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Inventor(s)	Dees, Jr.; Roger Ryan et al.

Anatomical motion hinged prosthesis

Abstract

A hinged knee prosthesis comprises a tibial component and a femoral component. The tibial component is configured to attach to a tibia. The tibial component has a bearing surface. The femoral component is configured to hingedly attach to the tibial component and rotate relative to the tibial component. The femoral component comprises a medial condyle and a lateral condyle. The medial and lateral condyles have an eccentric sagittal curvature surface configured to rotate and translate on the bearing surface of the tibial component. A method of rotating a hinged knee through a range of flexion is provided. The method fixedly attaches a femoral component to a tibial component. Axial rotation of the femoral component is induced relative to the tibial component when the hinged knee is flexed.

Inventors: **Dees, Jr.; Roger Ryan (Senatobia, MS), Crabtree, Jr.; Paul Charles (Nesbit, MS), Nielsen; Jonathan Kirk (Dana Point, CA)**

Applicant: **Smith & Nephew, Inc.** (Memphis, TN)

Family ID: **1000008748710**

Assignee: **Smith & Nephew, Inc. (Memphis, TN)**

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Primary Examiner: Tyson; Melanie R

Assistant Examiner: Hoban; Melissa A

Attorney, Agent or Firm: KDW Firm PLLC

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION (1) This application is a continuation of pending U.S. patent application Ser. No. 16/684,801, filed Nov. 15, 2019, which is a division of U.S. patent application Ser. No. 15/676,024, filed Aug. 14, 2017, now U.S. Pat. No. 10,779,949, issued Sep. 22, 2020, which is a continuation of U.S. patent application Ser. No. 13/964,306, filed Aug. 12, 2013, now U.S. Pat. No. 9,730,799, issued Aug. 15, 2017, which is a continuation of U.S. patent application Ser. No. 12/307,102, filed Feb. 3, 2010, now U.S. Pat. No. 8,523,950, issued Sep. 3, 2013, which is a U.S. National Phase of International Application No. PCT/US2007/072611, filed Jun. 30, 2007, which claims the benefit of U.S. Provisional Application No. 60/806,383, filed Jun. 30, 2006. Each of the prior applications is incorporated by reference herein in its entirety.

BACKGROUND
1. Field
(1) This application relates generally to knee prostheses and, more particularly, the application relates to hinged knee prostheses.
2. Related Art
(2) Most hinged-knee prostheses only provide a mechanical means to restore the joint in a hinge-like function. Other hinged-knee prostheses provide for more kinematically-correct prostheses; however, they rely mostly on remaining soft tissue to restore normal kinematics to the joint. In most cases, the remaining soft tissue has been compromised and/or missing/removed during surgery. Thus, the soft tissue cannot contribute significantly to restoring normal kinematics, particularly anterior/posterior (A/P) translation or normal axial rotation including rotation to the ‘screw-home’ position. Moreover, the remaining soft tissue may be damaged when restoring normal kinematics by forcing motion of the prostheses.
(3) In prosthetic systems that address axial rotation, current systems address rotation by allowing a rotating platform. Generally, one of the two articulating prostheses (usually the tibial insert or construct) is allowed rotational freedom. This allows the soft tissues to rotate the joint in a more normal fashion. However, most soft tissue has been compromised and cannot reproduce normal or near normal rotation.
(4) A/P translation is a motion that is seldom addressed. In those prostheses that do address A/P

translation, a cam mechanism against the joint-linking mechanism (usually a post) or against the tibial articular geometry is used to force the tibia anteriorly relative to the distal femur as the knee flexes. This method of A/P translation is common in a primary total knee arthroplasty (TKA) by the use of a cam and post method in which the cam is on the femoral articulating prosthesis and the post is found on the tibial articulating prosthesis. This is commonly referred to as a posterior or cruciate stabilized knee implant. These hinged knees generally focus forces on a small area (such as a cam with point and/or line contact and post), which may increase wear and decrease the life span of the implant.

(5) In U.S. Pat. Nos. 5,358,527 and 5,800,552, A/P translation is allowed through flexion, yet the hinged knee does not control and/or maintain a constant limit on A/P translation. In other words, the femoral can be flexed and can translate posteriorly when contact to the tibial bearing surface is not maintained. Thus, the femoral component does not maintain contact with the tibial component when A/P translation occurs.

