A New Hinge Prosthesis Offers Ease of Use and the Ability to Retain the Revision Tibial Baseplate

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ABSTRACT

Total knee arthroplasty (TKA) is a widely practiced surgical procedure, with its efficacy underscored by the increasing number of patients benefiting from it. As primary TKAs rise, the orthopaedic community must prepare for a surge in complex primary and revision knee arthroplasties in the future. While most revisions use non-constrained or semi-constrained prostheses, certain scenarios require a fully constrained (hinge) prosthesis to address major ligamentous and/or bone loss. Over time, hinge designs have evolved, but outcomes with these designs have been mixed. To help address challenges seen with some earlier designs, a new modular revision solution has been designed for both primary and revision surgeries. This system has a new revision baseplate that has compatibilities with varying distal femoral components and introduces an enhanced hinge mechanism. This paper aims to explore the evolution of hinge designs, elaborate on the surgical workflows and intended compatibilities of this new revision hinge system in six different scenarios, and discuss its various potential advantages.

INTRODUCTION

Total knee arthroplasty (TKA) has been designated by the centers for Medicare and Medicaid as one of the most common surgical procedures.[1] The efficacy of TKA cannot be undervalued and due to its success, nearly a million patients are undergoing TKA annually, with most reporting excellent outcomes.[2,3] As the number of primary TKAs increases, orthopaedic surgeons should be prepared for a potential corresponding increase in complex revision knee arthroplasty procedures in the coming decades. With advancements, these procedures have become more adaptable, facilitating intraoperative adjustments and choices, including the option to shift to a hinge construct when deemed appropriate for complex primary or revision indications.

Most revisions can be performed with non-constrained or semi-constrained prostheses. However, in certain cases, such as major ligament insufficiency or bone loss, a fully constrained prosthesis (hinge) becomes essential. Historically, hinge designs have seen substantial evolution, with various arthroplasty systems offering a range of designs to cater to the diverse needs of patients. Currently available hinge systems include the Modular Rotating Hinge (MRH) (Stryker, Mahwah, New Jersey), NexGen Rotating Hinge Knee (RHK) (Zimmer Biomet, Warsaw, Indiana), Sivash-range of motion (S-ROM) (DePuy Synthes, Raynham, Massachusetts), and Legion HK Hinge Knee System (Smith & Nephew, Andover, Massachusetts).

Contemporary rotating-hinge TKA implants have shown variable survivorship,[4–7] underscoring the complexity of knee replacement surgeries and the importance of patient selection, implant choice, and ongoing research to help improve outcomes. The Modular Rotating Hinge Knee System, Triathlon Total Stabilized (TS) Knee System (Stryker, Mahwah, New Jersey), and Global Modular Replacement System (GMRS; Stryker, Mahwah, New Jersey), in particular, have demonstrated clinical success in numerous studies,[4,5,8–16] of which the MRH and TS were the predicate devices for the new system being presented in this paper.

Some current hinge systems present other potential limitations. Most are incompatible with total stabilized and segmental distal femoral reconstruction systems, necessitating the complete removal of all components during revision surgeries. Designed to address these existing challenges in knee surgery, a new modular revision system (Triathlon Hinge) is intended for primary and revision surgeries (Fig. 1a–e). The system encompasses a diverse array of components—including a new femoral component—and offers compatibility with existing fluted and cemented stems along with various augmentation choices. Importantly, the baseplate of this revision system is designed to be compatible with multiple distal femoral components presently available on the market (MRH, GMRS, TS). The hinge mechanism of this system is derived from the clinically-proven design of the MRH.[4,5,17,18] The Triathlon Hinge system offers three Tibial Bearing Component sizes with varying posterior offsets designed to enhance patellofemoral kinematics. Certain features of the femoral component, such as the patellofemoral articulation, anteriorly-shifted boss location, and range of size options, were based on the clinically-proven design of the Triathlon TS.[9–15] This paper aims to provide an overview of the evolution and outcomes of available hinge designs and describes the surgical workflows and intended compatibilities of the new Triathlon Hinge, part of the Triathlon Knee Revision System.

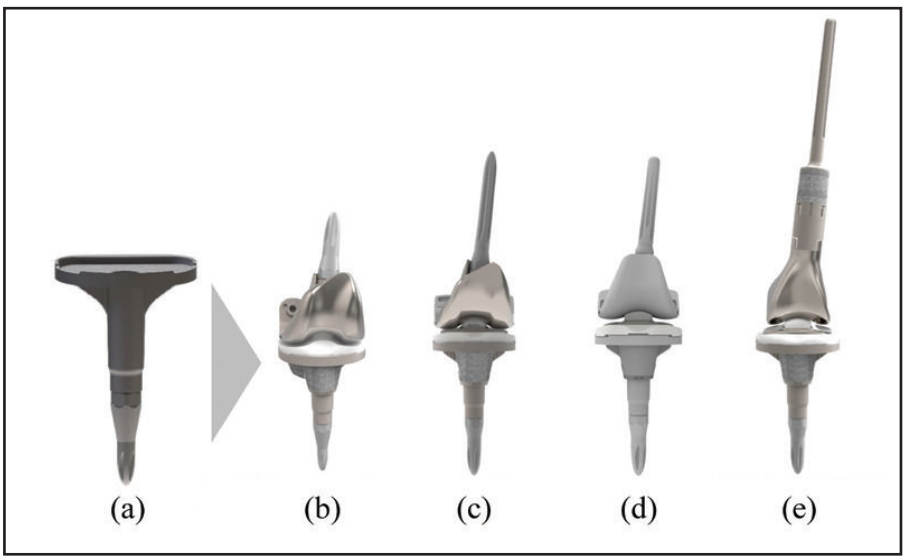

Figure 1. System compatibility. (a) Triathlon Revision Baseplate is compatible with (b) Triathlon Total Stabilized (TS) femoral component, (c) Triathlon Hinge Femoral Component, (d) Modular Rotating Hinge (MRH) knee femoral component, and (e) GMRS distal femoral component.

First-generation hinged designs

An early hinge design was the Walldius prosthesis (Walldius, Stockholm, Sweden).[19,20] This prosthesis was characterized by its fixed hinged design that replaced the joint surfaces of both the femur and the tibia. This hinged prosthesis was considered easy to implant, because it allowed for the removal of all ligaments and soft tissues, and it provided mechanical and structural stability.[21] This design was beneficial as it allowed the intramedullary stem to align with the artificial knee joint.[21] However, while this hinged TKA showed promising results during the 1950s and 1960s, it had some limitations.[19] The simple hinged design could not replicate the intricate movements of the natural knee joint since it only allowed simple flexion and extension.[22] Moreover, there was a high failure rate due to early loosening, which was attributed to overloading the prosthesis and transferring high stresses to the implant-cement bone interface.[22] Early outcomes were sub-optimal with a reported survivorship of 75 to 81%, an infection rate of 11%, and a failure rate of 20 to 25% at three years.[19] Subsequent early designs included the Guepar (Plerin, Bretagne, France), which had complication rates as high as 58% at three-year follow up.[23] Complications and failures of these first-generation designs led to the development of less constrained second-generation designs.

