US 20250255726A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2025/0255726 A1
(43) Pub. Date: Aug. 14, 2025

Zwolinski et al.

(54) VARIABLE GEOMETRY RADIAL HEAD STEM

(71) Applicant: **Acumed LLC**, Hillsboro, OR (US)

(72) Inventors: **Michael Zwolinski**, Willoughby, OH (US); **Larry Ehmke**, Portland, OR (US); **Jeffrey Sander**, Parkville, MO (US)

(21) Appl. No.: **19/051,502**

(22) Filed: **Feb. 12, 2025**

Related U.S. Application Data

(60) Provisional application No. 63/552,518, filed on Feb. 12, 2024.

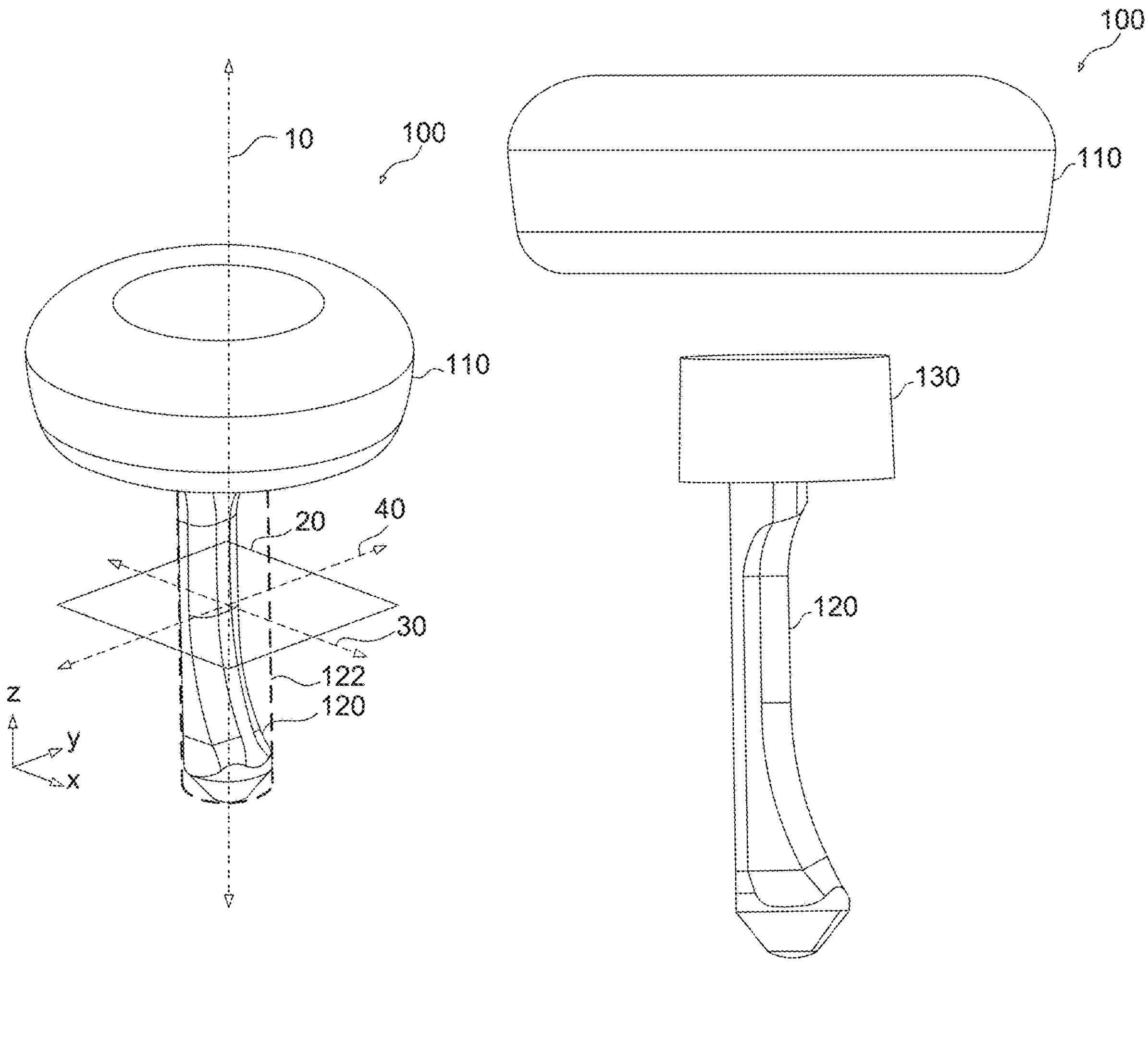
Publication Classification

(51) **Int. Cl.**
A61F 2/38 (2006.01)

(52) **U.S. Cl.**
CPC ***A61F 2/3804*** (2013.01); *A61F 2002/3827* (2013.01)

(57) **ABSTRACT**

Provided herein are prostheses for replacement of a proximal end of a radius bone. The prosthesis may include a head and a stem directly or indirectly coupled to the head. The stem may be configured to fit in a bore of a radius bone. The stem may define a virtual cylindrical shaft having a central axis. The stem may include a side surface portion coinciding with a side surface portion of the virtual cylindrical shaft. The virtual cylindrical shaft may include a portion occupied by the stem and a vacant portion.