(6) There remains a need in the art for kinematically-correct prostheses including A/P translation and/or normal axial rotation. In addition, there remains a need for kinematically-correct prostheses that reduce wear on the prosthesis and reduce forces on the remaining soft tissue.

SUMMARY

(7) The disclosure provides a hinged knee prosthesis comprising a tibial component and a femoral component. The tibial component is configured to attach to a tibia. The tibial component has a bearing surface. The femoral component is configured to hingedly attach to the tibial component and rotate relative to the tibial component. The femoral component comprises a medial condyle and a lateral condyle. The medial and lateral condyles have a sagittal curvature surface configured to induce axial rotation on the bearing surface of the tibial component.

(8) The medial and lateral condyles may have a plurality of eccentric sagittal curvature surfaces configured to rotate on the bearing surface of the tibial component.

(9) The bearing surface of the tibial component is configured with an anterior portion and a posterior portion. The posterior portion of the bearing surface has a portion configured to guide the medial and lateral condyles of the femoral component. Contact points between the femoral component and the tibial component translate in the anterior/posterior direction and rotate axially.

(10) The hinged knee may further comprise an axle hinge pin. The axle hinge pin is located transversely between the medial and lateral condyles. The eccentric sagittal curvature surface has a center of rotation not aligned with the axle hinge pin.

(11) The hinged knee prosthesis may further comprise a post configured to extend from the tibial component to the femoral component. A proximal portion of the post is configured to attach to the axle hinge pin.

(12) The center of rotation of a portion of the eccentric sagittal curvature surface of the medial condyle may not be aligned with the center of rotation of a portion of the eccentric sagittal curvature surface of the lateral condyle. The medial and lateral condyles direct axial rotation of the femoral component relative to the tibial component.

(13) The center of rotation of a portion of the eccentric sagittal curvature surface of the medial condyle may be aligned with the center of rotation of a portion of the eccentric sagittal curvature surface of the lateral condyle, wherein the medial and lateral condyles direct anterior/posterior translation of the femoral component relative to the tibial component.

(14) The medial condyle of the femoral component may further comprise a concentric sagittal curvature surface. The center of rotation of the concentric sagittal curvature surface of the medial condyle is not aligned with the center of rotation of a portion of the eccentric sagittal curvature surface of the lateral condyle. The medial and lateral condyles direct axial rotation of the femoral component relative to the tibial component.

(15) The center of rotation of a first eccentric sagittal curvature surface of the medial condyle may not be aligned with the center of rotation of a first eccentric sagittal curvature surface of the lateral

condyle. The medial and lateral condyles direct axial rotation and anterior/posterior translation of the femoral component relative to the tibial component when the first eccentric sagittal curvature surfaces contact the tibial component. The center of rotation of a second eccentric sagittal curvature surface of the medial condyle is aligned with the center of rotation of a second eccentric sagittal curvature surface of the lateral condyle, wherein the medial and lateral condyles direct anterior/posterior translation of the femoral component relative to the tibial component when the second eccentric sagittal curvature surfaces contact the tibial component.

(16) The hinged knee prosthesis may comprise a sleeve configured to receive the post. The sleeve is configured to allow axial rotation of the femoral component relative to the tibial component.

(17) The disclosure provides a method of rotating a hinged knee through a range of flexion. The method fixedly attaches a femoral component to a tibial component. Axial rotation of the femoral component is induced relative to the tibial component when the hinged knee is flexed.

(18) The method may further comprise the step of inducing translation of the femoral component in an anterior/posterior direction relative to the tibial component when the hinged knee is flexed.

(19) The inducing translation step and the inducing axial rotation steps may occur simultaneously.

(20) The inducing axial rotation step may occur through a portion of the range of flexion of the prosthetic knee.

(21) The inducing axial rotation step may occur through a first portion of the range of flexion of the prosthetic knee and a second portion of the range of flexion of the prosthetic knee.

(22) The first portion of the range of flexion may not be adjacent to the second portion of the range of flexion.

(23) The inducing axial rotation step may occur at varying angular velocities as the hinged knee passes through the range of flexion of the knee.