Second-generation hinged designs

In 1979, a major evolution in the design of the hinge system was introduced. This change incorporated a rotating hinge mechanism which aimed to better mimic the natural movement of the knee joint by allowing for both hinge-like motion and rotational movement.[24] The

rotating hinge became a distinguishing feature of the system, setting it apart from other hinge designs of the time and improving early survival and functional outcomes.[24–27]

The development of the rotating hinge and its improved risk profile allowed for indications for hinged TKA to be expanded to include patients who had large defects of bone or soft tissue, including severe imbalance or deficient medial and/or lateral collateral ligaments.[28] Also, patients who had large constitutional deformities >20 degrees and sizable flexion-extension mismatches could be addressed.[28] Furthermore, patients who had neurocognitive disorders (e.g., poliovirus, stroke), ankylosing arthritis, severe hyperlaxity, or malunions of the distal femur were also considered as candidates for a hinged TKA.[28] Despite clinical improvements in second generation over the first generation, these devices still witnessed some mid-term failure rates and complications, and the market now offers a third generation of implants.

Third-generation hinged designs

Third-generation designs, such as the MRH, NexGen Rotating Hinge Knee, S-ROM, and Legion HK, also use the rotating hinge concept. Recent designs have also focused on condylar loading, hinge design, modularity, and enhanced component fixation, which have further contributed to the improvement of patient outcomes following complex knee arthroplasty.[26,29,30]

Modularity has also been a key area of development, enabling surgeons to utilize the same surgical system for uncomplicated primary TKA and complex reconstructions. Surgeons can plan for an unconstrained prosthesis, and if the soft-tissue deficits are too large, they can modify their plans to a constrained or hinged prosthesis or a distal femoral replacement in cases with tumor resection or scenarios involving a distal femoral fracture. Third-generation hinge total knee systems have also incorporated a variety of proprietary augmentation options ranging from wedges, cones, sleeves, and stems designed to provide a stable foundation for reconstruction in the setting of large bone defects, while offering surgeons different options for fixation and allowing them to consider host bone stock and construct fixation goals.

Despite the strides made within the realm of hinged TKA, there are still some limitations. While hinged knees are typically associated with revision procedures, they can also address complex primary clinical situations. In primary TKA, when the outcome for osteoarthritis is considered, the Australian Orthopaedic Association National Joint Registry and UK National Joint Registry show that all aggregated hinged knee prostheses have higher rates of revision compared to all aggregated minimally stabilized prostheses.[31,32] For all aggregated hinged knee designs, following index surgery, infection is the most common reason for revision, followed by loosening and fracture.[31] A large multi-center study retrospectively reviewed the complications and failures of non-tumoral hinged total knee arthroplasty in primary, aseptic revision surgeries, and surgery following a recent fracture, and found in the primary TKA group, the main complication leading to reoperation was infection, while it was loosening for the revision TKA group and infection for the fracture TKA group.[33] Additionally, many of these patients have higher comorbidities, which is associated with added risks. It should also be appreciated that although many of these patients experience favorable outcomes, their revision rates are typically higher than patients who have non-hinged TKAs.[31]

Stryker revision continuum

Within the multitude of hinged TKA devices, the new Triathlon Hinge Knee Revision System (Stryker, Mahwah, New Jersey) is designed to enhance many of the clinically successful third-generation design features. This system offers surgeons the flexibility to transition between the Triathlon Total Stabilized System, Triathlon Hinge Femur, and Global Modular Replacement System, and it also has compatibility with the MRH femur. These systems allow orthopaedic surgeons to utilize constrained or hinged prostheses without the need to revise the Triathlon Revision Baseplate, as the Revision Baseplate is compatible with the aforementioned femoral components. Moreover, constructs can be enhanced with cone augments, which are designed for biological fixation and have previously demonstrated excellent survivorship following revision TKA.[34–36]

The hinged mechanism within the Triathlon Hinge Knee Revision (THK) System builds upon the MRH System's over 20 years of clinical success,[4,5,17,18] while also leveraging features of the clinically successful Triathlon TS design.[9–15] For example, the femoral design aligns with the articulation of the Triathlon TS femoral component and is intended to enhance patellar tracking, which aims to ease the extensor mechanism, facilitate deeper flexion, and help minimize contact stresses at the patello-femoral joint. The anteroposterior location of the hinge mechanism can differ between hinged knee designs, and the Triathlon Hinge Femoral Component has a posterior hinge mechanism. A posterior hinge mechanism is designed to increase the patellar tendon moment arm and reduce the quadriceps' force required for certain activities, which may benefit the patient.[37] The Triathlon Hinge Femoral Component also has an anterior boss location that has been designed to help enhance anterior-posterior fit. Compared to MRH, the system offers a broader range of size options, enabling the surgeon to choose the most suitable prosthesis size for the patient's anatomy.

Enhancements have been made to help streamline the revision TKA experience with multiple workflow pathways. For the Triathlon Hinge Knee Revision System, we will explore various configurations, including the 1) Primary Hinge, 2) Total Stabilized Femur and Revision Baseplate, 3) Conversion to Hinge with 3-in-1 (with Revision Baseplate), 4) Conversion to Hinge with Trial Cutting Guide (with Revision Baseplate), 5) Revision Baseplate and Modular Rotating Hinge Femur, and the 6) Revision Baseplate and GMRS distal femur, and highlight some potential advantages of each workflow.

SURGICAL TECHNIQUE

Primary hinge

Clinical context

In instances where the knee is set to receive a hinge on untouched bone, the objective is to address the complex distal femoral geometry. This includes addressing instances where there is destruction of the joint surfaces, with or without significant bone deformity, cruciate and/or collateral ligaments do not stabilize the knee joint, and ligaments are inadequate and/or the musculature is weak.

