the first end is configured to be received by an automated surgical impactor; a first lever that extends from a pivot end to a latch end, wherein the pivot end is pivotally coupled to the elongated body; a second lever pivotally coupled to the elongated body, the second lever comprising a hook extending toward a top surface of the elongated body; a leaf spring having a first end that is pivotally coupled to the first lever and a second end that is pivotally coupled to the second lever; and a pushbutton catch coupled to the elongated body, wherein the pushbutton catch comprises a button surface positioned toward the first side wall of the elongated body; wherein the pushbutton catch is moveable between a first position and a second position, wherein in the first position the pushbutton catch engages the latch end of the first lever when the first lever is in a latched position, and wherein in the second position the pushbutton catch does not engage the latch end; and wherein when the pushbutton catch moves from the first position to the second position the button surface moves within the elongated body in a direction transverse to the longitudinal tool axis.
14. The orthopaedic surgical instrument of claim 13, wherein when the pushbutton catch is in the first position, the button surface of the pushbutton catch is positioned flush with the first side wall of the elongated body or is recessed within the elongated body from the first side wall.
15. The orthopaedic surgical instrument of claim 13, wherein the button surface of the pushbutton catch comprises a textured grip feature.
16. The orthopaedic surgical instrument of claim 13, further comprising a second spring positioned within the elongated body, wherein the second spring is configured to bias the pushbutton catch in the first position.
17. The orthopaedic surgical instrument of claim 13, wherein the pushbutton catch comprises a catch that extends within the elongated body, and wherein when the first lever is in the latched position, the latch of first lever is captured within the elongated body by the catch of the

pushbutton catch.

18. The orthopaedic surgical instrument of claim 17, wherein the latch of the first lever comprises a first cam surface, wherein the catch of the pushbutton catch comprises a second cam surface, wherein when the first lever is moved from an open position in which the latch end is spaced apart from the elongated body to the latched position, the first cam surface engages the second cam surface, and wherein when the first cam surface engages the second cam surface the pushbutton catch is urged from the first position to the second position.