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The Modern Universal Total Knee Arthroplasty: Maximized Value, Streamlined Efficiency

Bryant Bonner, Jesua I. Law, Erin Hofmann and Eric Dacus

Abstract

A universal total knee arthroplasty system able to accurately resurface either left or right knees of all shapes and sizes is compelling as there is an increased need for improved efficiency and value. With a modern universal total knee system, a single instrument tray can be utilized for more than 90% of cases and doesn't require any specific customization or disposable instruments. This streamlined workflow is accomplished with unique instrumentation that features a symmetrical femoral and tibial implant for all patients. Symmetrical tibial implants have been shown to have equivalent outcomes and low complications compared to asymmetric tibial trays. The universal symmetrical femoral implant, with its deepened trochlear groove, allows for optimal patellar tracking and recent studies have demonstrated this symmetrical femoral implant to have comparable femoral rollback and axial rotation to native knees. This efficient instrumentation reduces overall inventory, decreases turnover times, and exposes fewer instruments that may otherwise be susceptible to contamination. All without detriment to the patient outcome or surgeon workflow. Studies have shown clinical scores of the modern universal total knee arthroplasty system are a great value not only to the surgeon but also to the healthcare system as a whole—a necessity in modern healthcare.

Keywords: total knee arthroplasty, universal total knee, symmetrical component, efficient design, economics

1. Introduction

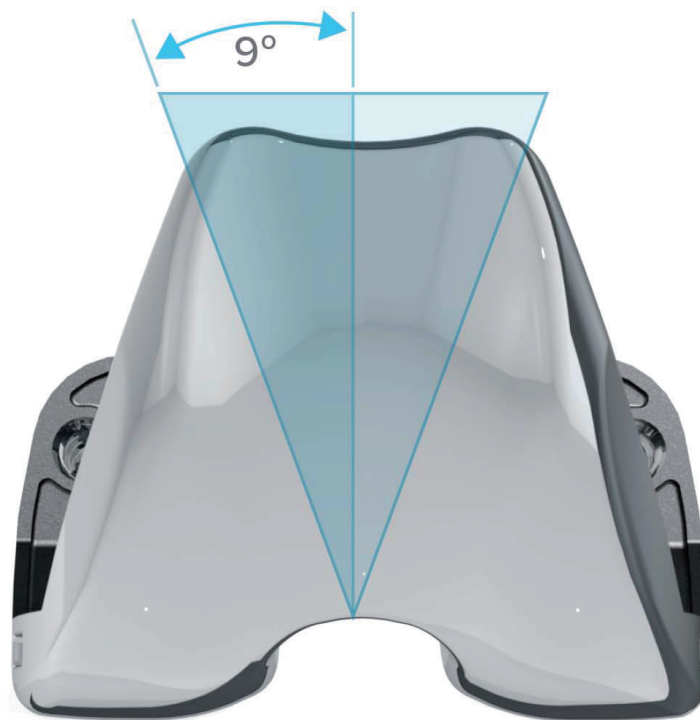
Total knee arthroplasty (TKA) is one of the most successful elective surgical procedures available [1], allowing for the treatment of end-stage osteoarthritis and functional limitation to restore patient mobility and functional activity. Recent reports project that elective joint replacement surgery will be the most common surgical procedure over the next 10 years [2, 3], and the number of TKAs performed in the United States (US) is estimated to increase exponentially—approximately 401% by 2040 compared to the 2014 US National Implant Services (NIS) database [4]. Meanwhile, according to the Centers for Medicare and Medicaid, healthcare expenditures are projected to grow at a rate of 5.8% per year [5] with a significant number of hospital costs being derived from operating room expenses [6]. Consequently, there is a push to maximize efficiency, including streamlining operating room flow (set up, surgical time, turnaround time) while reducing cost and risks of infection. This improved efficiency must come without sacrificing patient outcomes in an effort to rein in ballooning healthcare

costs. In this chapter, we will highlight the significance of a modern universal total knee arthroplasty system in helping to simplify the OR and save on healthcare expenditures.