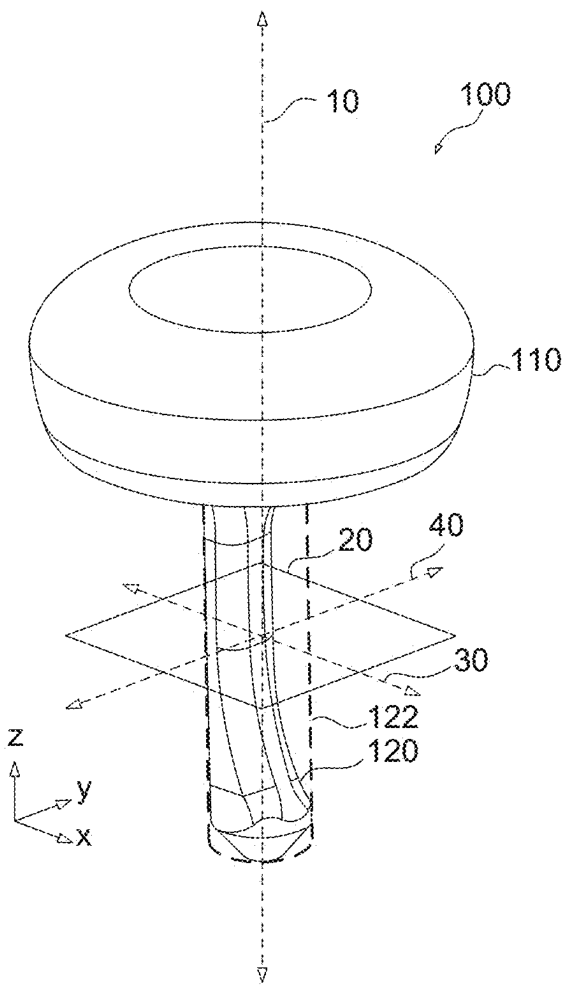


FIG. 1A

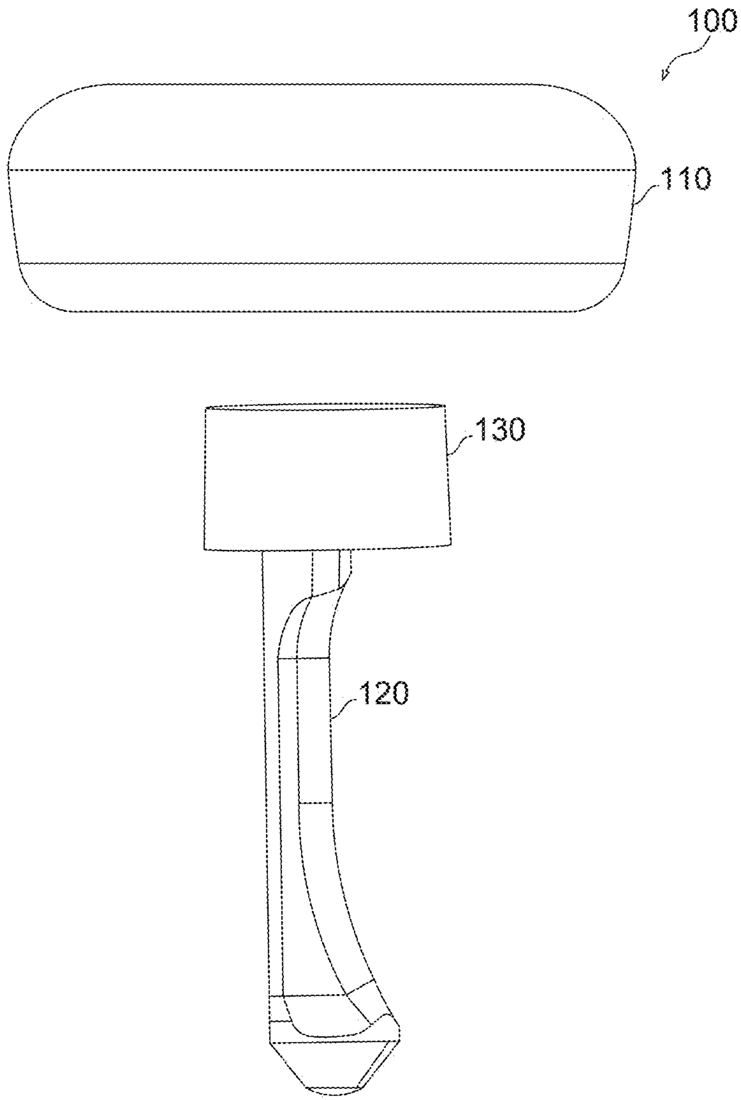


FIG. 1B

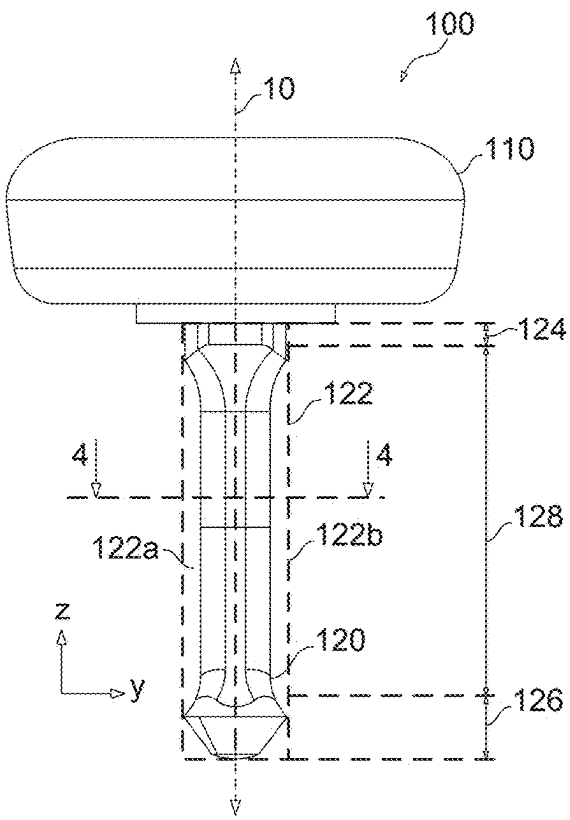

100
10
110
124
122
4
4
122a
122b
128
z
y
120
126

FIG. 2A

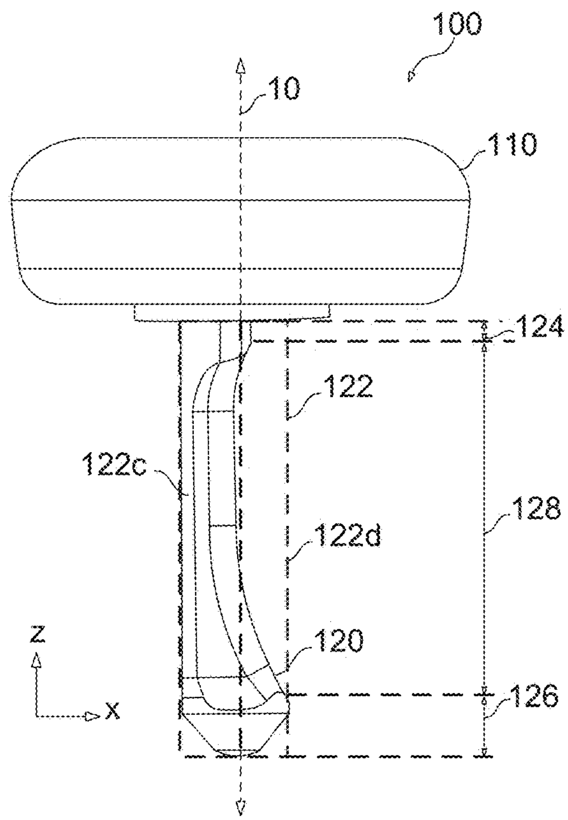

100
10
110
124
122
122c
128
122d
z
x
120
126

FIG. 2B

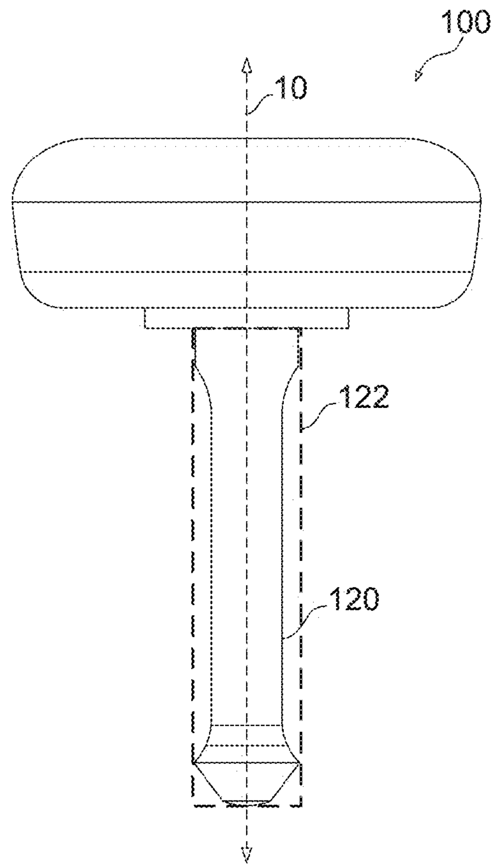


FIG. 3

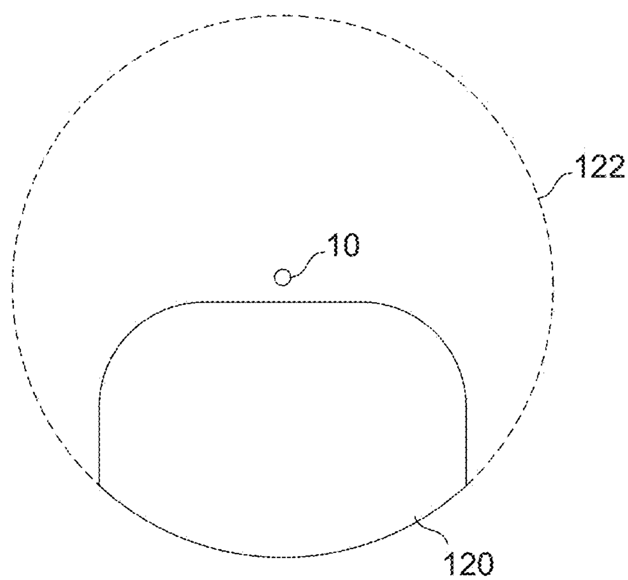


FIG. 4

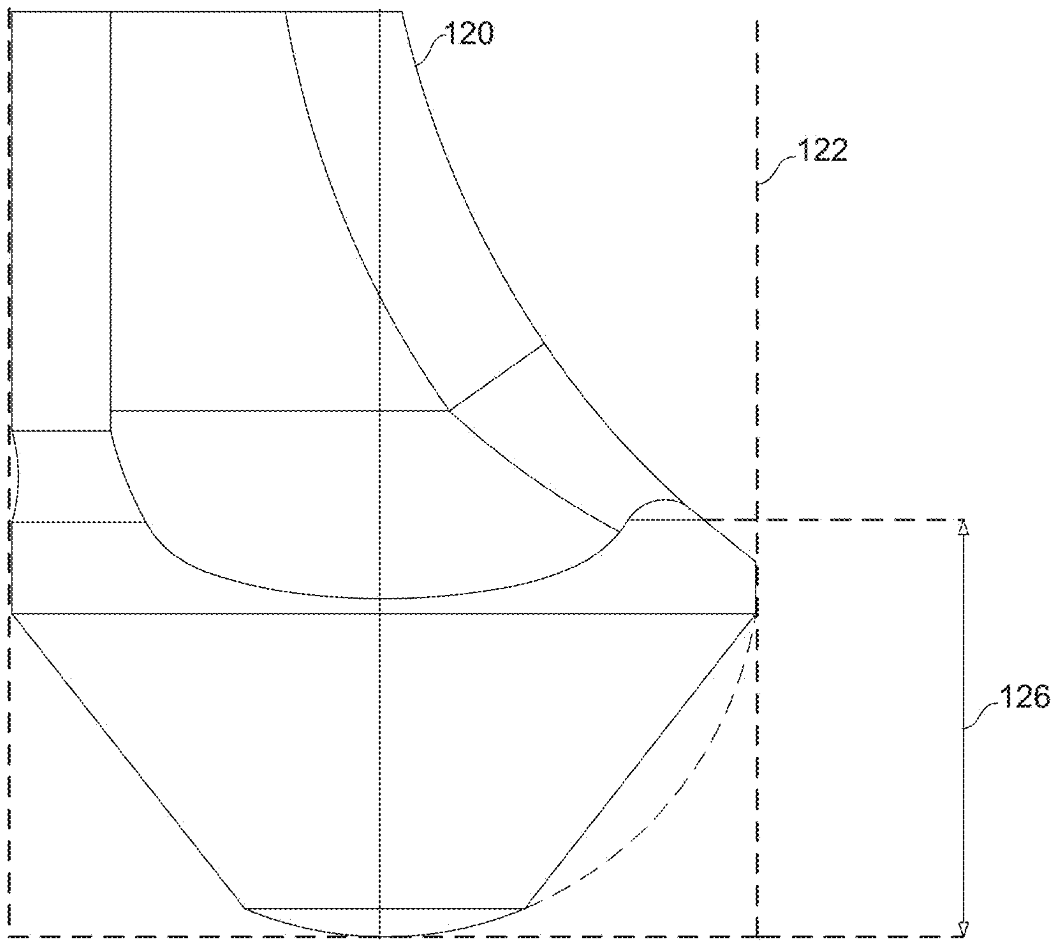


FIG. 5

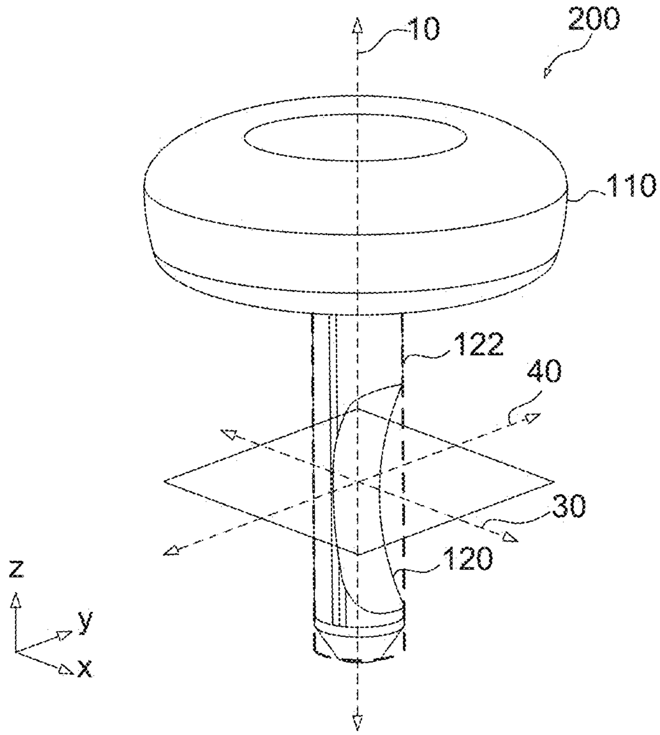


FIG. 6

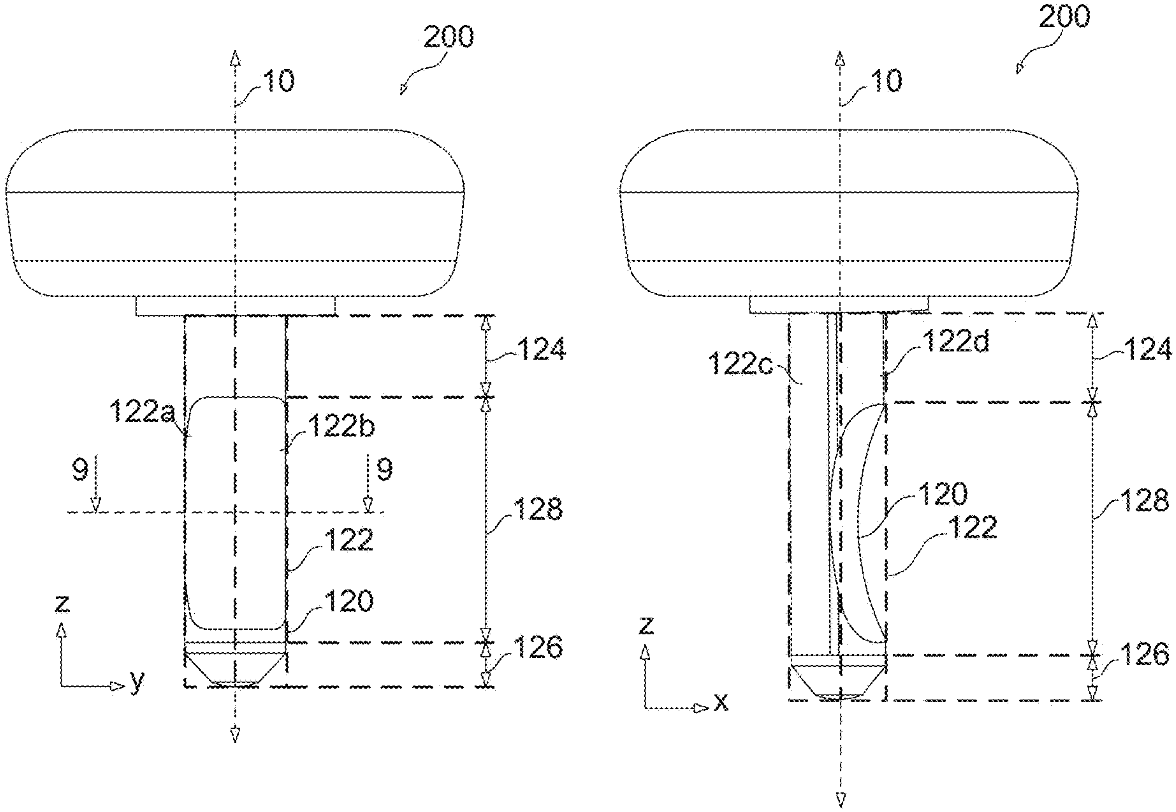

200
10
124
122a
122b
9
9
128
122
120
126
z
y
200
10
122c
122d
124
128
120
122
126
z
x