(24) The fixedly attaching step may include connecting a sleeved post to the tibial insert such that a sleeved portion of the sleeved post and a post portion of the sleeved post axially rotate relative to each other. Further the fixedly attaching step may include fixing an axial hinge pin to the sleeved post such that the axial hinge pin transversely connects a medial condyle of the femoral component to the lateral condyle of the femoral component.

(25) The method may further comprise the step of fixing the sleeved portion of the sleeved post to a stem in the tibial component.

(26) The method may further comprise the step of axially displacing the sleeved portion of the sleeved post relative to the post portion of the sleeved post when the hinged knee is flexed.

(27) Thus, kinematically-correct prostheses including A/P translation and/or normal axial rotation may be achieved by the structures in the disclosure. These kinematically-correct prostheses may reduce wear on the prosthesis and reduce forces on the remaining soft tissue. Further features, aspects, and advantages of the present invention, as well as the structure and operation of various embodiments of the present invention, are described in detail below with reference to the accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) The accompanying drawings, which are incorporated in and form a part of the specification, illustrate embodiments and together with the description, serve to explain the principles of the invention. In the drawings:

(2) FIG. **1** is an isometric view of an embodiment of a hinged knee;

(3) FIG. **2** is a cutaway view of the embodiment of FIG. **1**;

(4) FIG. **3** is a side view of the embodiment of FIG. **1**;

(5) FIG. **4** is a cutaway view of the embodiment of FIG. **3**;

(6) FIG. **5** is an isometric view of an embodiment of a hinged knee;
(7) FIG. **6** is a cutaway view of the embodiment of FIG. **5**;
(8) FIG. **7** is a side view of the embodiment of FIG. **5**;
(9) FIG. **8** is a cutaway view of the embodiment of FIG. **7**;
(10) FIG. **9** is an isometric view of an embodiment of a tibial insert;
(11) FIG. **10** is a top view of the tibial insert of FIG. **9**;
(12) FIG. **11** is a side view of an embodiment of femoral component of a hinged knee;
(13) FIGS. **12** and **13** are a side view and an isometric view, respectively, of an embodiment of a hinged knee at extension;
(14) FIGS. **14** and **15** are a side view and an isometric view, respectively, of the hinged knee of FIG. **12** at 20 degrees flexion;
(15) FIGS. **16** and **17** are a side view and an isometric view, respectively, of the hinged knee of FIG. **12** at 40 degrees flexion;
(16) FIGS. **18** and **19** are a side view and an isometric view, respectively, of the hinged knee of FIG. **12** at 90 degrees flexion;
(17) FIGS. **20** and **21** are a side view and an isometric view, respectively, of the hinged knee of FIG. **12** at 120 degrees flexion;
(18) FIGS. **22** and **23** are a side view and an isometric view, respectively, of the hinged knee of FIG. **12** at 150 degrees flexion;
(19) FIGS. **24-26** are a side view, an isometric view, and a top view, respectively, of an embodiment of a hinged knee at extension;
(20) FIGS. **27-29** are a side view, an isometric view, and a top view, respectively, of the hinged knee of FIG. **27** at 20 degrees flexion;
(21) FIGS. **30-32** are a side view, an isometric view, and a top view, respectively, of the hinged knee of FIG. **27** at 40 degrees flexion;
(22) FIGS. **33-35** are a side view, an isometric view, and a top view, respectively, of the hinged knee of FIG. **27** at 90 degrees flexion;
(23) FIGS. **36-38** are a side view, an isometric view, and a top view, respectively, of the hinged knee of FIG. **27** at 120 degrees flexion; and
(24) FIGS. **39-41** are a side view, an isometric view, and a top view, respectively, of the hinged knee of FIG. **27** at 150 degrees flexion.

DETAILED DESCRIPTION OF THE EMBODIMENTS

(25) Referring to the accompanying drawings in which like reference numbers indicate like elements, FIGS. **1-4** show views of an embodiment of a hinged knee.

(26) Turning now to FIG. **1**, FIG. **1** is an isometric view of an embodiment of a hinged knee **10**. The hinged knee **10** includes a femoral component **14**, a tibial component **16**, a pin sleeve **18** and a pin **20**. The tibial component **16** includes a tibial insert **24** and a tibial base **26**. The femoral component **14** includes a medial condyle **30** and a lateral condyle **32**. The pin **20** connects the condyles **30** and **32** to the sleeve **18**. The sleeve **18** connects to the tibial component through a sleeved post (discussed below).