Tibial preparation (Fig. 2a–g)

The tibial preparation uses instrumentation and a workflow that is similar to the Triathlon TS System, which may help lower the learning curve for this workflow compared to MRH. Similar to TS, the tibial bone is reamed, resected, sized,

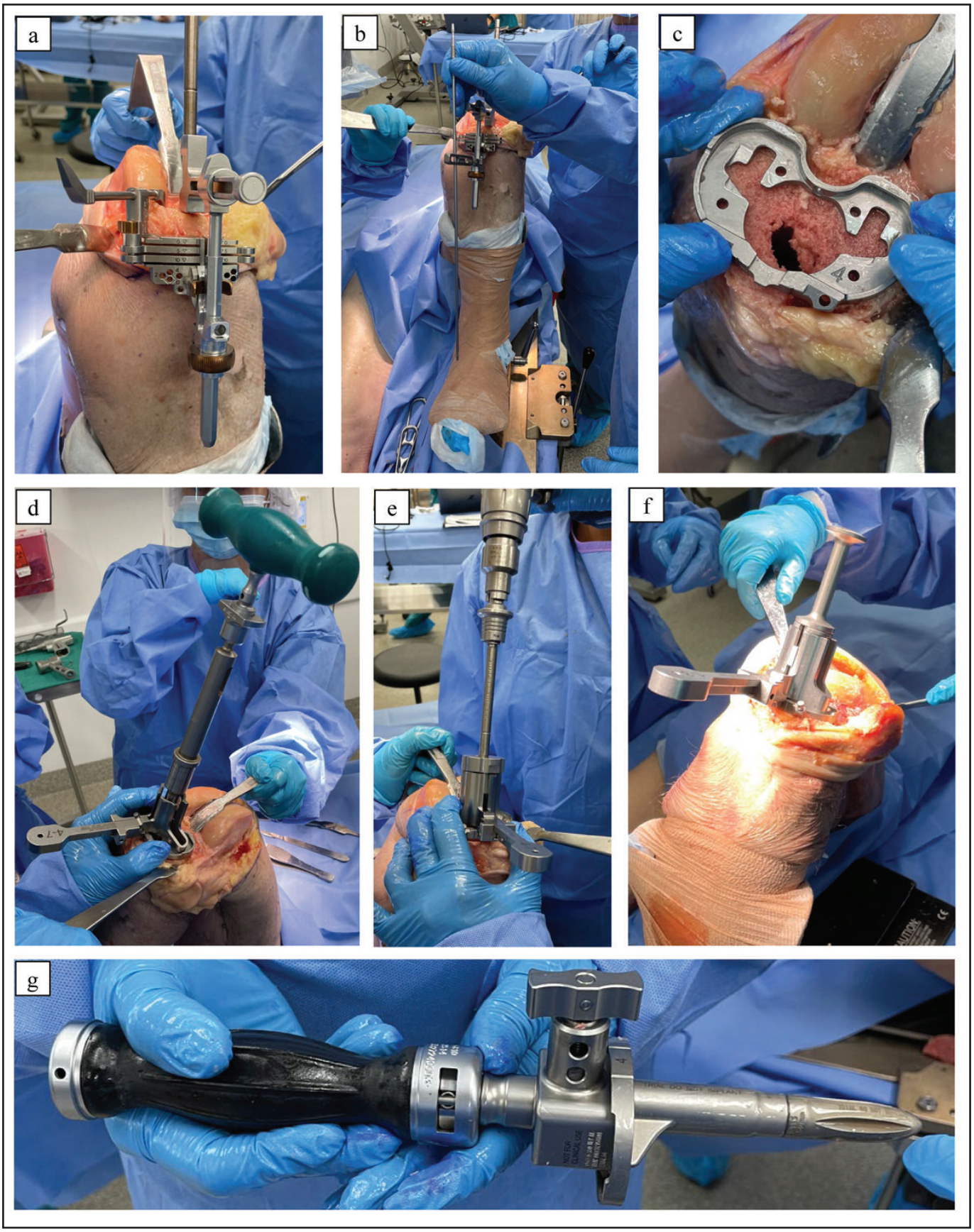

Figure 2. Steps of tibial preparation for the Revision Baseplate. (a) Intramedullary tibial alignment guide used for measured resection of the tibial shaft, (b) drop rod used to check alignment, (c) template used to check appropriate implant size for the tibia, (d, e, f) tibial implant preparations made with boss reaming the proximal tibia and preparing the canal for the stem and keel, and (g) final implant or trial implant installed on Revision Baseplate Impactor/Extractor for proper insertion.

boss reamed, and keel punched. In situations of bone loss, 5 and 10mm augments can be utilized to help enhance joint line height and the positioning of the prosthesis. The new baseplate is compatible with Triathlon Tibial Cones (symmetric and asymmetric, size B and up) (Fig. 3).

The cemented tibial workflow allows surgeons to place the baseplate independent of intramedullary (IM) canal to follow the trend of short, cemented stems and ensure the preparation for the construct is not driven by the tibial bow. An additional reaming step is required if preparing for a cemented tibial stem to ensure stem preparation is coaxial with the boss placement. The tibial template is aligned on the cut tibia, guiding the preparation for the boss, stem, and keel. By design, offsetting is not feasible with the Revision Baseplate, since offsetting on the distal end of the Revision Baseplate boss may make potential future revisions more difficult to revise and offsetting may not be feasible for more distal tibial resections. In certain tibiae, especially smaller ones, it is advisable to visually assess the anatomy before pinning the template. This is to determine if downsizing or repositioning the tibial template (e.g., placing it more anterior or posterior), or even downsizing the stem, might be necessary to prevent impingement in subsequent steps. In addition to the cemented stem workflow, the Triathlon Revision Baseplate and Hinge Knee surgical protocol offers a fluted stem preparation workflow. The fluted stem tibial workflow follows similar stem, boss, and keel preparation steps with all tibial preparation performed concentric to the IM canal.

Femoral preparation (Fig. 4a–i)

Similar to the tibial preparation, the femoral preparation also uses instrumentation and follows a workflow that closely resembles the Triathlon TS System. The femoral canal is IM and boss reamed (only if final reamer is <16mm), and then a distal resection is made. The Hinge Femur has built-in 5mm distal augments, when compared to the TS femoral component, and can be additionally used with 5 and 10mm augments. The new Distal Femoral Resection Guide accounts for the 5mm built-in augments, such that the 0mm cut slot, along with the 5 and 10mm slots, can be employed for 5, 10, and 15mm augment resections, respectively, when compared to TS. The Hinge Femur was intentionally designed without offsetting capabilities to simplify potential future revisions and accommodate more proximal femoral resections. The boss position on the Hinge Femur matches the boss position on the TS Femur, which by design reduces the need for additional offsets.[38]

A Spacer Block is used as a go or no-go gauge to ensure there is sufficient joint space to accommodate the hinge prosthesis in extension. A Hinge 3-in-1 Cutting Block is used to make anterior flange, anterior chamfer, and posterior chamfer resections. Sizing of the 3-in-1 Cutting Block should be considered based on the following expanded size compatibilities:

- Size 1 Revision Baseplate: Compatible with sizes 1 and 2 femoral components.
- Sizes 2 and 3 Revision Baseplates: Compatible with sizes 1 to 4 femoral components.
- Sizes 4 to 7 Revision Baseplates: Compatible with all sizes of femoral components (1 to 6).

The system is designed to be compatible with central femoral cones (Fig. 5).