FIG. 7A

FIG. 7B

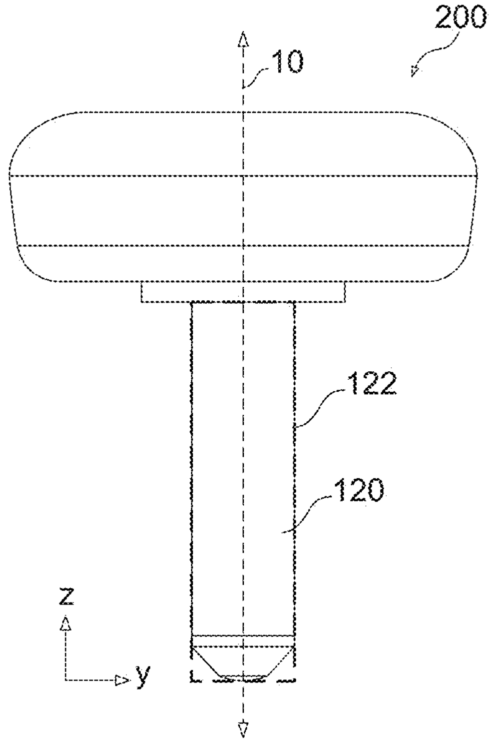


FIG. 8

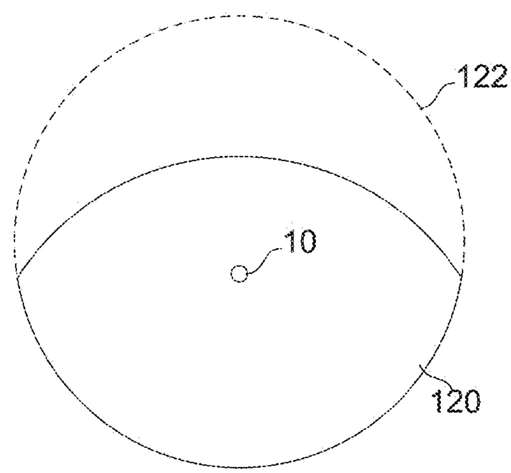


FIG. 9

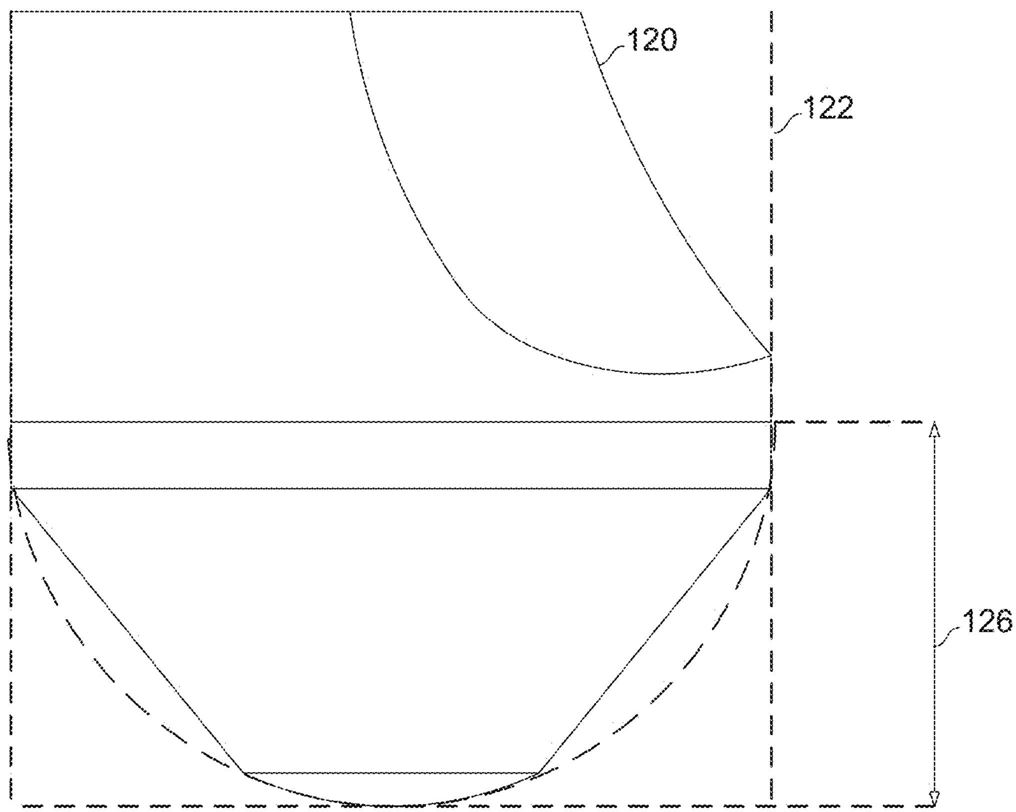


FIG. 10

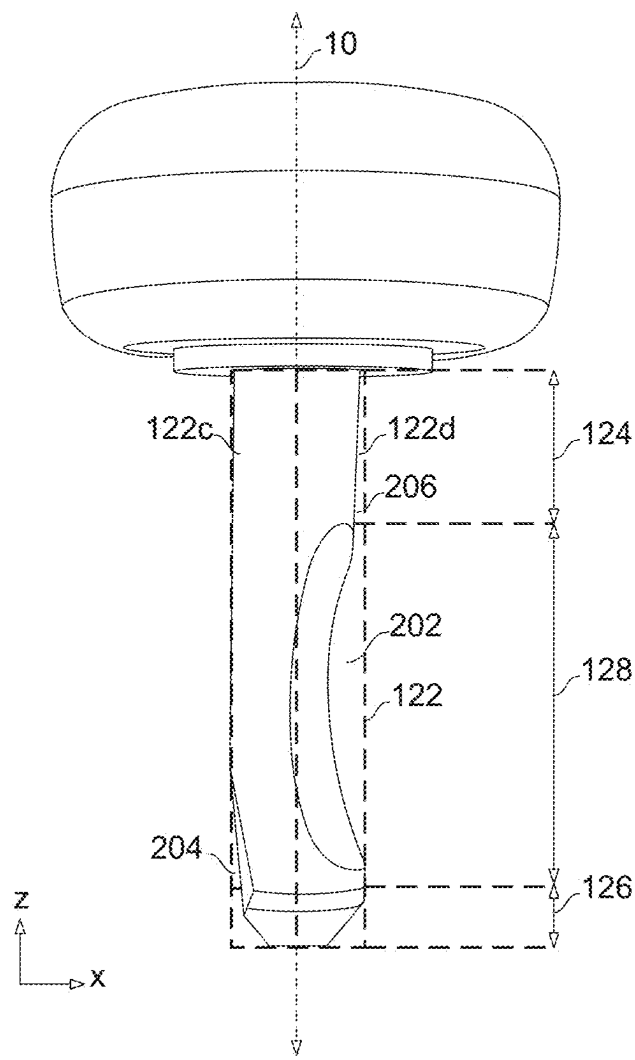


FIG. 11

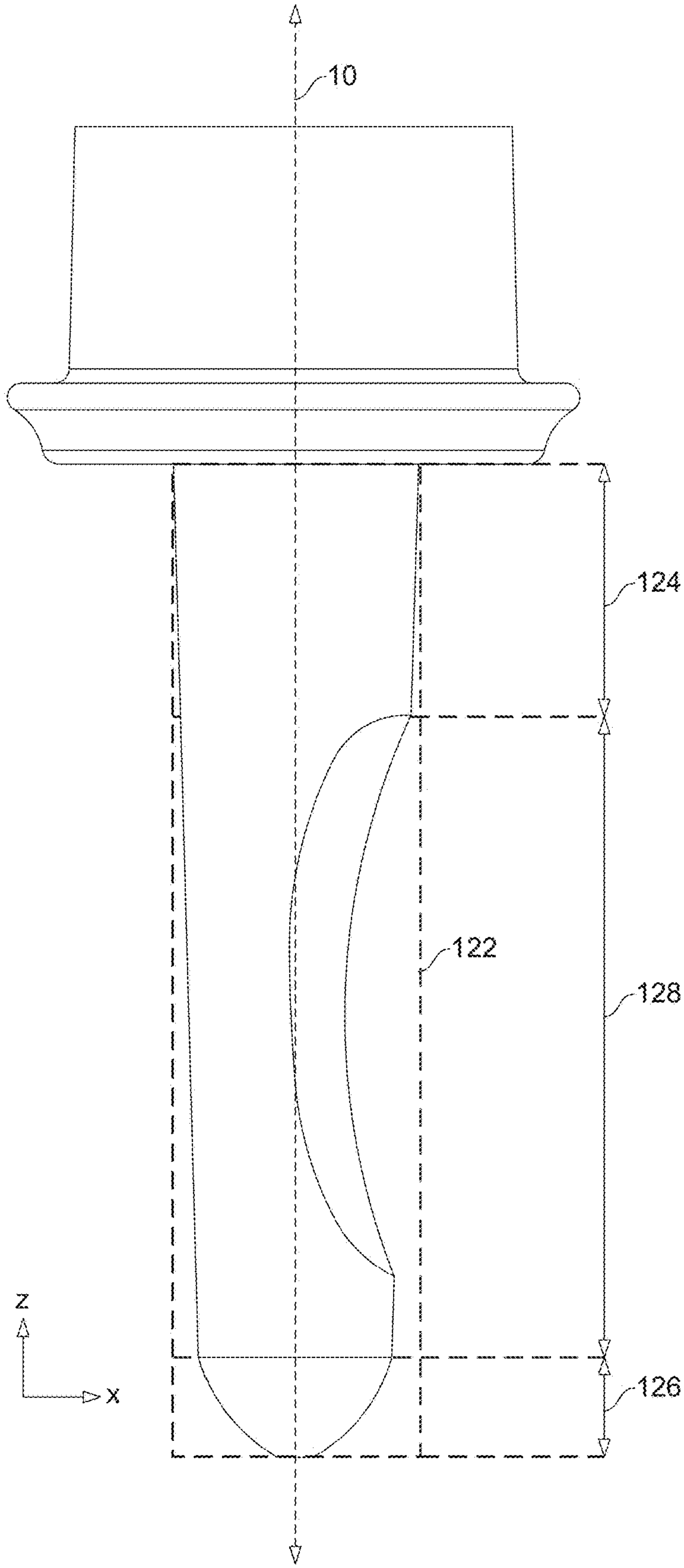


FIG. 12