(27) As the knee flexes, the femoral component **14** rotates relative to the tibial component **16**. The femoral component **14** rotates about the pin **20**. Axial rotation and anterior/posterior (A/P) translation of the femoral component **14** is urged by the shape of the tibial insert **24** and the condyles **30** and **32**. The axial rotation and anterior/posterior (A/P) translation of the femoral component **14** may occur because the pin **20** is able to axial rotate and be axially translated relative to the post and sleeve of the hinged knee **10**.

(28) The femoral component **14** and the tibial component **16** are connected to the femur and tibia, respectively. Stems **36** are inserted into the femur and tibia to fix the femoral component and tibial component to the bones. The length and thickness of these stems may be adjusted based upon required fixation, size of the bones, and size of the intramedullary canals in the bones.

(29) Turning now to FIG. **2**, FIG. **2** is a cutaway view of the embodiment of FIG. **1**. The cutaway is taken in a sagittal plane between the femoral condyles. FIG. **2** shows the pin **20** in the sleeve **18**. The sleeve **18** is attached to a post sleeve **40** which surrounds a post **42**. The post **42** is attached to the tibial base **26**, and may be attached asymmetrically to the tibial base **26**. The post sleeve **40** may be axially rotated and axially translated relative to the post **42**. The sleeve **18** (and thus the pin **20**) may rotate axially and translate axially relative to the tibial component **16**. The rotation and translation allow for the femoral component **14** to axially rotate and to translate in the A/P direction. The A/P translation may be accomplished by the condyle surface having a curvature with a center of rotation outside the pin **20**. As the femoral component **14** rotates, a bushing **46** stops hyper extension so that the knee may not overextend.
(30) Turning now to FIG. **3**, FIG. **3** is a side view of the embodiment of FIG. **1**. The pin **20** is located posterior to the center of the knee **10**. The curve **50** of the condyle **32** is eccentric with respect to the center of rotation of the femoral component **14**, which is the pin **20**. With respect to the tibial component **16**, the pin **20** axially rotates and axially translates as the knee flexes.
(31) Turning now to FIG. **4**, FIG. **4** is a cutaway view of the embodiment of FIG. **3**. The cutaway is taken along the same sagittal plane of the cutaway in FIG. **2**. The cutaway shows the post sleeve **40** and post **42** of the hinged knee **10**. A screw **56** fixes a post receiver **58** to the post to lock the post sleeve **40** on the post **42**. The post sleeve **40** and pin sleeve **18** then may rotate and translate axially without pulling off the post **42**.
(32) Turning now to FIGS. **5-8**, these FIGs. show views of another embodiment of a hinged knee **70**. Turning now to FIG. **5**, FIG. **5** is an isometric view of an embodiment of the hinged knee **70**. The hinged knee **70** includes a femoral component **74**, a tibial component **76**, a pin sleeve **78** and a pin **80**. The tibial component **76** includes a tibial insert **84** and a tibial base **86**. The femoral component **74** includes a medial condyle **90** and a lateral condyle **92**. The pin **80** connects the condyles **90** and **92** to the sleeve **78**. The sleeve **78** connects to the tibial component through a sleeved post.
(33) As the knee flexes, the femoral component **74** rotates relative to the tibial component **76**. The femoral component **74** rotates about the pin **80**. Axial rotation and anterior/posterior (A/P) translation of the femoral component **74** is urged by the shape of the tibial insert **84** and the condyles **90** and **92**. The axial rotation and anterior/posterior (A/P) translation of the femoral component **74** may occur because the pin **80** is able to axially rotate and be axially translated relative to the post and sleeve of the hinged knee **70**.
(34) The femoral component **74** and the tibial component **76** are connected to the femur and tibia, respectively. Stems **96** are inserted into the femur and tibia to fix the femoral component and tibial component to the bones. The length and thickness of these stems may be adjusted based upon required fixation, size of the bones, and size of the intramedullary canals in the bones.
(35) Turning now to FIG. **6**, FIG. **6** is a cutaway view of the embodiment of FIG. **5**. The cutaway is taken in a sagittal plane between the femoral condyles. FIG. **6** shows the pin **80** in the sleeve **78**. The sleeve **78** is attached to a post **100** which is inserted into a post sleeve **102**. The post sleeve **102** is attached to the tibial base **86**. The post **100** may be axially rotated and axially translated relative to the post sleeve **102**. The pin sleeve **78** (and thus the pin **80**) may rotate axially and translate axially relative to the tibial component **76**. The rotation and translation allow for the femoral component **74** to axially rotate and to translate in the A/P direction. The A/P translation may be accomplished by the condyle surface having a curvature with a center of rotation outside the pin **80**. As the femoral component **74** rotates, a bushing **106** stops hyper extension so that the knee may not overextend.
(36) Turning now to FIG. **7**, FIG. **7** is a side view of the embodiment of FIG. **5**. The pin **80** is located posterior to the center of the knee **70**. The curve **110** of the condyle **92** is eccentric with respect to the center of rotation of the femoral component **74**, which is the pin **80**. With respect to the tibial component **76**, the pin **80** axially rotates and axially translates as the knee flexes.