Trialing and final implant placement

The surgeon is now ready to trial the femoral and baseplate trial components. The Hinge Tibial Bearing Post Trial and Trial Bearing Plate are used to determine the desired Hinge insert thickness (11, 13, 16, 19, and 22mm) without having to disassemble the full construct, which reduces the number of steps required during trialing compared to MRH (Fig. 6a–e). In addition, a new instrument, the Alignment Guide, helps the surgeon assemble the Hinge Trial Axle into the Hinge Femoral Trial, by aligning the Femoral Trial and Tibial Bearing Post Trial axle holes in flexion. This instrument can also be used during implant assembly. A trial reduction is performed, and joint stability is assessed. Adjustments to the insert thickness are made as required in flexion.

Once the surgeon has completed the adjustments and is satisfied with the stability and range of motion of the knee, the final implants are assembled using the trial implants as a template, as illustrated in Figure 7a–k. Following assembly, the final implants are positioned within the knee utilizing the standard cementation or press-fit technique. The final knee range of motion (ROM) is assessed prior to the closure of the knee arthrotomy.

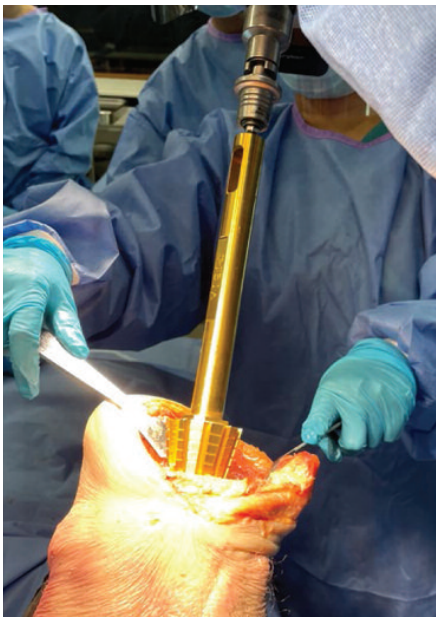

Figure 3. Optional Tibial Cone step. Tibial cone reamer goes over the intramedullary reamer left in the tibia to help center the cone reamer ream down to the appropriate letter (size: B, C, D, and E).

Total Stabilized Femur and Revision Baseplate

Clinical context

In standard Total Stabilized (TS) cases, surgeons can now choose the Revision Baseplate over the Universal Baseplate. The Revision Baseplate allows for the potential to convert to a Hinge or GMRS distal femur in future scenarios.

Tibial preparation

The tibial preparation remains consistent with previously mentioned techniques. The surgeon can consider tibial resection depths and implications on joint line for future conversions. Surgeons have the option to use augments, stem extenders, and cones during this phase of the procedure.

TS femoral preparation

The existing surgical technique for Triathlon TS femoral preparation is utilized, and it includes options for offsets, cones, augments, and stem extenders.

Trialing and final implant placement

During this stage, the assembly of the femoral and baseplate trial components is undertaken. A trial reduction is performed to ensure the correct fit and alignment. The new Triathlon TS Tibial Insert Trials assemble to Revision Baseplate and are designed to maintain compatibility with the Universal Baseplate as well. The final implant placement consists of the

Revision Baseplate, Revision Insert X3 with Filler Bushing, and Stabilizer Pin. The Filler Bushing is carefully placed into the bearing post hole to capture the Stabilizer Pin in the Revision Baseplate, similar to how the Stabilizer Pin is captured in the Universal Baseplate. The Revision Insert X3, which has an identical articular surface and post geometry as the legacy TS component, is assembled into the Revision Baseplate. Subsequently, the Stabilizer Pin is inserted into the Revision Insert X3 post with the "barbed" end facing upward. This is then seated using the Stabilizer Post Impactor. Assembly of