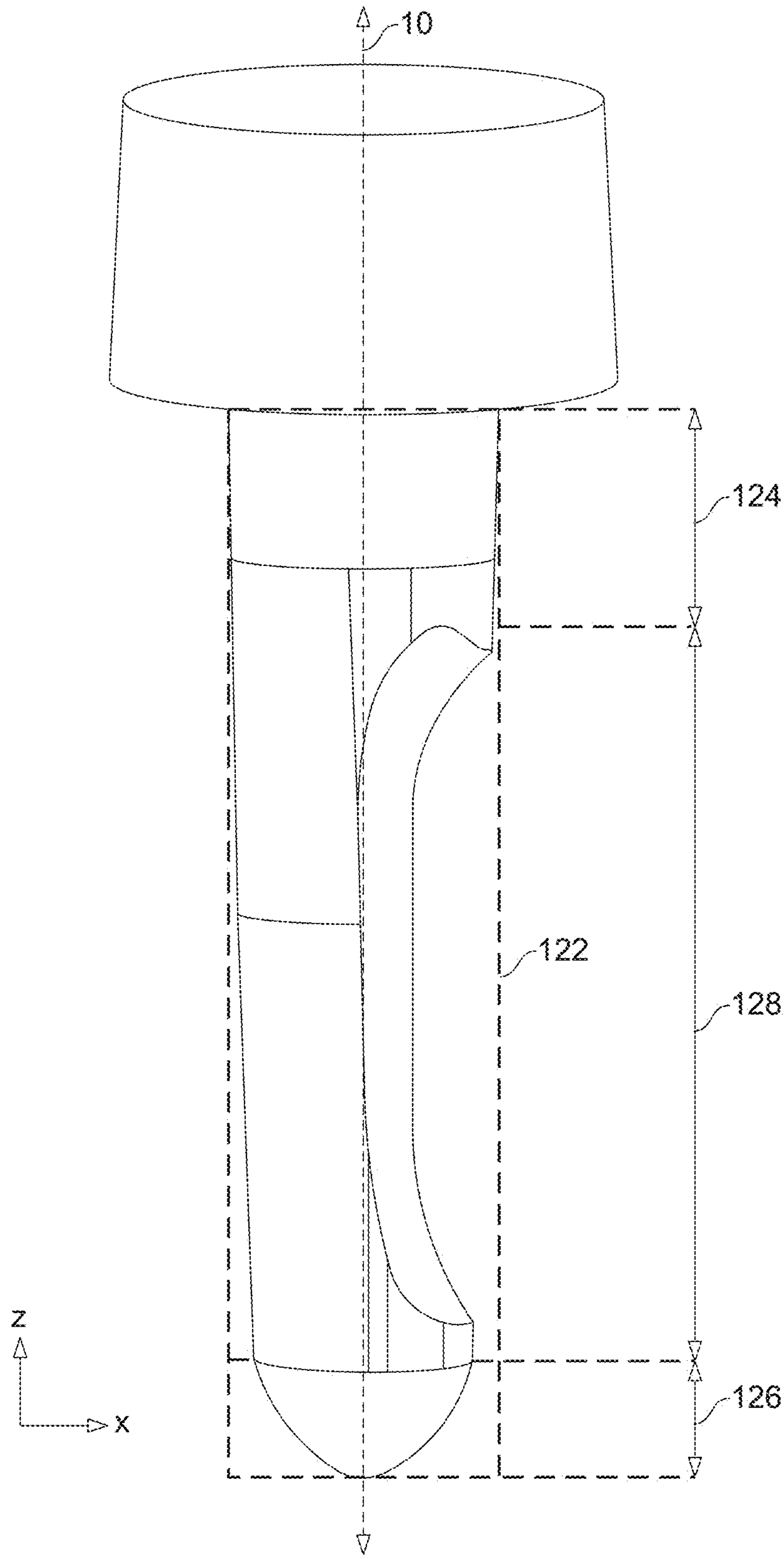


FIG. 13

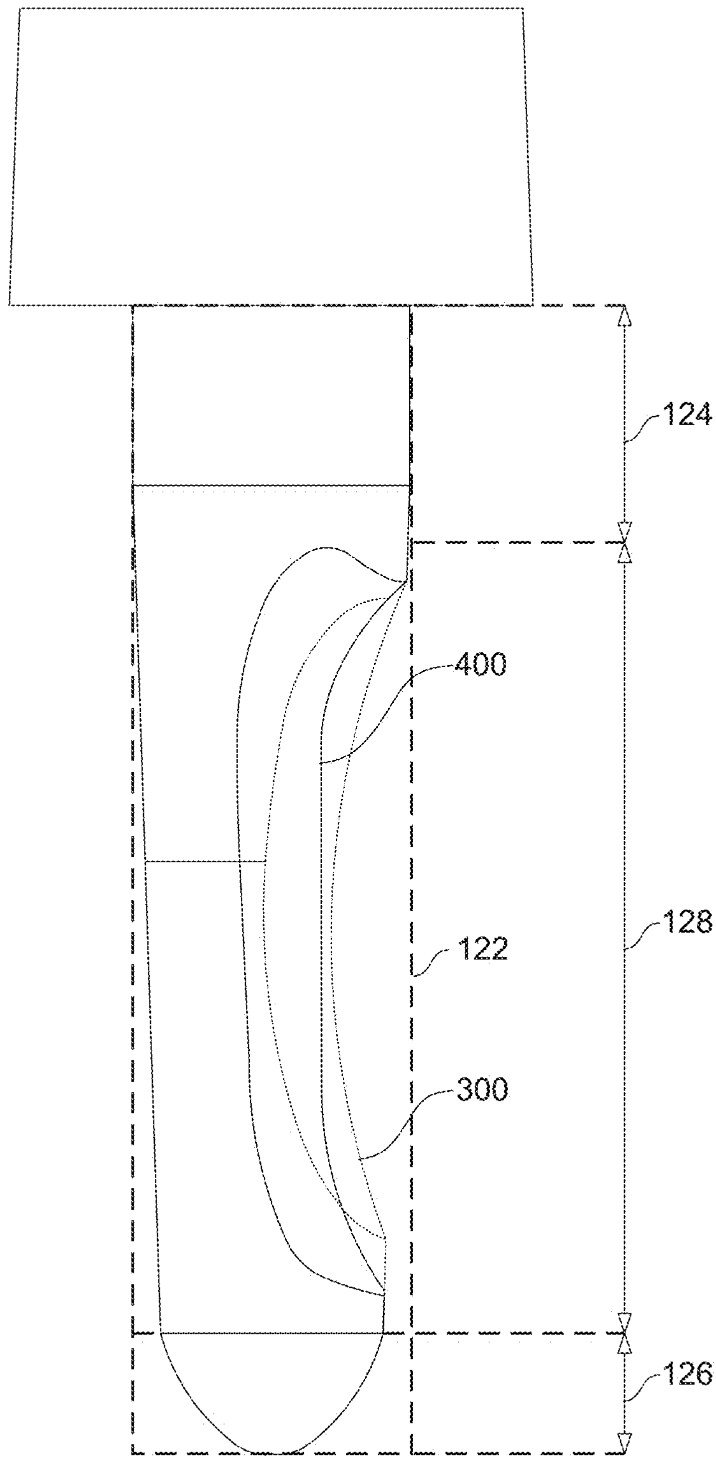
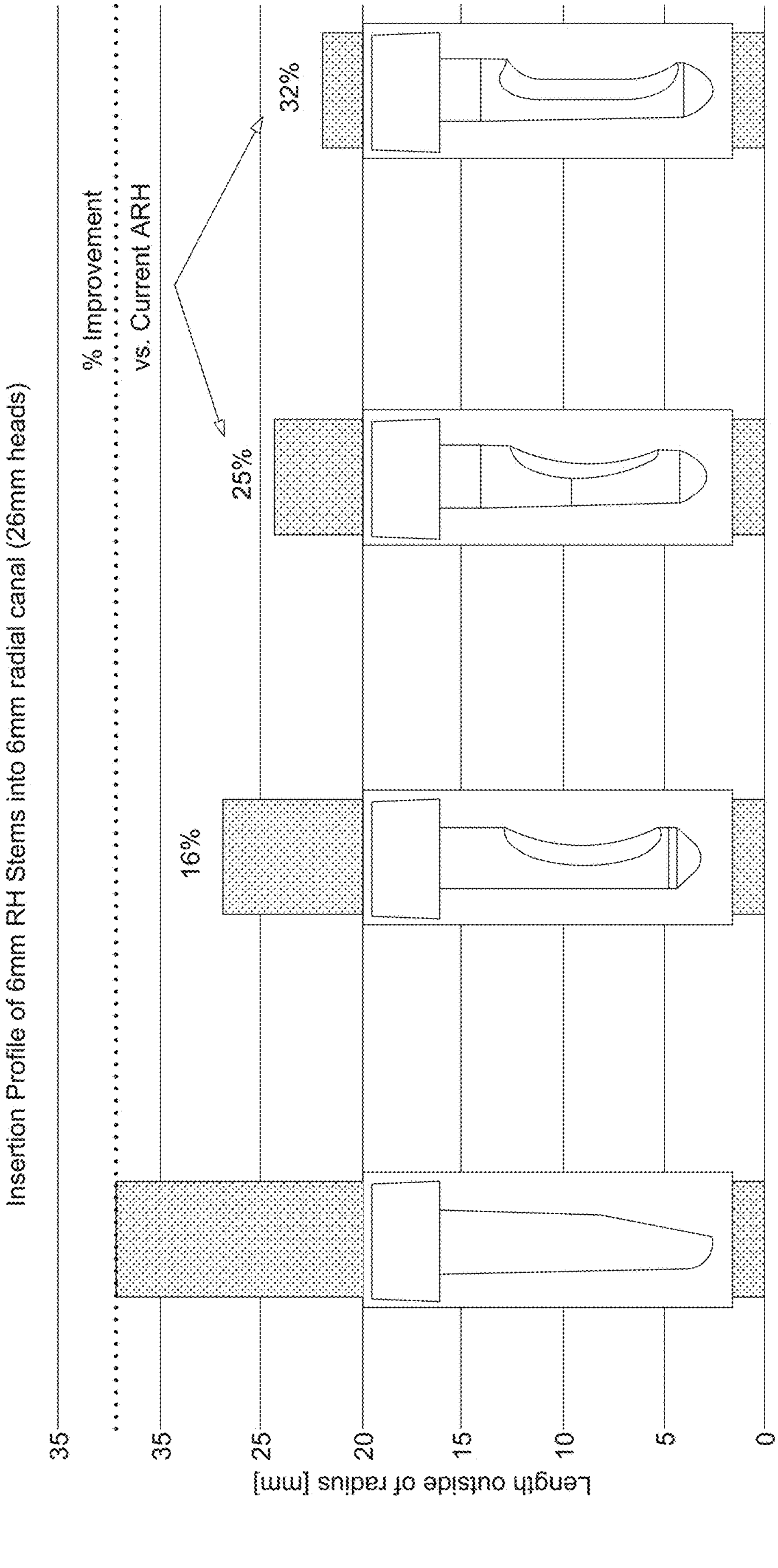


FIG. 14



Insertion Profile of 6mm RH Stems into 6mm radial canal (26mm heads)
% Improvement
vs. Current ARH
32%
25%
16%
35
35
25
20
15
10
5
0
Length outside of radius [mm]