2. Design history

Total knee arthroplasty has evolved significantly since its first inception in the late 19th and 20th centuries; implant designs have improved and advances in surgical tools have born less invasive techniques. Originally, the first arthroplasty was conceived as a simple resection arthroplasty in the 1860s. Excess bone was removed to improve motion, but this was limited by the recurrence of bone formation, at times, knee fusion and this arthroplasty often lead to instability if too much bone was removed [7]. This technique evolved to interposition arthroplasty, by which the insertion of soft tissue was used to reconstruct the joint surface and help prevent bone formation; this method was abandoned due to continued pain and failure of the interposition [8]. The hinged prosthesis of the 1950s was the first to replace the femoral and tibial surfaces, and patients experienced significant pain relief. Unfortunately, these linked prostheses were unable to replace complex knee kinematics and had high failure rates due to early loosening from stress shielding [9]. The 1970s saw the evolution of the condylar TKA prosthesis from Ranawat, Coventry, and Townley, which set the foundation of the less constrained and more anatomic modern implants of today [10–12].

Initially designed with a symmetrical femoral component, these condylar implant systems offered pain relief but featured a shallow, straight trochlear groove, and struggled to replicate natural patellar tracking. The 1980s brought a shift to an asymmetric, side-specific design [13] to better match the normal bony anatomy



Patented Double Q-Angle

Figure 1. Total Joint Orthopedics, Inc.'s (TJO) Klassic® Femur featuring a 9° double Q-angle to optimize patellofemoral tracking for both left and right-sided anatomy.

of the distal femur of a patient and thus improve knee kinematics [13]. Multiple studies have failed to show any significant difference in knee clinical or functional scores in patients with a modern universal femoral component when compared to those with asymmetrical femoral design [14–17].

While the symmetrical femoral component fell out of favor due to patello-femoral complications that were encountered during the design evolution, such as poor tracking and dislocation, these issues have since been corrected with modern universal designs [13]. For example, one implant company, Total Joint Orthopedics, Inc.'s (TJO) patented Klassic Femur has a unique deepened anatomical trochlear groove, allowing for optimal patellar tracking along a 9° double Q-angle for both left and right-sided knees while still retaining a neutral outside profile of the anterior flange and restoring native kinematics (**Figure 1**) [18, 19].

3. Design and rationale

There are a number of ways surgeons can address surgical techniques to help improve efficiency, including, but not limited to, patient-specific instrumentation, navigation assistance, and type of implant. A universal knee system is one way to help improve efficiency and reduce operating room costs. This system optimizes efficiency in a number of ways, one of which involves the implant design itself, which allows the surgeon to utilize the same system for the majority of primary TKA, but also allows the flexibility to progress from a cruciate-retaining primary TKA to a maximally stabilized revision TKA with the same family of instrumentation.

The femur is designed with a specific trochlear groove to accommodate patellar tracking for both left and right knee anatomy. This trochlear groove design is based on the quadriceps, or Q-angle, which describes the vector of the pull of the quadriceps on the patella and is fashioned so that its angle allows for optimal tracking for both left and right knees. Moreover, the universal knee system femur is designed to be compatible with a variety of polyethylene inserts, such as cruciate-retaining (CR); posterior cruciate ligament (PCL) sacrificing (PS) in both a posted posterior-stabilized, or ultra-congruent (UC), with a raised anterior lip for cruciate stabilization; and a varus/valgus constrained; polyethylene inserts, offering a full evolution of stability with one implant and instrumentation system. This alone significantly reduces the number of instruments and implants that must be shipped, sterilized, and stored at the hospital or surgical center. Because the system was designed holistically, cuts, peg locations, and trialing are standardized throughout the workflow, eliminating time-consuming steps when alternative sizing or additional stability is required. For example, a more constrained femoral trial can be utilized before making any further cuts to assess the need for a more constrained polyethylene insert.

The symmetrical tibial baseplate is optimized to fit both right and left proximal tibias using a potbellied design. Throughout development, design surgeons traced native tibial resections during routine TKA, and this gradual anterior bump optimizes fit in most patient anatomy. A plethora of studies have examined the universal tibial design, which suggests there is improved tibial coverage, improved external rotation, and decreased risk for overstuffing components [20, 21]. Additionally, consistent polyethylene thickness to the peripheral edges and matching conforming geometry of the baseplate and polyethylene insert optimize congruency, offering exceptional mid-flexion stability [19]. All baseplates, whether cemented or cementless, offer modularity so that they can accommodate a stem extension in either a primary or revision setting. Studies have shown that stemmed tibial components offer enhanced fixation and additional stability, and improve outcomes in heavier patients [22, 23].