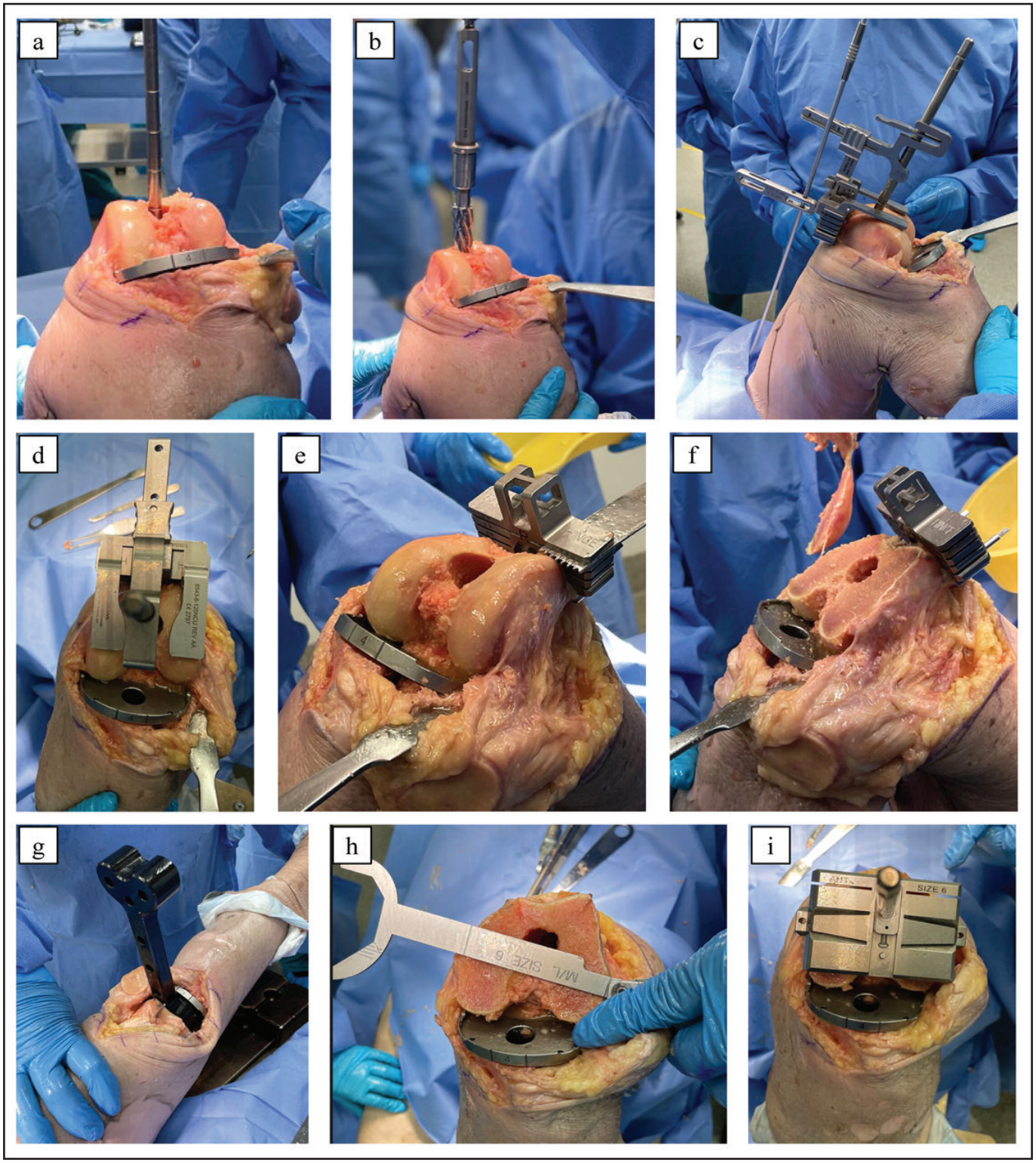

Figure 4. Femoral preparation Hinge Femur steps. (a) Intramedullary reaming and (b) boss reaming of the femur performed, (c, d) Hinge Distal Femoral Resection Guide with Hinge Distal Resection Plate used to cut standard depth or to cut for different augment thicknesses, either medial and/or lateral, (e, f) distal femoral resection made for the Hinge Femur, (g) Spacer Block used to help ensure the minimum construct fits, (h) Femoral Sizers used to help decide on size of femoral cutting block, and (i) Hinge 3-in-1 Cutting Block pinned to bone to make femoral cuts.

the Revision Insert X3 construct is shown in Figure 8a and b.

Final ROM assessment

A final range of motion assessment is conducted to ensure desired joint movement post implantation.

Femoral conversion: TS Femur to Hinge Femur, using 3-in-1

Clinical context

In certain clinical scenarios, the need arises to convert a TS femoral component to a Hinge Femoral Component. This decision to convert may occur intraoperatively or as a revision of previously implanted components. These situations may emerge due to challenges, such as an unmanageable flexion gap or collateral ligament damage, and may not require revision of a well-fixed Revision Baseplate. The workflow described below addresses a conversion of previously implanted components via revision surgery.

Instrumentation requirements

For the conversion, surgeons would require three additional trays: Hinge Femoral Trials Tray (either left or right), Hinge Insert Trials Tray, and the Hinge Femoral Prep Tray.

Component removal and femoral preparation

The initial step involves the removal of the TS femoral implant, revision insert X3, Stabilizer Pin, and Filler Bushing. There is a dedicated Filler Bushing Removal Tool to remove the Filler Bushing. A visual representation of this procedure can be referenced in Figure 9a and b. The Hinge Femoral Preparation is then performed, which begins with an extension gap assessment using the Spacer Block (on the 26mm side due to the pre-existing baseplate), intended to ensure there is sufficient joint space to accommodate the prosthesis. This is followed by the distal femoral and augment resections, after which a Spacer Block extension gap assessment is repeated. A 3-in-1 resection block is then used, as described above, to make the anterior flange, anterior chamfer, and posterior chamfer resections. This is followed by final trialing and implant placement, as described in the above sections.

Postoperative assessment

The procedure culminates with a final ROM assessment, ensuring that the joint achieves desired movement post implantation.

TS Femur to Hinge Femur, using the Hinge Trial Cutting Guide

Clinical context

The optional Hinge Trial Cutting Guide (TCG) is specifically designed to help streamline the femoral bone preparation during the conversion from a TS to a Triathlon Hinge. This tool not only helps simplify the procedure, but it also facilitates assessments of the joint line, rotation, and patella location.

Instrumentation requirements

The conversion process mandates the use of four additional trays: Hinge Femoral Trials Tray (either left or right), Hinge Insert Trials Tray, Hinge Femoral Prep Tray, and the Hinge TCG Tray.

Component removal

With the Revision Baseplate left intact, the procedure commences by removing the TS Femoral Implant, Revision Insert X3, Stabilizer Pin, and Filler Bushing. If there is not a Revision Baseplate in place, convert to Revision Baseplate, using the steps described above.

Femoral preparation

The initial step in preparation is the extension gap assessment, focusing on the Spacer Block's 26mm side due to the pre-existing baseplate to assess if there is space for the Hinge minimum construct thickness. This is followed by the distal femoral and augment resection, after which the Spacer Block extension gap assessment is reiterated for precision. Subsequent steps include IM reaming, boss reaming, femoral size selection, and Hinge TCG assembly. During the Hinge TCG assembly,

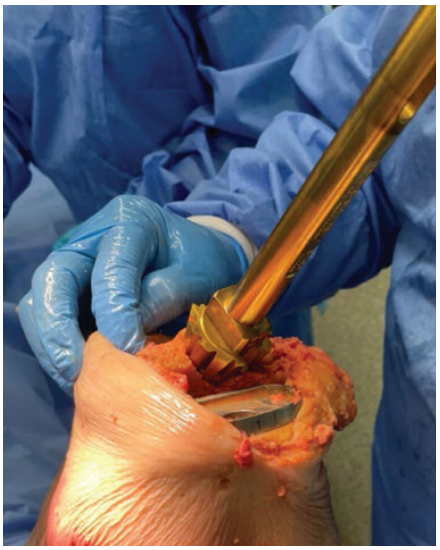

Figure 5. Optional Femoral Cones step. Femoral cone reamer used over intramedullary reamers left in femur to help center and ream down to the appropriate size (1-2, 3-4, 5, 6, and 7-8).