FIG. 15

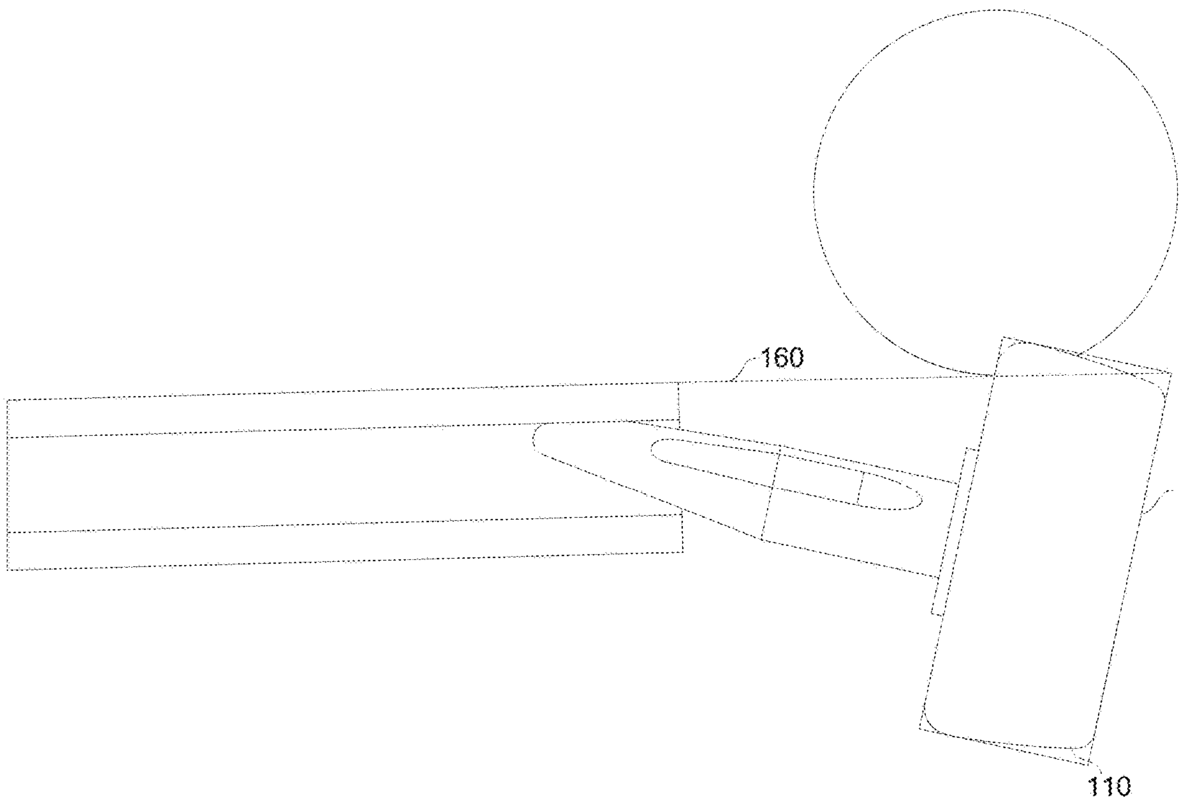


FIG. 16

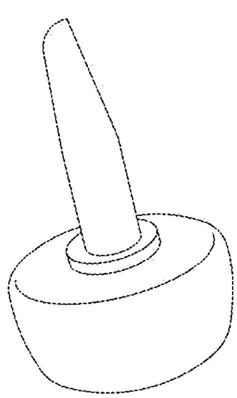


FIG. 17A

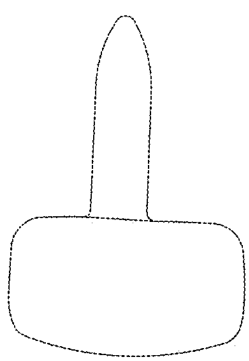


FIG. 17B

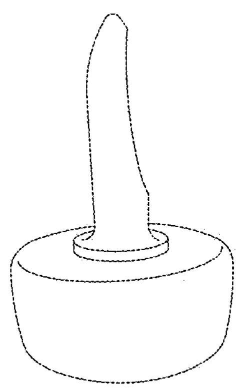


FIG. 17C

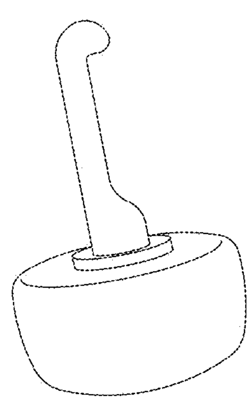


FIG. 17D

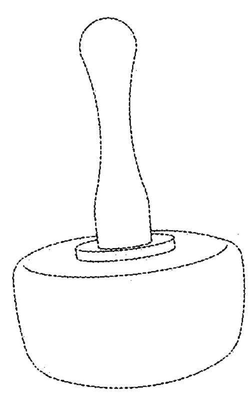


FIG. 17E

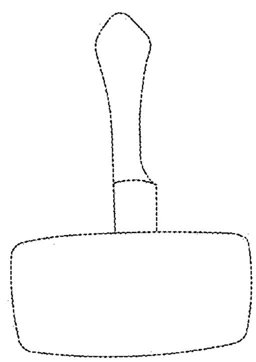


FIG. 17F

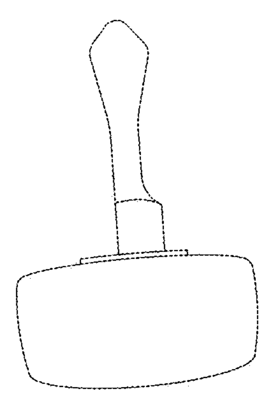


FIG. 17G

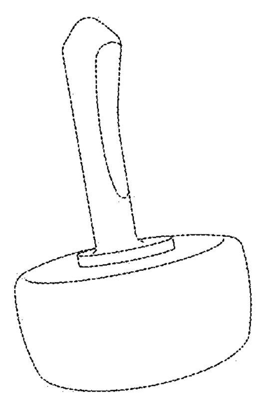


FIG. 17H

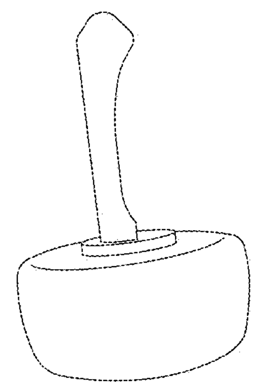


FIG. 17I

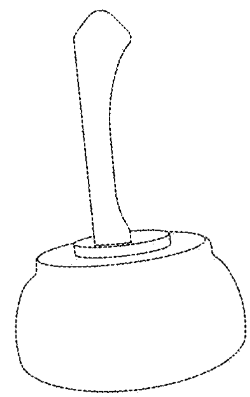


FIG. 17J

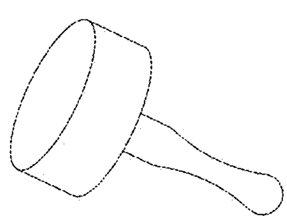


FIG. 18A

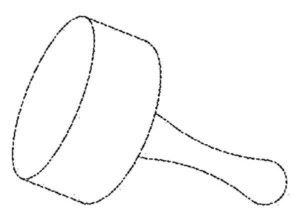


FIG. 18B

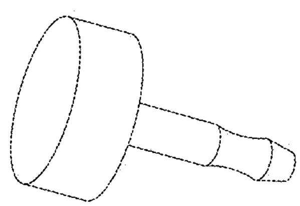


FIG. 18C

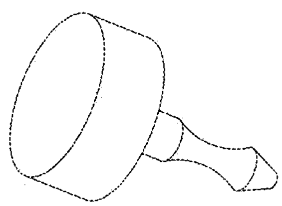


FIG. 18D

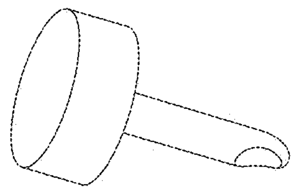


FIG. 18E

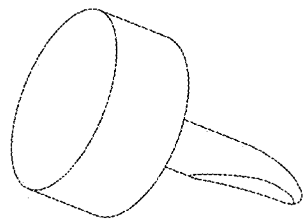


FIG. 18F

VARIABLE GEOMETRY RADIAL HEAD STEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present disclosure claims priority to U.S. Provisional Patent Application 63/552,518 titled "VARIABLE GEOMETRY RADIAL HEAD STEM", which was filed on Feb. 12, 2024, and which is incorporated herein in its entirety.

BACKGROUND

[0002] The head of a bone generally includes a rounded extension that is used to form a part of a joint. The head is the main articulating surface with the adjacent bone. When the head of a bone becomes fractured or otherwise damaged, it may be difficult to repair. When the head is irreparable, prosthetic replacement of the head of the bone may be necessary to keep the joint intact.

[0003] Specifically, prosthetic replacement of the radial head in the elbow joint may be performed. The elbow joint is comprised of the humerus, the radius, and the ulna. The radial head articulates at its end with the capitellum of the humerus, to form the humeroradial joint, and on its side with the radial notch of the ulna, to form the proximal radioulnar joint.

[0004] A radial head replacement may include removing the entirety of the radial head and replacing it with a radial head prosthesis. Typical radial head replacements include a stem portion and a head portion. The stem portion is used to secure the head to the radius, while the head is configured to mimic the articulating surfaces of the radial head. During replacement, a bore may be drilled into the radius bone. The stem portion of the radial head prosthesis may be configured to fit in the bore of the radius to secure the prosthesis to the radius.

[0005] Upon implantation of the radial head prosthesis, it may be difficult to maneuver the stem into a bore of the radius without interfering with the capitellum and surrounding soft tissue. This may result in the surgeon having to remove more bone of the radius than necessary to fit the radial head prosthesis into place or resect additional soft tissue. There exists a need for a radial head prosthesis that allows ease of insertion.

SUMMARY

[0006] The present disclosure provides a new and innovative radial head prostheses that may be easier to insert than current solutions. The prostheses provided herein may allow a surgeon to implant a radial head prosthesis without having to remove bone from the radius unnecessarily or resect additional soft tissue. The prostheses according to the present disclosure may include a monoblock design where the head is directly coupled to the stem, or the prostheses may include a modular design where the head is indirectly coupled to the stem, such as through use of a morse taper connection.

[0007] One aspect of the present disclosure provides a radial head prosthesis including a stem defining a virtual cylindrical shaft having a central axis. The stem may include a side surface portion coinciding with a side surface portion of the virtual cylindrical shaft.

[0008] Further, the virtual cylindrical shaft may include a portion occupied by the stem and a vacant portion. The stem may further define a plane perpendicular to the central axis of the virtual cylindrical shaft, a first axis on the plane and passing through the central axis of the virtual cylindrical shaft, and a second axis on the plane, passing through the central axis of the virtual cylindrical shaft, and perpendicular to the first axis.

[0009] When viewed from the first axis, the virtual cylindrical shaft may be divided, by the central axis, into a first portion and a second portion. Over 80% of the first and second portions may be covered by the stem. When viewed from the second axis, the virtual cylindrical shaft may be divided, by the central axis, into a third portion and a fourth portion. Over 95% of the third portion may be covered by the stem and less than 90% of the fourth portion may be covered by the stem.

[0010] In some examples, a volume ratio between the portion occupied by the stem and the vacant portion in the virtual cylindrical shaft may be in a range of about 1:1.5 to about 7:1. In other examples, a volume ratio between the portion occupied by the stem and the vacant portion in the virtual cylindrical shaft may be in a range of about 1:1.5 to about 1.5:1.

[0011] Additional features and advantages of the disclosed methods are described in, and will be apparent from, the following Detailed Description and the Figures.

BRIEF DESCRIPTION OF THE FIGURES

[0012] FIGS. **1**A and **1**B illustrates a perspective view of a prosthesis for replacement of a proximal end of a radius bone according to an example of the present disclosure.

[0013] FIGS. **2**A and **2**B illustrate the prosthesis of FIG. **1**A from a first axis (FIG. **2**A) and from a second axis (FIG. **2**B).

[0014] FIG. **3** illustrates the prosthesis of FIG. **1**A from a first axis.

[0015] FIG. **4** illustrates a cross-sectional view taken along the line **4-4** of FIG. **2**A.

[0016] FIG. **5** illustrates a second end portion of the prosthesis of FIG. **1**A according to an example of the present disclosure.

[0017] FIG. **6** illustrates a perspective view of a prosthesis for replacement of a proximal end of a radius bone according to an example of the present disclosure.