(37) Turning now to FIG. **8**, FIG. **8** is a cutaway view of the embodiment of FIG. **7**. The cutaway is taken along the same sagittal plane of the cutaway in FIG. **6**. The cutaway shows the post **100** and post sleeve **102** of the hinged knee **70**. An enlarged portion **106** of the post **100** fixes the post **100** to the femoral component **74** so that when the post **100** is inserted in the post sleeve **102**, the femoral component **74** is aligned and held in place relative to the tibial component **76**. The post **100** and pin sleeve **78** then may rotate and translate axially without pulling the femoral component **74** off the tibial base **76**.
(38) Turning now to FIGS. **9** and **10**, these FIGs. show views of a tibial insert **120**. FIG. **9** is an isometric view of an embodiment of a tibial insert **120** and FIG. **10** is a top view of the tibial insert **120** of FIG. **9**. The tibial insert **120** includes a post hole **124** for receiving the post from either the tibial base or the femoral component. Direction lines **126** on a bearing surface **128** show the lines the femoral component articulates on the tibial insert **120**. As the femoral component rotates on the insert **120**, the position on the line **126** travels posteriorly. The posterior portion of the tibial insert **120** slopes to axially rotate and translate the femoral component posteriorly. Together in conjunction with the curvature of the condyles, the tibial insert **120** cause A/P translation and axial rotation of the femoral component.
(39) Turning now to FIG. **11**, FIG. **11** is a side view of an embodiment of femoral component **130** of a hinged knee. The curvature of a condyle **131** includes a first distal portion **132** having a first center of rotation **134**, a second posterior portion **136** having a second center of rotation **138** concentric with a pin hole **140**, and a third proximal portion **142** having a third center of rotation **144**. The centers of rotation **134** and **144** are eccentric to the pin hole **140**. As the knee rotates, the contact point between the femoral component **130** and the tibial insert produces a force normal to the femoral component **130** and aligned with the center of rotation for that section of the curvature. While the contact point is within the distal portion of the curvature, the normal force points toward the center of rotation **134**. At the interface between the distal portion **132** and the posterior portion **136**, the normal force is collinear with the centers of rotation **134** and **138**. Similarly, at the interface between the posterior portion **136** and the proximal portion **142**, the normal force is collinear with the centers of rotation **138** and **144**. Thus, the contact points do not jump during rotation but smoothly move.
(40) The eccentricity of the curvatures allows for the lateral forces at the contact points to control axial rotation and A/P translation. Because the forces are normal to the tibial and femoral surfaces, reactive forces at the contact points induce A/P motion and axial rotation. The pins, sleeves, and posts of the hinged knee allow for the translation and rotation of the femoral component **130** with respect to the tibial component.
(41) Turning now to FIGS. **12-23**, the FIGs. show side views and isometric views of an embodiment of a hinged knee in different angles of flexion. FIGS. **12** and **13** are a side view and an isometric view, respectively, of an embodiment of a hinged knee at extension. A contact point **150** anterior to the pin axis is the contact point between a femoral component **152** and a tibial component **154**. The tibial component is posteriorly distal sloped at the contact point **150** so there is a reactive contact force attempting to push the femoral component backwards. FIG. **13** shows the position of the femoral component **152** at extension.
(42) Turning now to FIGS. **14** and **15**, FIGS. **14** and **15** are a side view and an isometric view, respectively, of the hinged knee of FIG. **12** at 20 degrees flexion. As the knee flexes, the contact point **150** moves posteriorly. Additionally, as shown in FIG. **15**, the femoral component **152** has rotated relative to the tibial component **154**. The axial rotation is urged by a differential between the moments created by the reactive forces at the medial and lateral condyles.
(43) Turning now to FIGS. **16** and **17**, FIGS. **16** and **17** are a side view and an isometric view, respectively, of the hinged knee of FIG. **12** at 40 degrees flexion. The contact point **150** has shifted posteriorly and the femoral component has continued to rotate axially. This change in contact point shows the A/P translation of the femoral component as the knee rotates. While most of the motion