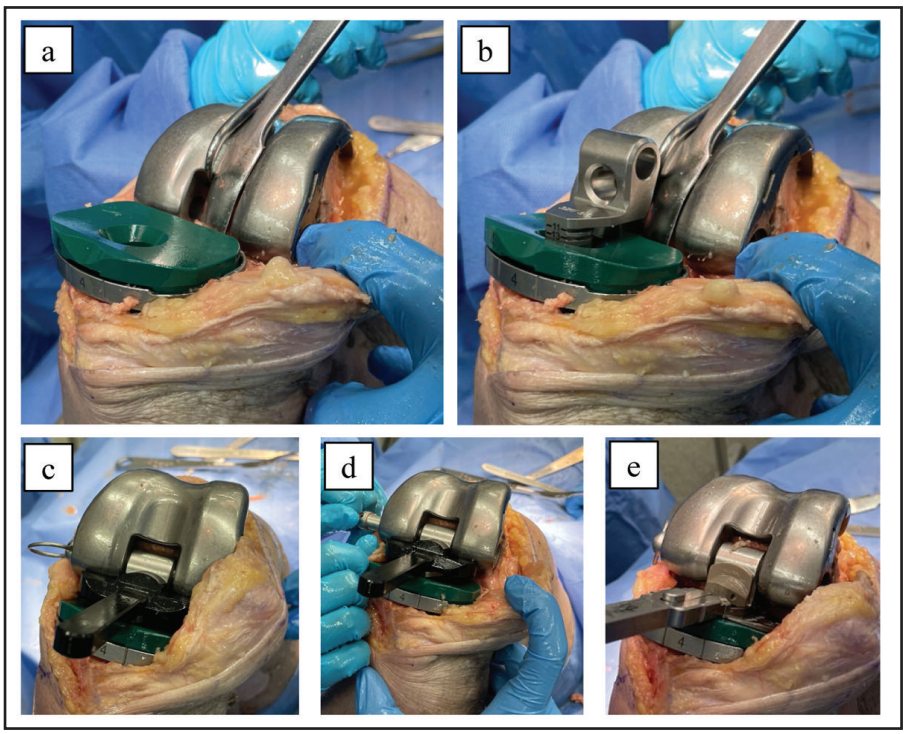

Figure 6. Hinge Femoral and Revision Baseplate Trial assembly steps. (a) Hinge Femoral Trial and Hinge Insert Trial placed on the new Revision Baseplate Trial, (b) Tibial Bearing Post Trial placed in the Revision Baseplate Trial, (c, d) Femoral Trial rests on the Alignment Guide, which is inserted into the Tibial Bearing Post Trial to assist with Trial Axle insertion, and (e) Insertion/Removal Handle used to insert Trial Bearing Plate into Tibial Bearing Post Trial to assess the proper insert thicknesses needed.

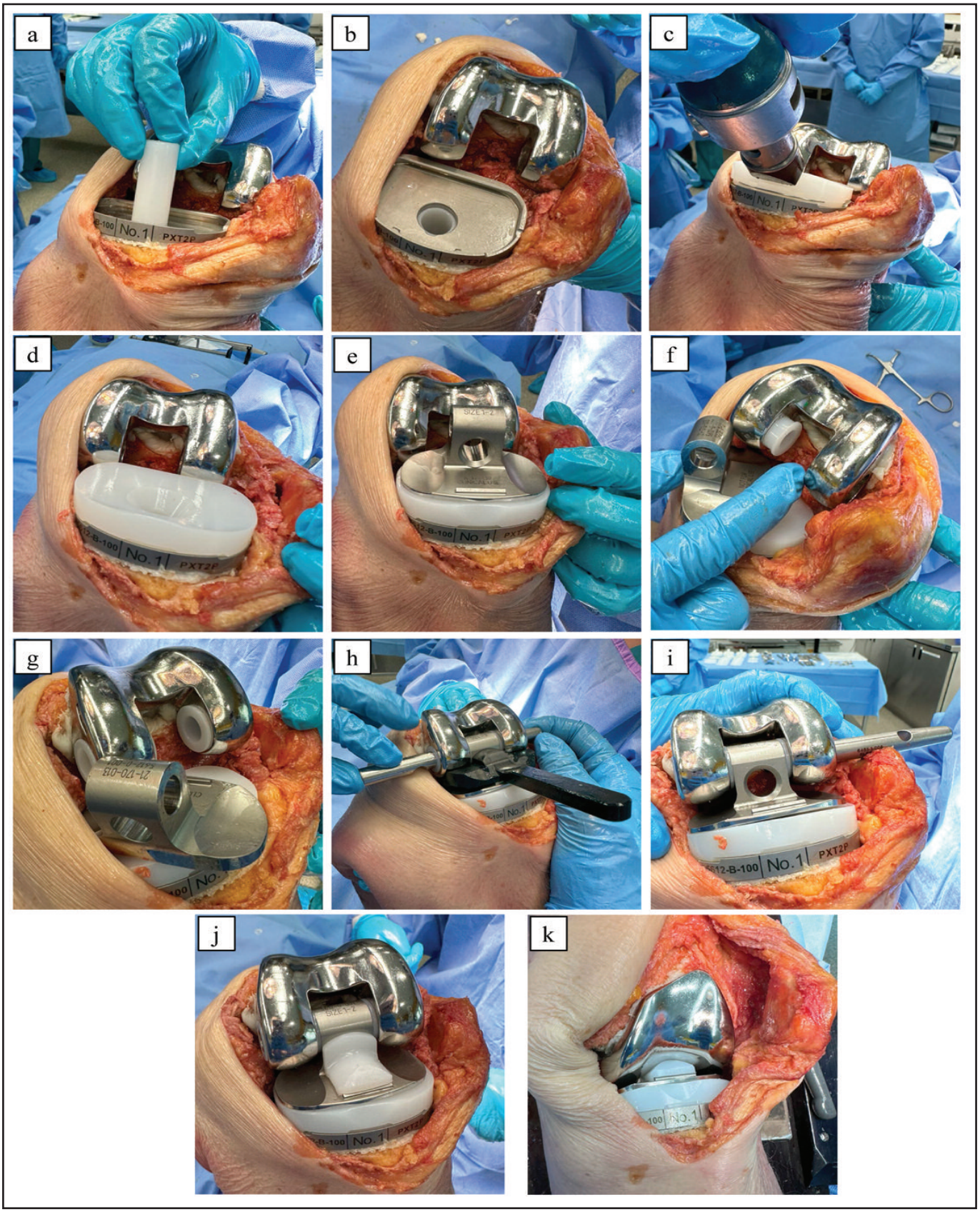

Figure 7. Implantation steps. (a) Tibial Sleeve implant inserted into the Revision Baseplate, (b) alternate view confirming sleeve is seated in the Revision Baseplate, (c) Hinge Insert impacted into the Revision Baseplate, (d) alternate view of the Hinge Insert seated in Revision Baseplate, (e) Hinge Bearing Component placed in Revision Baseplate with it sitting on top of the Hinge Insert, (f, g) Femoral Bushings placed in inner medial and lateral holes of Hinge Femur, (h) Alignment Guide used to help align the Hinge Femur with the Hinge Bearing Component and insert the Hinge Axle, (i) Hinge Axle inserted into the Hinge Femur and Hinge Bearing Component, (j) Hinge Bumper placed into the Hinge Bearing Component to hold the Hinge Axle in place (there are two Hinge Bumper options, Neutral and 3 degrees), and (k) final range of motion assessed.

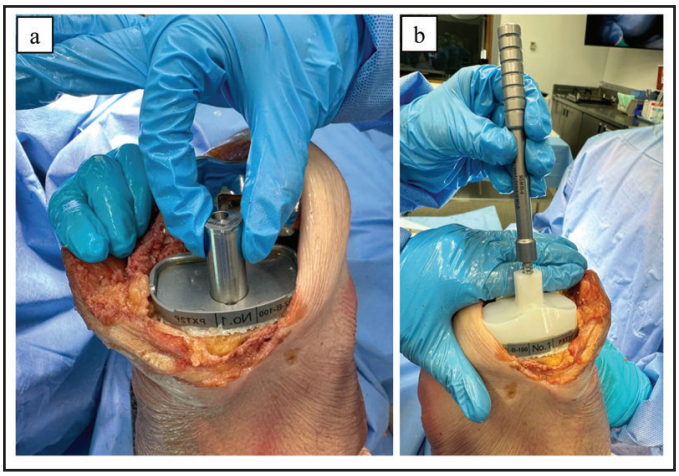

Figure 8. Filler Bushing and Stabilizer Pin used with Revision Baseplate for TS Femur. (a) Revision Baseplate with Filler Bushing inserted, and (b) Stabilizer Pin inserted into Revision Insert.