[0018] FIGS. **7**A and **7**B illustrate the prosthesis of FIG. **6** from a first axis (FIG. **7**A) and from a second axis (FIG. **7**B).

[0019] FIG. **8** illustrates the prosthesis of FIG. **6** from the first axis.

[0020] FIG. **9** illustrates a cross-sectional view taken along the line **9-9** of FIG. **7**A.

[0021] FIG. **10** illustrates a second end portion of the prosthesis of FIG. **6** according to an example of the present disclosure.

[0022] FIGS. **11-14** illustrate modified prostheses of FIG. **6** from the second axis.

[0023] FIG. **15** illustrates a graph showing the ease of insertion of various prostheses according to examples of the present disclosure.

[0024] FIG. **16** illustrates a relative measurement of ease of insertion according to an example of the present disclosure.

[0025] FIGS. **17**A-**17**J illustrate alternative geometries of prostheses according to examples of the present disclosure.

[0026] FIGS. **18**A-**18**F illustrate alternative geometries of prostheses according to examples of the present disclosure.

DETAILED DESCRIPTION OF EXAMPLES

[0027] The present disclosure is directed to a prosthesis for a proximal end of a radius bone that allows ease of insertion into a bore of the radius bone.

[0028] FIGS. **1**A to **5** illustrate an example prosthesis **100** for replacement of a proximal end of a radius bone according to an example of the present disclosure. Referring to FIGS. **1**A and **1**B, the prosthesis **100** may include a head **110** and a stem **120**. The stem **120** may be directly or indirectly coupled to the head **110**. In some examples, the head **110** may have a central axis **10**. In some examples, the central axis **10** of the head **110** may coincide with a central axis **10** of the stem **120**. In some examples, when coupled to the stem **120**, the head **110** may be orthogonal to the stem **120**. In other examples, when coupled to the stem **120**, the head **110** may be tilted relative to a central axis **10** of the stem **120**.

[0029] As shown in FIG. **1**A, in some examples, the prosthesis **100** may have a monoblock design where the stem **120** may be directly coupled to or formed integrally with a bottom surface of the head **110**. As shown in FIG. **1**B, in other examples, the prosthesis **100** may have a modular design where the stem **120** may be indirectly coupled to the head **110**, such as through a morse taper connection. The stem **120** may be directly coupled to a trunnion **130**, and the head **110** may have an opening configured to receive the trunnion **130**. This may allow the head **110** to be removably coupled to the stem **120** and/or the trunnion **130**.

[0030] The head **110** may be configured to mimic the head of a radius bone. For example, the head **110** may be (substantially) cylindrical in shape and may include a top surface configured to engage with a capitellum of the humerus bone to form the elbow joint. Additionally or alternatively, the head **110** may include a side surface configured to engage with a radial notch of the ulna.

[0031] The head **110** and/or stem **120** may be comprised of any suitable material, such as biocompatible materials (metal alloys (titanium alloys, cobalt chromium alloys, stainless steel, etc.), composite materials, plastics (polyethylene, among others), ceramics, and/or the like), and/or bioabsorbable materials (polygalactic acid (PGA), polylactic acid (PLA), copolymers thereof, etc.), among others. In some examples, the stem **120** may be made of a substantially rigid material so that the prosthesis is secured in the bore of the radius bone without substantial movement.

[0032] The stem **120** may include an elongated shaft configured to be received in a bore of the radius bone to secure the prosthesis **100** to the radius. In some examples, the stem **120** may be (substantially) cylindrical or have any desired shape. For example, as can be seen in FIGS. **1**A, the stem **120** may define a virtual cylinder **122** with portions occupied by the stem **120** and portions removed from the virtual cylinder **122**, also known as vacant portions. In some examples, the virtual cylinder **122** may have a diameter between about 6 mm and about 12 mm, for example, 6 mm, 7 mm, 8 mm, 9 mm, 10 mm, 11 mm, or 12 mm. In other examples, the virtual cylinder **122** may have any other suitable diameter. In some examples, a side surface portion of the stem **120** (for example, at least one point of the stem **120**) may coincide with a side surface portion of the virtual cylinder **122**. Removing portions of the virtual cylinder **122** from the stem **120** (e.g., the vacant portions of the stem **120**) may allow better insertion angles for implanting the prosthesis **100** into the bore of the radius.

[0033] The virtual cylinder **122** may extend from the top end of the stem **120** to the bottom end of the stem **120**. For example, the top face of the virtual cylinder **122** may be on the same plane as at least one top surface portion of the stem **120** and the bottom face of the virtual cylinder **122** may be on the same plane as at least one bottom surface portion of the stem **120**. The entire body of the stem **120** may be located within the virtual cylinder **122**. That is, there is no portion of the stem **120** that is not located within the virtual cylinder **122**. In some examples, a central axis of a virtual cylinder **122** of the stem **120** may coincide with the central axis **10** of the head **110**. The largest distance from central axis **10** to a side surface of the stem **120** may be the radius of the virtual cylinder **122**. In some examples, the virtual cylinder **122** may be defined as having i) a central axis **10** coinciding with the central axis **10** of the head **110**, ii) a length extending along the central axis **10** from the top end of the stem **120** to the bottom end of the stem **120**, and iii) a radius that is the same as the largest distance from the central axis **10** to a side surface of the stem **120**.

[0034] In some examples, the outside surface of stem **120** that faces the vacant portion of the virtual cylinder **122** may include a smooth surface. As used herein, a smooth surface may mean a surface without sharp, angled edges. In some examples, a surface of the stem **120** facing the vacant portions of the virtual cylinder **122** includes an angled or a curved surface. The angled or a curved surface may provide a better angle of insertion for implantation of prosthesis **100**.

[0035] In some examples, at least one cross-sectional area of the stem **120**, perpendicular to the central axis **10**, may include a width equal to the diameter of the virtual cylinder **122**. This may ensure stability of the stem **120**. In some examples, at least one cross-sectional area of the stem **120**, perpendicular to the central axis **10**, may be circular in shape and may have a circumference the same as the circumference of the virtual cylinder **122**. In other examples, at least one cross-sectional area of the stem **120**, perpendicular to the central axis **10**, may be circular in shape and may have a circumference smaller than the circumference of the virtual cylinder **122**.

[0036] In some examples, a volume ratio between the portion occupied by the stem **120** and the vacant portion in the virtual cylinder **122** may be in a range of about 1:1.5 to about 7:1, such as in a range of about 1:1.5 to about 1:1, about 2:1 to about 3:1, about 3:1 to about 4:1, about 4:1 to about 5:1, about 5:1 to about 6:1, or about 6:1 to about 7:1.

[0037] Still referring to FIG. **1**A, the stem **120** may define a plane **20** orthogonal to the central axis **10**. The stem may define a first axis **30**, which may be on the plane **20** and may pass through the central axis **10** of the stem **120**. In some examples, the first axis **30** may pass through the side surface portion of the stem **120** that coincides with the virtual cylinder **122**. The stem **120** may define a second axis **40**, which may be on the plane **20** and may pass through the central axis **10** of the stem **120**. In some examples, the second axis **40** does not pass through the side surface portion of the stem **120** that coincides with the virtual cylinder **122**.

[0038] In some examples, the first axis **30** and the second axis **40** may be orthogonal to each other, such that the first axis **30**, the second axis **40**, and the central axis **10** make up an x-axis, a y-axis, and a z-axis, respectively. In some examples, the first axis **30** and the second axis **40** may be at a non-90° angle relative to one another, such between a 60° angle and a 90° angle, for example, between a 60° angle and a 70° angle, between a 70° angle and an 80° angle, or between an 80° angle and a 90° angle.

[0039] Referring to FIGS. **2**A and **2**B, the stem **120** may include a first end portion **124**, a second end portion **126** opposite the first end portion **124**, and an intermediate portion **128** between the first end portion **124** and the second end portion **126**. In some examples, the first end portion **124** may make up the top 1 to 30% of the stem **120** (e.g., near the head **110**), for example the top 1-5%, 5-10%, 10-15%, 15-20%, 20-25%, or 25-30% of the stem. In some examples, the second end portion **126** may make up the bottom 1 to 30% of the stem **120**, for example the bottom 1-5%, 5-10%, 10-15%, 15-20%, 20-25%, or 25-30% of the stem **120**.

[0040] In some examples, the plane **20** is disposed in the intermediate portion **128**. In some examples, the plane **20** may be disposed at the middle of the stem **120** and the virtual cylinder **122**. In other examples, the plane **20** may be disposed at any other suitable part of the intermediate portion **128**.

[0041] In some examples, as shown in FIG. **5**, at least a portion of the second end portion **126** of the stem **120** may be curved or partially spherical with some portions removed. In some examples, a side surface of the second end portion **126** defines one or more chords of the partial sphere. Alternatively, the second end portion **126** may be spherical. A portion of the second end portion **126** may coincide with a surface of the partial sphere. For example, the bottom surface of the second end portion **126** may coincide with a surface of the partial sphere. Additionally or alternatively, the side surface of the second end portion **126** may coincide with a portion of the surface of the partial sphere.

[0042] The second end portion **126** of the stem **120** may include a first end coupled to the intermediate portion **128** and a second end opposite the first end. At least a portion of the second end portion **126** may include the second end and a largest width of the portion may taper toward the second end.

[0043] FIG. **2**A illustrates the prosthesis **100** when viewed from the first axis **30** (i.e. first axis **30** going into the page). As shown, in this 2-dimensional view, a portion of the virtual cylinder **122** may be covered by the shaft of the stem **120** and a portion of the virtual cylinder **122** may be vacant. From this 2-dimensional view, the virtual cylinder **122** may be divided, by the central axis **10**, into a first portion **122***a* (on the left side of the central axis **10**) and a second portion **122***b* (on the right side of the central axis **10**).

[0044] In some examples, when viewed from the first axis **30**, the stem **120** covers over 80% (e.g., 80-85%, 85-90%, 90-95% or 95-100%) of the first portion **122***a*. In some examples, when viewed from the first axis **30**, the vacant portion covers under 20% (e.g., 0-5%, 5-10%, 10-15%, or 15-20%) of the first portion **122***a*. In some examples, when viewed from the first axis **30**, the stem **120** covers over 80% (e.g., 80-85%, 85-90%, 90-95% or 95-100%) of the second portion **122***b*. In some examples, when viewed from the first axis **30**, the vacant portion covers under 20% (e.g., 0-5%, 5-10%, 10-15%, or 15-20%) of the second portion **122***b*.

[0045] In some examples, when viewed from the first axis **30**, the stem **120** may be symmetrical about the central axis **10**. In other examples, when viewed from the first axis **30**, the stem **120** may be asymmetrical about the central axis **10**.

[0046] In some examples, when viewed from the first axis **30**, the largest width of the first end portion **124** and/or the second end portion **126** may be greater than the smallest width of the intermediate portion **128**. Additionally or alternatively, when viewed from the first axis **30**, the largest width of the first end portion **124** may be the same as the width of the virtual cylinder **122**. In some examples, when viewed from the first axis **30**, the largest width of the second end portion **126** may be the same as the width of the virtual cylinder **122**. In some examples, the smallest width of the intermediate portion **128** may taper to a larger width of the first end portion **124** and/or the second end portion **126**. As used herein, a width of a portion of the stem **120** when viewed from an axis (e.g., first axis) may refer to a distance, in a 2-dimensional view from the axis (e.g., first axis), between two points of the stem **120** that are i) on a side surface of the stem **120** and ii) on a plane perpendicular to the central axis **10**.