during early knee flexion is axial rotation, some A/P translation occurs. This “rollback” and rotation is similar to normal joint kinematics. These movements are urged by the shapes of the tibial and femoral component. This minimizes shear forces on the patella which may otherwise try to force these movements of the femoral components. Generation of the shear forces in the patella may cause pain or prosthetic failure.
(44) The contact force **150** is directed through the center of the pin hole as the curvature of the condyle transitions from the distal eccentric portion to the posterior concentric portion discussed with reference to FIG. **11**.
(45) Turning now to FIGS. **18** and **19**, FIGS. **18** and **19** are a side view and an isometric view, respectively, of the hinged knee of FIG. **12** at 90 degrees flexion. While flexion continues through the concentric portion, the A/P translation and axial rotation stops. The distance to the center of the pin hole remains constant as the center of curvature for the posterior portion of the condyle is concentric with the pin hole.
(46) Turning now to FIGS. **20** and **21**, FIGS. **20** and **21** are a side view and an isometric view, respectively, of the hinged knee of FIG. **12** at 120 degrees flexion. The contact force **150** is directed through the center of the pin hole as the curvature of the condyle transitions from the posterior concentric portion of the curvature to the proximal eccentric portion discussed with reference to FIG. **11**. As the contact force **150** moves posterior the center of the pin hole, the distance from the contact point to the center of the pinhole lessens.
(47) Turning now to FIGS. **22** and **23**, FIGS. **22** and **23** are a side view and an isometric view, respectively, of the hinged knee of FIG. **12** at 150 degrees flexion. As the hinged knee continues to rotate, the contact force generally creates A/P translation, and little axial rotation. Again, this is generally consistent with normal knee kinematics. While this embodiment has described A/P translation and axial rotation by surface characteristics of the tibial and femoral components **154** and **152**, other embodiments may accomplish these motions in other ways.
(48) The additional embodiments generally try to control lateral forces between the femoral and tibial components. For example, differences in the lateral forces between condyles may create motion. Additionally keeping lateral forces on one side small or zero while controlling the forces on the other side can control axial rotation. For more rotation, forces may be opposite in direction to increase axial rotation. Because rotation is controlled by moments, another method of controlling rotation is to control the moment arms.
(49) Another embodiment may create contact points with corresponding tibial articulation of the femoral articulating surfaces to vary from a plane perpendicular to the transverse axle hinge pin. Generally, the plane would extend through a medial/lateral and/or lateral/medial direction. As the knee moves through the range of motion of the knee, the corresponding insert articulating geometry remains parallel or varies from the same plane creating an axial rotation through whole, in part, and/or various ranges of the range of motion of the joint.
(50) In another embodiment, a concentric sagittal curvature of the medial or lateral femoral condyle's articular surface relative to the transverse hinge pin location and the opposite femoral condyle's articular surface may have eccentric curvature sagittally to the hinge pin location. This shifts the contact with the tibial articulation medial/lateral or lateral/medial at least in part through a range of motion. The tibial articulating surfaces correspond to femoral curvatures and induce axial rotation through whole, in part, and/or various ranges of the range of motion of the joint.
(51) Alternatively, a concentric sagittal curvature of the medial or lateral condyle's articular surface relative to the transverse hinge pin location and the opposite condyle's articular surface having eccentric curvature sagittally to the hinge pin location may create the motion. The tibial articulating surfaces corresponds to femoral curvatures where the corresponding eccentric medial or lateral compartment follows a predetermined path relative to multiple angles of flexion and its corresponding contact points movement. The radial translation of these contact points around the axial rotation around the tibial post/sleeve axis and the corresponding concentric medial or lateral

compartment follows a predetermined path relative to multiple angles of flexion and its corresponding contact point's movement around the axial rotation around the tibial post/sleeve axis. This induces an axial rotation through whole, in part, and/or various ranges of the range of motion of the joint.