In addition to the components, the instruments and number of trays utilized during the case can also significantly affect efficiency and cost. A majority of the instruments in the tray have multiple functions and are utilized at different times throughout the case. This universal knee system design allows up to 90% of cases, regardless of a workflow (e.g., gap balancing or measured resection technique), to be completed with a single tray of instruments; revision cases require one or two additional trays depending on the level of stability needed (**Figure 2**).

This significant optimization in the number of required instrumentation results in a reduced amount of inventory needed for a TKA which can help improve surgeon and hospital efficiency as well as reduce costs. A recent Harvard Business School study demonstrated that hospitals often underestimate the costs of idle space and equipment resulting in errors in utilization [24].

By reducing the number of trays, studies have also demonstrated that surgeons are able to reduce OR time and sterilization costs, the incidence of infection as well as optimize efficiency and ergonomics [25, 26]. Fewer instrument trays require less time to set up and break down and need less space and time to sterilize. Moreover, with respect to cleaning and sterilization, fewer instruments mean that there is less total exposed instrumentation surface area that is susceptible to contamination. Additional studies have also confirmed that the decreased inventory and instrumentation do not adversely affect patient outcomes but may actually improve them [26].

Studies in Europe have analyzed the cost of sterilizing and packaging reusable instruments somewhere between \$0.59 and \$11.52 (USD) per surgical instrument [27–29]. If a surgeon is able to reduce the number of instrument trays the savings could be huge, with one study looking at a reduction from 7.5 trays in a TKA to three trays. This reduction led to an estimated annual savings of \$159,600 in sterilization costs and \$99,000 in improved turnover times [30]. Each tray costs between \$60 and \$150 dollars to sterilize, and each tray averages 2 minutes to open onto the



Figure 2.

With a modern universal total knee system, a single standard instrument tray may be used for up to 90% of primary total knee arthroplasty while following AORN guidelines to weigh less than 25 lbs. A second tray is offered for micro/macro trials, allowing a primary TKA to be performed with two trays or fewer 10% of the time. TJO's Klassic ONE® Knee System single instrumentation tray is featured as an example here.

sterile field; some systems have estimated a cost savings of up to \$1350 per case compared to a typical eight tray implant system [1, 25, 26, 31, 32]. As a result, there is a significant opportunity to improve value through reducing and making hospital inventory more efficient.

4. Conclusion

Total knee arthroplasty remains one of the most successful elective operations and the number of cases is only expected to increase in the years ahead. Originally conceived as simple resection arthroplasty, total knee arthroplasty has seen many iterations through failures and redesigns to reach the condylar implant designs of today, however, the field remains hungry for further innovation in order to meet the anticipated demand of the future. One such method to maximize efficiency and reduce costs, while maintaining or improving patient outcomes, is the use of a modern universal total knee arthroplasty system.

Universal symmetrical tibial baseplates are already commonplace in many modern implant systems, with recent studies demonstrating the decreased inventory and instrumentation does not adversely affect patient outcomes, but it is the modern design of the universal femoral component that is especially intriguing. While there have been concerns in the past with patellofemoral tracking issues, the modern designs, such as those from Total Joint Orthopedics, Inc. (TJO), feature a patented trochlear groove allowing for optimal patellar tracking along a 9° double Q-angle for both left and right anatomy [18]. Furthermore, a modern universal total knee system features a reduced total number of instruments needed as the system is holistically designed using standardized connections and multi-use instruments. These innovations require less instrumentation for each TKA without sacrificing crucial steps or surgeon workflow, which provides significant cost savings, improvement in operating room efficiency, and a decreased infection risk. Fewer instrumentation trays require less inventory space, allow for faster sterilization, the decreased time needed for setup and breakdown, and less exposed instrumentation surface area that is susceptible to contamination. With these factors combined, some studies estimate a potential cost savings of around \$250,000 annually, and some system manufacturers estimate potential savings of \$1350 per TKA case. While some may see this as a relic of the past, the updated modern design of the components and revamped instrumentation of these systems provide cost savings and efficiency that is a premium in healthcare today. A modern universal total knee arthroplasty system is a crucial asset in any surgical setting, like hospitals and ambulatory surgery centers alike seek to reduce costs as healthcare expenditures balloon and sterile processing and storage space become more limited.

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