[0047] FIG. **2**B illustrates the prosthesis **100** when viewed from the second axis **40** (i.e. second axis **40** going into the page). As shown, a portion of the virtual cylinder **122** may be covered by the shaft of the stem **120** and a portion of the virtual cylinder **122** may be vacant. From this 2-dimensional view, the virtual cylinder **122** may be divided, by the central axis **10**, into a third portion **122***c* (on the left side of the central axis **10**) and a fourth portion **122***d* (on the right side of the central axis **10**). In some examples, when viewed from the second axis **40**, the stem **120** covers over 80%, 90%, or 95% (e.g. 85%, 87%, 92%, 96%, 97%, 98%, 99%, or 100%) of the third portion **122***c*. In some examples, when viewed from the second axis **40**, less than 90%, 50%, or 30% (10-20%, 20-30%, 30-40%, 40-50%, 50-60%, 60-70%, 70-80%, 80-90%) of the fourth portion **122***d* may be covered by the stem **120**.

[0048] In some examples, the first axis **30** may be defined as an axis on the plane **20**, where, in a 2-dimensional view from this axis, the percentage of the portion of the virtual cylinder **122** that is covered by the stem **120** (hereinafter "stem coverage percentage" of the virtual cylinder **122**) is maximum (e.g., over 70%, 80% or 90%) compared to a 2-dimensional view from other axes on the plane **20**. That is, in this 2-dimensional view from the first axis **30**, the least portion of the virtual cylinder **122** is covered by the vacant portion compared to a 2-dimensional view from other axes on the plane **20**.

[0049] In some examples, the second axis **40** may be defined as an axis on the plane **20**, where, in a 2-dimensional view from this axis, the stem coverage percentage of the virtual cylinder **122** is minimum (e.g., less than 90%, 80%, 70% or 60%) compared to a 2-dimensional view from other axes on the plane **20**. That is, in this 2-dimensional view from the second axis **40**, the largest portion of the virtual cylinder **122** is covered by the vacant portion (compared to a 2-dimensional view from other axes on the plane **20**).

[0050] In some examples, in a 2-dimensional view from the second axis **40**, the difference between the stem coverage percentage of the third portion **122***c* and the stem coverage percentage of the fourth portion **122***d* is maximum compared to a 2-dimensional view from other axes on the plane **20**. In some examples, in a 2-dimensional view from the second axis **40**, a ratio between the stem coverage percentage of the third portion **122***c* and the stem coverage percentage of the fourth portion **122***d* is in a range of about 10:1 to about 1.2:1, for example, about 10:1 to about 8:1, about 8:1 to about 6:1, about 6:1 to about 4:1, about 4:1 to about 2:1, or about 2:1 to about 1.2:1.

[0051] In some examples, as depicted in FIG. **2**B, the central axis **10** may transverse at least a portion of the vacant portion of the virtual cylinder **122**. Stated differently, in some examples, the smallest width of the stem **120** of the virtual cylinder **122** (when viewed from the first axis **30** or the second axis **40**) may be smaller than a radius of the virtual cylinder **122**. In other examples, the central axis **10** may only traverse the stem **120** portion of the virtual cylinder **122** and the smallest width of the stem **120** within the virtual cylinder **122** (when viewed from the first axis **30** or the second axis **40**) may be larger than a radius of the virtual cylinder **122**.

[0052] When viewed from the second axis **40**, the smallest width of the first end portion **124** may be greater that the smallest width of the intermediate portion **128**. Additionally or alternatively, when viewed from the second axis **40**, the largest width of the second end portion **126** may be greater than the smallest width of the intermediate portion **128**.

[0053] In some examples, when viewed from the second axis **40**, the largest width of the first end portion **124** may be smaller than the diameter of the virtual cylinder **122**. In other examples, when viewed from the second axis **40**, the largest width of the first end portion **124** may be the same as the diameter of the virtual cylinder **122**.

[0054] In some examples, when viewed from the second axis **40**, the largest width of the second end portion **126** may be the same as the diameter of the virtual cylinder **122**. In other examples, when viewed from the second axis **40**, the largest width of the second end portion **126** may be smaller than the diameter of the virtual cylinder **122**. In some examples, the smallest width of the intermediate portion **128** may taper to a larger width of the first end portion **124** and/or the second end portion **126**.

[0055] FIG. **3** illustrates prosthesis **100** when viewed from the first axis **30** from the direction opposite from FIG. **2**A. FIG. **4** illustrates a cross-sectional view taken along the line **4-4** of FIG. **2**A. As shown in FIGS. **2**B, **3**, and **4**, a side surface portion of the stem **120** may coincide with a surface of the virtual cylinder **122**.

[0056] FIGS. **6** to **10** illustrate an example prosthesis **200** according to another example of the present disclosure. The prosthesis **200** may be similar to the prosthesis **100**, but with different stem dimensions and/or shapes. Various configurations/features/characteristics of the prosthesis **200** (e.g., material, virtual cylinder, central axis, stem coverage percentage, first axis, second axis, first end portion, second end portion, intermediate portion, etc.) may be similar to and/or same as the ones described above with respect to the prosthesis **100** and, thus, duplicate description may be omitted.

[0057] FIGS. **7**A and **7**B illustrate the prosthesis **200** from the first axis **30** and from the second axis **40**, respectively. As shown in FIGS. **7**A and **7**B, the first end portion **124** may have the same width of the virtual cylinder **122** when viewed from both the first axis **30** and the second axis **40**. The first end portion **124** of stem **120** may occupy the whole volume of the virtual cylinder **122**, while the intermediate portion **128** may include one or more vacant portions of the virtual cylinder **122**. In some examples, when viewed from the first axis **30**, the intermediate portion **128** may have the same width as the virtual cylinder **122**.

[0058] As shown in FIG. **7**B, when viewed from the second axis **40**, in some examples, the stem **120** may cover over 90%, for example, over 90%, 95% or 99%, or cover 100% of the third portion **122***c* of the virtual cylinder **122**. In some examples, when viewed from the second axis **40**, the stem **120** may cover between 30-85%, for example between about 30-40%, about 40-50%, about 50-60%, about 60-70%, about 70-80%, or about 80-85% of the fourth portion **122***d* of the virtual cylinder **122**.

[0059] While FIG. **7**B shows the first end portion **124** and the intermediate portion **128** of the stem **120** covering 100% of the third portion **122***c* of the virtual cylinder **122** when viewed from the second axis **40**, it can be appreciated that the first end portion **124** and the intermediate portion **128** of the stem **120** may cover less than 100% of the third portion **122***c* of the stem **120**.

[0060] FIG. **8** illustrates prosthesis **200** when viewed from the first axis **30** from the direction opposite from FIG. **7**A. As shown in FIG. **9**, when viewed from the first axis **30** from an opposite direction, the first end portion and the intermediate portion of the stem **120** cover 100% of the virtual cylinder **122**. From this view, the entire surface of the first end portion and the intermediate portion of the stem **120** coincides with a portion of the surface of the virtual cylinder **122**.

[0061] FIG. **10** illustrates an example of the second end portion **126** of the stem **120** of the prosthesis **200**. At least a portion of the second end portion **126** of the stem **120** may be curved or partially spherical with some portions removed. In some examples, a side surface of the second end portion **126** defines one or more chords of the partial sphere. Alternatively, the second end portion **126** may be spherical. A portion of the second end portion **126** may coincide with a surface of the partial sphere. For example, the bottom surface of the second end portion **126** may coincide with a surface of the partial sphere.

[0062] FIGS. **11** to **13** illustrate modified prostheses of FIG. **6**. As depicted in FIG. **11**, in some examples, portions of the stem **120** may be removed from the first end portion **124**, intermediate portion **128**, and/or second end portion **126** of the stem **120**. In some examples, the intermediate portion **128** of the stem may include a primary, first vacant portion **202**. Additionally, a second vacant portion **204** may be formed in the lower part of the intermediate portion **128** and a portion of the second end portion **126**. A third vacant portion **206** may be formed in the first end portion **124**. In some examples, the second and/or third vacant portions **204**, **206** may taper along the length.

[0063] The second vacant portion **204** may be opposite the first vacant portion **202** and/or the third vacant portion **206**. For example, when viewed from the second axis **40** as depicted in FIG. **11**, the first vacant portion **202** and/or the third vacant portion **206** may be formed in the fourth portion **122***d* contacting the right side of the virtual cylinder **122**, while the second vacant portion **204** may be formed in the third portion **122***c* contacting the left side of the virtual cylinder **122**. This configuration may limit the surface area of the stem **120** that has to inserted into the radial canal at an angle.

[0064] As depicted in FIGS. **12** and **13**, in some examples, the stem **120** may taper from a largest width or diameter in at least a portion of first end portion **124** to a smaller width or diameter towards the second end portion **126**. Stated differently, in some examples, the largest width of the first end portion **124** may be greater than a largest width of the second end portion **126** and/or the largest width of the intermediate portion **128**.

[0065] FIG. **14** illustrates a transparent prosthesis **300** of FIG. **12** overlaid on the prosthesis **400** of FIG. **13**. As shown, the prosthesis **400** depicted in FIG. **13** has slightly more volume removed in the intermediate portion **128** of the stem **120** from virtual cylinder **122** than the prosthesis **300** shown in FIG. **12**. More portions removed as depicted in FIG. **13**, in portions that typically interfere with the radial canal, allows better ease of insertion.

[0066] An easier insertion refers to the ability of the stem to be inserted into the radial canal at a greater depth without interference of the head with the capitellum. FIG. **15** illustrates a graph depicting a relative comparison of ease of insertion according to an example of the present disclosure measured for different embodiments of the radial head prosthesis. In some examples, ease of insertion may be measured using length outside of radius (LOR) **160** as depicted in FIG. **16**. For purposes of measuring the LOR, it is assumed that the head **110** has a largest height of 11 mm and a largest width/diameter of 26 mm (for example, at least when viewed from the second axis). The LOR may be measured from the edge of the radius to a point representing the intersection of the side and top of the minimum bounding box **111** of the head **110**.

[0067] While the geometries of radial head prosthesis **100** and **200** are shown in FIGS. **1** through **13**, respectively, it can be appreciated that other geometries of radial head prostheses are suitable. FIGS. **17A-17**J and **18A-18**F illustrate other example embodiments of a radial head prosthesis according to examples of the present disclosure.

Embodiments

[0068] Various aspects of the subject matter described herein are set out in the following numbered embodiments:

[0069] Embodiment 1. A prosthesis for replacement of a proximal end of a radius bone comprising: a head; and a stem defining a virtual cylindrical shaft having a central axis, wherein the stem includes a side surface portion coinciding with a side surface portion of the virtual cylindrical shaft, wherein the virtual cylindrical shaft comprises: a portion occupied by the stem; and a vacant portion, wherein the stem further defines: a plane perpendicular to the central axis of the virtual cylindrical shaft; a first axis on the plane and passing through the central axis of the virtual cylindrical shaft; and a second axis on the plane, passing through the central axis of the virtual cylindrical shaft, and perpendicular to the first axis, wherein, when viewed from the first axis: the virtual cylindrical shaft is divided, by the central axis, into a first portion and a second portion, and over 80% of the first and second portions are covered by the stem; and wherein, when viewed from the second axis: the virtual cylindrical shaft is divided, by the central axis, into a third portion and a fourth portion, and over 95% of the third portion is covered by the stem and less than 90% of the fourth portion is covered by the stem.

[0070] Embodiment 2. The prosthesis of embodiment 1, wherein, when viewed from the second axis, less than 50% of the fourth portion is covered by the stem.