(52) Another embodiment includes a femoral prosthesis with eccentric sagittal curvature for both of the medial and lateral articulating condylar portions of the femoral prosthesis relative to the transverse axle pin position. A tibial insert with the corresponding articulating geometry, either inclining and/or declining as the eccentric contact points of the femoral articulation translates, shift in a medial/lateral and/or lateral/medial direction to induce an axial rotation through whole, in part, and/or various ranges of the range of motion of the joint.

(53) In another embodiment, a concentric sagittal curvature of the medial or lateral condyle's articular surface relative to the transverse hinge pin location and the opposite condyle's articular surface having eccentric curvature sagittally to the hinge pin location. The tibial articulating surfaces correspond to femoral curvatures where the corresponding eccentric medial or lateral compartment follows a predetermined path relative to multiple angles of flexion and its corresponding contact points movement and the radial translation of these contact points around the axial rotation around the tibial post/sleeve axis. The corresponding concentric medial or lateral compartment follows a predetermined inclining and/or declining path relative to multiple angles of flexion and its corresponding contact points movement around the axial rotation around the tibial post/sleeve axis which induces an axial rotation through whole, in part, and/or various ranges of the range of motion of the joint.

(54) Alternatively, a femoral prosthesis with concentric sagittal curvature for both of the medial and lateral articulating condylar portions of the femoral prosthesis relative to the transverse pin position. A tibial insert with the corresponding articulating geometry, either inclining and/or declining, form an axial rotating path relative to the femoral articulating surfaces. Translational/rotational freedom allows the transverse pin to rotate and translate the femoral prosthesis.

(55) Turning now to FIGS. **24-41**, the FIGs. Show side views, isometric views, and top views of an embodiment of a hinged knee in different angles of flexion. FIGS. **24-26** are a side view, an isometric view, and a top view, respectively, of an embodiment of a hinged knee at extension. A femoral component **180** rotates about a pin **182** relative to a tibial component **184**. Contact areas **200** show the area in which a tibial insert **186** may contact the femoral component **180**. The contact areas **200** in FIGS. **24-41** show how the femoral component **180** rotates and translates along the tibial insert **186**.

(56) Turning now to FIGS. **27-29**, FIGS. **27-29** are a side view, an isometric view, and a top view, respectively, of the hinged knee of FIG. **27** at 20 degrees flexion. The femoral component **180** continues to rotate about the pin **182** relative to the tibial component **184**. The contact areas **200**, particularly the lateral contact area, have rolled back. The roll back of the lateral contact area corresponds to axial rotation of the femoral component **180** relative to the tibial component **184**.

(57) Turning now to FIGS. **30-32**, FIGS. **30-32** are a side view, an isometric view, and a top view, respectively, of the hinged knee of FIG. **27** at 40 degrees flexion. The femoral component **180** continues to rotate about the pin **182** relative to the tibial component **184**. The contact areas **200** have continued to roll back, and again the lateral contact area has translated farther posteriorly compared to the medial condyle. This corresponds to more axial rotation.

(58) Turning now to FIGS. **33-35**, FIGS. **33-35** are a side view, an isometric view, and a top view, respectively, of the hinged knee of FIG. **27** at 90 degrees flexion. The femoral component **180** continues to rotate about the pin **182** relative to the tibial component **184**. From 40 degrees to 90 degrees of flexion, the rotation and translation are minimized as the rotation continues through the concentric portion of the curvature.

(59) Turning now to FIGS. **36-38**, FIGS. **36-38** are a side view, an isometric view, and a top view,

respectively, of the hinged knee of FIG. **27** at 120 degrees flexion. The femoral component **180** continues to rotate about the pin **182** relative to the tibial component **184**. Similar to the flexion between 40 and 90 degrees, from 90 degrees to 120 degrees of flexion, the rotation and translation are minimized as the rotation continues through the concentric portion of the curvature.