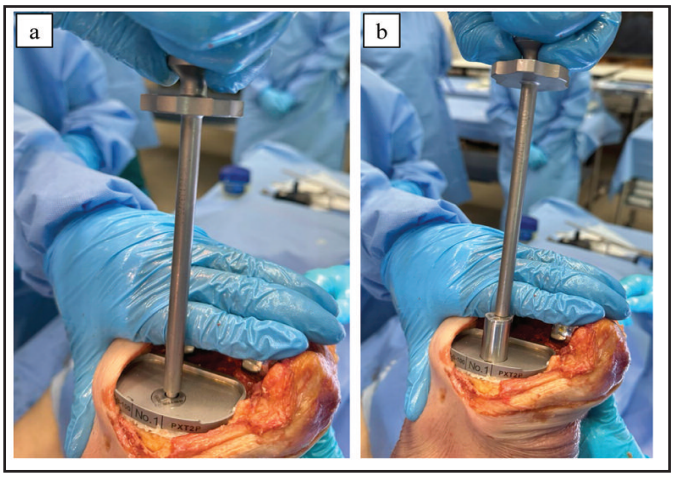

Figure 9. Removal of Filler Bushing for TS Femur to Hinge Femur conversion. (a) Filler Bushing Removal Tool engaged with thread of Filler Bushing and (b) Filler Bushing extracted.

both the Hinge TCG Valgus Adaptor and stem trial are assembled to the Hinge TCG. The Hinge TCG assembly is inserted into the femoral canal, aligning it to the ME scribe line reference mark with the medial epicondyle. If the ME line on the Hinge TCG is located distally to the anatomic ME, additional distal resection might be necessary. The distal/proximal location is then set. This is followed by an internal-external (I/E) rotation assessment, construct length assessment via assembly to the Revision Baseplate using the TCG Tibial Bearing Post Trial and Trial Bearing Plate, bone cuts (Fig. 10a-c), and, if required, an optional femoral cone preparation.

In summary, while the Hinge TCG is not a trial component, it allows the user to determine I/E rotation, evaluate joint line, and simulate fit and feel of the implant in flexion and extension before making any cuts. Additionally, the guide enables the surgeon to make any augment cuts as well as anterior and posterior chamfer cuts. Final trialing and implant placement is then performed as described in the above sections. The product may not be available in all markets because product availability is subject to the regulatory and/or medical practices in individual markets.

Postoperative assessment

The surgical process concludes with a final ROM assessment to ascertain desired joint movement post implantation.

Tibial conversion: Modular Rotating Hinge Femur stays, revision of MRH Baseplate to Triathlon Revision Baseplate

Clinical context

In specific clinical situations, there exists a well-fixed MRH femur, but there is often a need to revise the MRH Baseplate. This necessitates a careful approach to ensure the integrity of the MRH Femur while successfully revising the baseplate.

Baseplate removal

The procedure commences with the removal of the MRH Baseplate.

Tibial preparation for Revision Baseplate

The tibial preparation for the Revision Baseplate mirrors previously established techniques.

Trialing and implant placement

The process initiates with the tibial trial assembly to ascertain the components' fit. Following this, a trial reduction is conducted to ensure proper alignment and fit using the Hinge trialing mechanism (e.g., the Tibial Bearing Post Trial and Trial Bearing Plate). The tibial implant assembly is then prepared and implanted, and a final implant trialing assessment is carried out. The assembly of the remaining implants is subsequently completed.

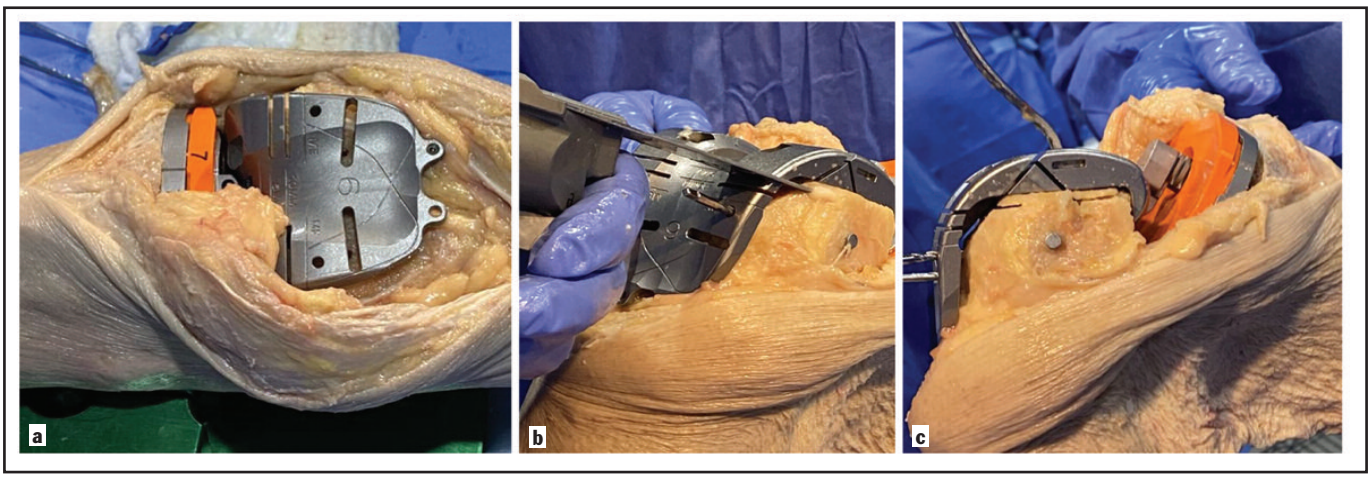

Figure 10. Hinge Trial Cutting Guide (TCG). (a, b) Hinge TCG placed and pinned in femur, and femoral chamfer cuts are made. (c) Distal augment cuts may be made through TCG, and trial for femur and tibia may be built.