[0071] Embodiment 3. The prosthesis of embodiment 2, wherein, when viewed from the second axis, less than 30% of the fourth portion is covered by the stem.

[0072] Embodiment 4. The prosthesis of any one of embodiments 1-3, wherein, when viewed from the second axis, over 97% of the third portion is covered by the stem.

[0073] Embodiment 5. The prosthesis of any one of embodiments 1-4, wherein a volume ratio between the portion occupied by the stem and the vacant portion in the virtual cylindrical shaft is in a range of about 1:1.5 to about 7:1.

[0074] Embodiment 6. The prosthesis of embodiment 5, wherein a volume ratio between the portion occupied by the stem and the vacant portion in the virtual cylindrical shaft is in a range of about 1:1.5 to about 1.5:1.

[0075] Embodiment 7. The prosthesis of any one of embodiments 1-6, wherein the first axis passes through the side surface portion of the stem, and the second axis does not pass through the side surface portion of the stem.

[0076] Embodiment 8. The prosthesis of any one of embodiments 1-7, wherein at least one cross-sectional area of the stem has a circular shape having a circumference the same as a circumference of the virtual cylindrical shaft, wherein the at least one cross-sectional area of the stem is perpendicular to the central axis of the virtual cylindrical shaft.

[0077] Embodiment 9. The prosthesis of any one of embodiments 1-8, wherein the stem comprises: a first end portion; a second end portion opposite the first end portion; and an intermediate portion disposed between the first end portion and the second end portion, wherein, when viewed from the second axis, a smallest width of the first end portion is greater than a smallest width of the intermediate portion.

[0078] Embodiment 10. The prosthesis of embodiment 9, wherein, when viewed from the second axis, a largest width of the second end portion of the stem is greater than a smallest width of the intermediate portion.

[0079] Embodiment 11. The prosthesis any one of embodiments 9 and 10, wherein, when viewed from the second axis, a largest width of the first end portion of the stem is less than a width of the virtual cylindrical shaft.

[0080] Embodiment 12. The prosthesis of any one of embodiments 9-11, wherein, when viewed from the second axis, a largest width of the second end portion of the stem is the same as a width of the virtual cylindrical shaft.

[0081] Embodiment 13. The prosthesis of any one of embodiments 9-12, wherein, when viewed from the second axis, a width of the stem tapers from a smaller width in the intermediate portion to a larger width in the first end portion and/or the second end portion.

[0082] Embodiment 14. The prosthesis of any one of embodiments 9-13, when viewed from the first axis, a largest width of the first end portion is greater than a smallest width of the intermediate portion.

[0083] Embodiment 15. The prosthesis of embodiment 14, wherein, when viewed from the first axis, a largest width of the first end portion is the same as a width of the virtual cylindrical shaft.

[0084] Embodiment 16. The prosthesis of any one of embodiments 9-15, wherein, when viewed from the first axis, a largest width of the second end portion is greater than a smallest width of the intermediate portion.

[0085] Embodiment 17. The prosthesis of embodiment 16, wherein, when viewed from the first axis, the largest width of the second end portion is the same as a width of the virtual cylindrical shaft.

[0086] Embodiment 18. The prosthesis of any one of embodiments 9-17, wherein the second end portion of the stem comprises a first end coupled to the intermediate portion and a second end opposite the first end, wherein at least a portion of the second end portion includes the second end and a largest width of the portion tapers toward the second end.

[0087] Embodiment 19. The prosthesis of any one of embodiments 1-18, wherein the central axis of the virtual cylindrical shaft transverses at least a portion of the vacant portion of the virtual cylindrical shaft.

[0088] Embodiment 20. The prosthesis of any one of embodiments 1-19, wherein a portion of a surface of the stem that faces the vacant portion of the virtual cylindrical shaft comprises a smooth surface.

[0089] Embodiment 21. The prosthesis of any one of embodiments 1-20, wherein a portion of a surface of the stem that faces the vacant portion of the virtual cylindrical shaft comprises an angled surface.

[0090] Embodiment 22. The prosthesis of any one of embodiments 1-21, wherein, when viewed from the first axis, the stem is symmetrical relative to the central axis of the virtual cylindrical shaft.

[0091] Embodiment 23. The prosthesis of any one of embodiments 1-22, wherein the head defines a central axis coinciding with the central axis of the virtual cylindrical shaft.

[0092] As used herein, "about," "approximately" and "substantially" are understood to refer to numbers in a range of numerals, for example the range of −10% to +10% of the referenced number, preferably −5% to +5% of the referenced number, more preferably −1% to +1% of the referenced number, most preferably −0.1% to +0.1% of the referenced number. Moreover, these numerical ranges should be construed as providing support for a claim directed to any number or subset of numbers in that range. For example, a disclosure of from 1 to 10 should be construed as supporting a range of from 1 to 8, from 3 to 7, from 1 to 9, from 3.6 to 4.6, from 3.5 to 9.9, and so forth.

[0093] Reference throughout the specification to "various aspects," "some aspects," "some examples," "other examples," "some cases," or "one aspect" means that a particular feature, structure, or characteristic described in connection with the aspect is included in at least one example. Thus, appearances of the phrases "in various aspects," "in some aspects," "certain embodiments," "some examples," "other examples," "certain other embodiments," "some cases," or "in one aspect" in places throughout the specification are not necessarily all referring to the same aspect. Furthermore, the particular features, structures, or characteristics illustrated or described in connection with one example may be combined, in whole or in part, with features, structures, or characteristics of one or more other aspects without limitation.

[0094] When the position relation between two parts is described using the terms such as "on," "above," "below," "under," and "next," one or more parts may be positioned between the two parts unless the terms are used with the term "immediately" or "directly." Similarly, as used herein, the terms "attachable," "attached," "connectable," "connected," or any similar terms may include directly or indirectly attachable, directly or indirectly attached, directly or indirectly connectable, and directly or indirectly connected.

[0095] It is to be understood that at least some of the figures and descriptions herein have been simplified to illustrate elements that are relevant for a clear understanding of the disclosure, while eliminating, for purposes of clarity, other elements. Those of ordinary skill in the art will recognize, however, that these and other elements may be desirable. However, because such elements are well known in the art, and because they do not facilitate a better understanding of the disclosure, a discussion of such elements is not provided herein.

[0096] The terminology used herein is intended to describe particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless otherwise indicated. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. As used herein, the term "at least one of X or Y" or "at least one of X and Y" should be interpreted as X, or Y, or X and Y.

[0097] Additionally, in describing the components of the system of the present disclosure, there may be terms used like first, second, third, and fourth. These terms may be used for the purpose of differentiating one component from the other, but not to imply or suggest the substances, order, sequence, or number of the components.

[0098] It should be understood that various changes and modifications to the examples described herein will be apparent to those skilled in the art. Such changes and modifications can be made without departing from the spirit and scope of the present subject matter and without diminishing its intended advantages. It is therefore intended that such changes and modifications be covered by the appended claims.

The invention is claimed as follows:

1. A prosthesis for replacement of a proximal end of a radius bone comprising:

a head; and

a stem defining a virtual cylindrical shaft having a central axis, wherein the stem includes a side surface portion coinciding with a side surface portion of the virtual cylindrical shaft,

wherein the virtual cylindrical shaft comprises:

a portion occupied by the stem; and

a vacant portion,

wherein the stem further defines:

a plane perpendicular to the central axis of the virtual cylindrical shaft;

a first axis on the plane and passing through the central axis of the virtual cylindrical shaft; and

a second axis on the plane, passing through the central axis of the virtual cylindrical shaft, and perpendicular to the first axis,

wherein, when viewed from the first axis:

the virtual cylindrical shaft is divided, by the central axis, into a first portion and a second portion, and over 80% of the first and second portions are covered by the stem; and

wherein, when viewed from the second axis:

the virtual cylindrical shaft is divided, by the central axis, into a third portion and a fourth portion, and over 95%

of the third portion is covered by the stem and less than 90% of the fourth portion is covered by the stem.

2. The prosthesis of claim **1**, wherein, when viewed from the second axis, less than 50% of the fourth portion is covered by the stem.

3. The prosthesis of claim **2**, wherein, when viewed from the second axis, less than 30% of the fourth portion is covered by the stem.

4. The prosthesis of claim **1**, wherein, when viewed from the second axis, over 97% of the third portion is covered by the stem.

5. The prosthesis of claim **1**, wherein a volume ratio between the portion occupied by the stem and the vacant portion in the virtual cylindrical shaft is in a range of about 1:1.5 to about 7:1.

6. The prosthesis of claim **5**, wherein a volume ratio between the portion occupied by the stem and the vacant portion in the virtual cylindrical shaft is in a range of about 1:1.5 to about 1.5:1.

7. The prosthesis of claim **1**, wherein the first axis passes through the side surface portion of the stem, and the second axis does not pass through the side surface portion of the stem.

8. The prosthesis of claim **1**, wherein at least one cross-sectional area of the stem has a circular shape having a circumference the same as a circumference of the virtual cylindrical shaft, wherein the at least one cross-sectional area of the stem is perpendicular to the central axis of the virtual cylindrical shaft.

9. The prosthesis of claim **1**, wherein the stem comprises:

a first end portion;

a second end portion opposite the first end portion; and

an intermediate portion disposed between the first end portion and the second end portion,

wherein, when viewed from the second axis, a smallest width of the first end portion is greater than a smallest width of the intermediate portion.

10. The prosthesis of claim **9**, wherein, when viewed from the second axis, a largest width of the second end portion of the stem is greater than a smallest width of the intermediate portion.

11. The prosthesis of claim **9**, wherein, when viewed from the second axis, a largest width of the first end portion of the stem is less than a width of the virtual cylindrical shaft.

12. The prosthesis of claim **9**, wherein, when viewed from the second axis, a largest width of the second end portion of the stem is the same as a width of the virtual cylindrical shaft.

13. The prosthesis of claim **9**, wherein, when viewed from the second axis, a width of the stem tapers from a smaller width in the intermediate portion to a larger width in the first end portion and/or the second end portion.

14. The prosthesis of claim **9**, wherein, when viewed from the first axis, a largest width of the first end portion is greater than a smallest width of the intermediate portion.

15. The prosthesis of claim **14**, wherein, when viewed from the first axis, a largest width of the first end portion is the same as a width of the virtual cylindrical shaft.

16. The prosthesis of claim **9**, wherein, when viewed from the first axis, a largest width of the second end portion is greater than a smallest width of the intermediate portion.

17. The prosthesis of claim **16**, wherein, when viewed from the first axis, the largest width of the second end portion is the same as a width of the virtual cylindrical shaft.

18. The prosthesis of claim **9**, wherein the second end portion of the stem comprises a first end coupled to the intermediate portion and a second end opposite the first end, wherein at least a portion of the second end portion includes the second end and a largest width of the portion tapers toward the second end.

19. The prosthesis of claim **1**, wherein the central axis of the virtual cylindrical shaft transverses at least a portion of the vacant portion of the virtual cylindrical shaft.

20. The prosthesis of claim **1**, wherein a portion of a surface of the stem that faces the vacant portion of the virtual cylindrical shaft comprises a smooth surface.

21. The prosthesis of claim **1**, wherein a portion of a surface of the stem that faces the vacant portion of the virtual cylindrical shaft comprises an angled surface.

22. The prosthesis of claim **1**, wherein, when viewed from the first axis, the stem is symmetrical relative to the central axis of the virtual cylindrical shaft.

23. The prosthesis of claim **1**, wherein the head defines a central axis coinciding with the central axis of the virtual cylindrical shaft.

* * * * *