(60) Turning now to FIGS. **39-41**, FIGS. **39-41** are a side view, an isometric view, and a top view, respectively, of the hinged knee of FIG. **27** at 150 degrees flexion. The femoral component **180** continues to rotate about the pin **182** relative to the tibial component **184**. As the flexion continues from 120 to 150 degrees, the contact areas **200** translate and have little axial rotation.

(61) Thus, as the knee flexes, the rotation allows for the patella to slide along the patellar groove without generating forces in the patella. Additionally, with movement approximating the natural movement, the hinged knee does not generate forces in the soft tissue. This may help preserve soft tissue that is initially damaged by surgery. Moreover, some soft tissue is removed during surgery, and thus the remaining soft tissue must work harder to complete tasks. Reducing the forces on soft tissue can reduce swelling, pain and additional stresses on the soft tissue after surgery.

(62) In view of the foregoing, it will be seen that the several advantages of the invention are achieved and attained.

(63) The embodiments were chosen and described in order to best explain the principles of the invention and its practical application to thereby enable others skilled in the art to best utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated.

(64) As various modifications could be made in the constructions and methods herein described and illustrated without departing from the scope of the invention, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative rather than limiting. Thus, the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims appended hereto and their equivalents.

Claims

1. A knee prosthesis comprising: a tibial component configured to attach to a patient's tibia, the tibial component including a bearing surface with a posterior portion, the posterior portion including medial and lateral posterior portions each having a contour that slopes medially in a posterior direction, the tibial component having a superior-inferior axis; and a femoral component configured to attach to a patient's femur, the femoral component being hingeably coupled to the tibial component so that the femoral component translates in an anterior/posterior (A/P) direction relative to the tibial component and axially rotates relative to the tibial component about the superior-inferior axis, the femoral component comprising: a medial condyle and a lateral condyle, wherein the medial condyle includes a concentric sagittal curvature surface, the lateral condyle including an eccentric sagittal curvature surface, and a center of rotation of the concentric sagittal curvature surface of the medial condyle is not aligned with the center of rotation of a portion of the eccentric sagittal curvature surface of the lateral condyle.
2. The knee prosthesis of claim 1, wherein the medial condyle and the bearing surface define a medial contact surface where the medial condyle contacts the bearing surface and the lateral condyle and the bearing surface define a lateral contact surface where the lateral condyle contacts the bearing surface; and wherein, in use, the lateral contact surface rolls back to a greater extent than the medial contact surface so that the lateral condyle translates to a greater extent posteriorly relative to the medial condyle.
3. The knee prosthesis of claim 1, further comprising an insert positioned between the tibial component and the femoral component, the insert including the bearing surface.
4. The knee prosthesis of claim 1, further comprising a pin, the femoral component rotates about

the pin relative to the tibial component.
5. The knee prosthesis of claim 4, wherein the pin is arranged and configured to axially rotate and axially translate in the A/P direction to enable rotation and translation of the femoral component relative to the tibial component.
6. The knee prosthesis of claim 4, wherein the femoral component includes a pin sleeve, the pin being positioned within the pin sleeve for coupling the pin sleeve to the medial and lateral condyles.
7. The knee prosthesis of claim 6 further comprising a post passing through a portion of the pin sleeve and into the tibial component.
8. The knee prosthesis of claim 7, wherein the pin sleeve includes an opening formed therein, the post passing through the opening for coupling the pin sleeve to the tibial component.
9. The knee prosthesis of claim 8, wherein the post extends from the tibial component.
10. The knee prosthesis of claim 8, wherein the post is asymmetrically positioned relative to the tibial component.
11. The knee prosthesis of claim 8, further comprising a post sleeve for coupling the post to the pin sleeve, the post sleeve being positioned between the post and the opening formed in the pin sleeve.
12. The knee prosthesis of claim 11, wherein the post sleeve is arranged and configured to rotate and translate relative to the post.
13. The knee prosthesis of claim 12, wherein the pin is arranged and configured to rotate and translate relative to the post and the post sleeve.
14. The knee prosthesis of claim 4, wherein the pin is positioned posteriorly relative to a center of the knee prosthesis.