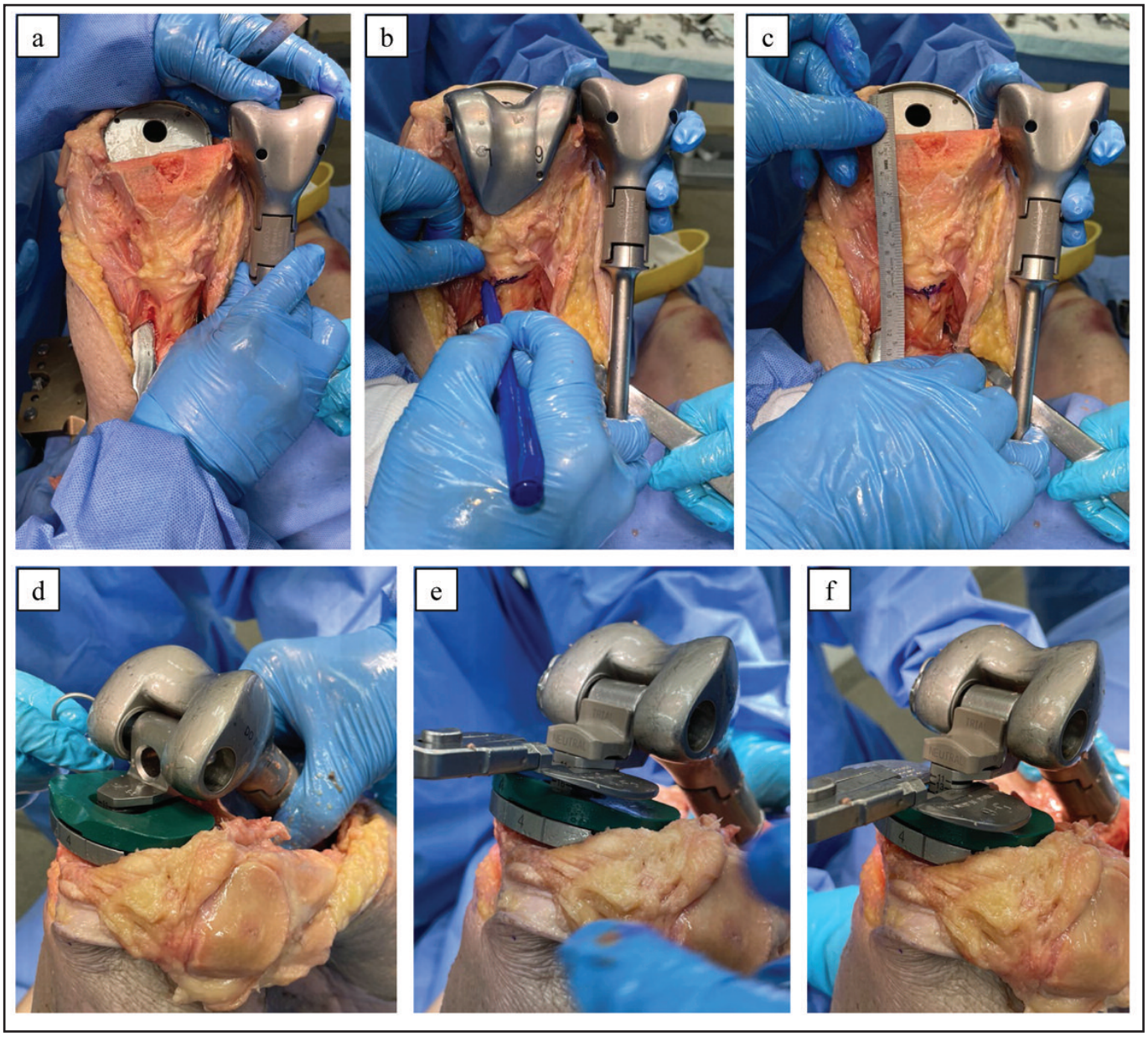

Figure 11. Conversion to GMRS femur. (a, b) Resection level of distal femur marked to incorporate a GMRS for fracture or for tumor, (c) ruler used to measure resection (femoral component is 65mm in length and stem is an additional 11mm, with minimal resection totaling 76mm), (d) GMRS trial distal femoral component trialed with Revision Baseplate and Hinge Insert Trial, (e) Tibial Bearing Post Trial inserted in Revision Baseplate Trial and connected to the GMRS Trial Distal Femoral Component, and (f) Insertion/Removal Handle and Trial Bearing Plate used to determine insert thickness.

Postoperative assessment

The surgical procedure culminates with a final ROM assessment, ensuring that the joint achieves desired movement post implantation.

Femoral conversion: Revision Baseplate stays, revision of femur to GMRS femur

Clinical context

In cases with tumor resection or scenarios involving a distal femoral fracture, there might be a need to retain the Revision Baseplate while revising to a GMRS femur. Additionally, there could be a primary indication where a GMRS femur would be prepared with a Triathlon Revision Baseplate.

Hinge Femur removal

The procedure begins with the removal of the femoral component, if applicable.

Femoral preparation for GMRS

The femoral preparation for GMRS in this scenario involves a femoral osteotomy at a minimum 76mm distance from the original joint line (to account for the distal femoral component length [65mm] and the stem addition [11mm]).

Trialing and implant placement

The trialing process starts with the GMRS trial distal femoral component assembly to ensure the components fit as intended. A trial reduction is then performed to confirm alignment and fit using the Hinge trialing mechanism (e.g., the Tibial Bearing Post Trial and Trial Bearing Plate). Subsequently, the femoral implant assembly is prepared and implanted, followed by a final implant trialing assessment. The assembly of the remaining implants is then finalized (Fig. 11a–f).

Postoperative assessment

The surgical process concludes with a final ROM assessment to ascertain desired joint movement post implantation.

DISCUSSION

The Triathlon Hinge Knee System is designed to add versatility to the Triathlon Knee Revision System. This system is designed to help streamline the surgical process. One notable feature is the ability to potentially leave the Revision Baseplate in place during a revision of the femoral component from a Triathlon TS to Triathlon Hinge, while only requiring three or four (if using TCG) additional trays. Additionally, the Revision Baseplate can potentially be retained while revising the femoral component to a GMRS distal femur. In this type of scenario, the avoidance of having to revise the baseplate may lead to potential reductions in resource utilization and procedural time.

CONCLUSION

The integrated approach is intended to equip orthopaedic surgeons with a comprehensive toolkit, capable of managing standard to complex TKA scenarios under one system. Such efficiencies may benefit not just the patient and surgeon, but the broader healthcare organization as well. STI

AUTHORS' DISCLOSURES

Dr. Hampp, Ms. Donde, Ms. Hatcher, Ms. Coulon, Ms. Mastrandrea, Ms. Weinberg, and Mr. LoPiccolo are employees of Stryker.

Dr. Mont is a board or committee member for the American Association of Hip and Knee Surgeons, Hip Society, and Knee Society. He holds stock in CERAS Health, MirrorAR, and PeerWell. Dr. Mont receives research support from CyMedica Orthopedics and the National Institutes of Health (NIAMS & NICHD), and he is on the editorial board for Surgical Technology International, the Journal of Arthroplasty, the Journal of Knee Surgery, and Orthopedics. He is a paid consultant for Kolon TissueGene, Pacira, Smith & Nephew, and Stryker. Dr. Mont receives royalties and research support from Stryker, UpToDate, and Wolters Kluwer Health - Lippincott Williams & Wilkins.

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