Significant advancements in implant materials and surgical technique, combined with increasing lifespans and activity levels among the population, have contributed to the growing prevalence of Total Hip Arthroplasty (THA) in the USA. In 2011, over 300,000 patients in the USA were treated with a primary THA, and in 2017 it is believed that nearly 400,000 patients will undergo a total hip arthroplasty procedure. Equally impressive is the overall prevalence of THA across the US population: it was estimated in 2010 that 3.25% of the US population had a total hip replacement by age 70, and these figures are expected to grow substantially in coming years.

Both economically and societally, THA represents one of the most advantageous and successful elective surgical interventions as measured by dollars and quality adjusted life years (QALY). Multiple clinical studies have demonstrated exceptional success rates for THA, and one landmark study from 2002 found that even at 25 years post-THA, over 77% of patients retained their artificial hip and had not undergone any further hip surgery.

Patients’ willingness to consider and undergo a THA procedure is likely influenced by high clinical success rates, excellent patient-reported satisfaction scores, and a generally low incidence of major complications even when THA is performed as an outpatient procedure.

However, despite the aggregate success of THA and expectation of increasing volumes of patients and procedures, expected to double from current levels in just a few years, surgeons and hospitals alike are almost universally plagued by intractable difficulties that inhibit optimal surgical outcomes, specifically regarding preventable complications which could be addressed with more robust pre-operative planning, software-enhanced intraoperative feedback, and confirmatory implant positioning data prior to the patient’s wound closure.
Imprecise Paper-based Preoperative Case Planning Tools

Transparent plastic film overlays for THA are time-consuming, subject to wide margins of error, and cannot be adjusted to account for X-ray magnification. Missing or lost overlays, exacerbated by multiple participating implant vendors and a lack of vendor engagement, can contribute to crowded ORs and unnecessary ingress and egress from active operating rooms. Moreover, a poorly planned THA procedure can bring unwelcome surprises to the physician that require corrections extending operative time, requiring more anesthesia, and potentially adversely affecting the outcome.

Inadequate Intraoperative Information, Visualization, and Guidance

Surgeons and staff frequently post a single printed X-ray on a lightbox in the operating room for intraoperative landmarking and visualization during THA. Often, because this is insufficient, surgeons supplement this by ordering mobile fluoroscopy to capture real-time imagery. However, X-ray methods alone still require the physician to rely solely on “eyeballing” the location of implants relative to bony anatomy, and the impracticalities associated with printing and measuring mobile X-ray geometries means that the surgeon has no choice but to operate only by look and feel.

Risks and Costs Associated With Complications, Readmissions, and Reoperation

Many complications such as leg length discrepancies, insufficient offset, overstuffed hips, excessive cup abduction, impingement due to cup retroversion, and early subsidence unrelated to trauma are preventable. However, surgeons lack real-time intraoperative feedback and guidance tools to indicate when any of these conditions may be present, and as a result, thousands of patients each year face the prospect of suboptimal outcomes.

Complications arising from THA requires hospitals to invest significant resources and personnel at an extraordinary expense. One easily measured complication of THA is dislocation, which has generally been reported at a rate of between 2% and 5%.17,18 One article published in the prestigious Journal of Bone & Joint Surgery reported a 2.4% incidence of dislocation, which increased the hospital’s cost by 19% for those patients managed without additional surgery, and 148% for those who required reoperation. Based on a weighted average, this hospital doubled their expense for each THA patient presenting with a dislocation.19

Readmission following THA is often related to complications of the hip surgery, and a recent analysis of 9,441 patients revealed a readmission rate for any reason of 3.65% within the first 30 days.20 Many readmissions attributable to cardiac events or diabetes cannot be prevented with better surgical technique, but the risk of hip dislocations, undiagnosed fractures at the time of surgery, implant subsidence, instability, audible clicking, impingement pain, and other hip-related issues may be reduced if effective tools are utilized PRE-OPERATIVELY, INTRA-OPERATIVELY, and AT FINAL IMPLANTATION. One fascinating study recently published in Clinical Orthopedics & Related Research showed that unplanned hospital readmission following total hip arthroplasty affects nearly 5% of patients within 90 days of surgery.20 Furthermore, of the reported surgical complications requiring readmission from this study of 989 primary hip arthroplasty patients, nearly 75% are attributable to hip dislocation.20

JointPoint represents the industry’s finest and most technologically advanced THA surgical assistive system to deliver critical information pre-operatively, intra-operatively, and at final implantation. Developed by engineers working in conjunction with highly experienced orthopedic physicians, the JointPoint System represents a revolutionary advance in automating procedural planning, implant assembly and fitting calculations, and final implant component verification. JointPoint is one of the only surgical assist platforms that has been cleared by the Food & Drug Administration and is also considered a non-invasive navigation system.

- Designed to preserve speed & efficiency in the OR
- Developed to be cost-effective, with no expensive disposables or instrumentation sterilization
- Engineered to embed seamlessly into surgeons’ existing workflow
PRE-OPERATIVE

From the moment a physician reads a patient’s hip x-ray and determines the need for a THA, preoperative planning commences. For years, surgeons have been forced to rely on x-ray printouts and transparent overlays from implant vendors in order to build a very rudimentary, paper-based surgical plan that is often inaccurate and therefore only marginally effective. Further compounding the manual procedures and time-consuming telephone calls and messages to vendor representatives is the requirement to maintain large totes of various implant inventory of many sizes and configurations, so that the physician can properly execute the THA surgery despite having incomplete and highly imprecise preoperative planning data.

The JointPoint System changes this paradigm completely by automating the flow of information in a HIPAA-compliant digital application between the physician, hospital, and vendor representative. All planned procedures can be uploaded, stored, and referenced on an iPad®, computer, or touchscreen device in order to minimize equipment in and around the operating room, ensure case coverage by the vendor, and quickly and easily confirm the availability of implant components previously planned through JointPoint’s automated templating system.

INTRA-OPERATIVE

The benefits of JointPoint becomes immediately apparent at the beginning of the total hip arthroplasty procedure, when the X-ray technician positions the C-Arm and the initial pelvic landmarking image is captured and transmitted automatically to the JointPoint system for analysis via its proprietary Overlay and OneTrial™ methods. This fast and simple process, which is already within the established workflow for many physicians performing THA, establishes a geometric baseline that does not require any pins, arrays, disposables, or other outdated artifacts of navigation systems commonly found many years ago. With the pelvic anatomy properly landmarked, the physician can perform the standard anterior approach procedure to open the wound, resect the femoral head, and prepare the femur with sequential broaching.
Next, the physician takes a second low-dose cup check X-ray to confirm the acetabular position and also capture additional data for relative positioning next to the acetabular anatomy to help establish offset and leg length calculations, all delivered virtually autonomously by the JointPoint System.

An often-cited study by Beamer, et al, showed that the use of fluoroscopy enabled a nearly 50% improvement in placing acetabular implant components into the safe zone. Another study in the *Journal of Arthroplasty* demonstrated significantly more safe zone placements of acetabular cups through the use of navigation aids. It is this combination of fluoroscopy and JointPoint's proprietary software navigation package which delivers a unique, high-value solution unavailable through any other vendor.

**FINAL IMPLANTATION**

It is during the critical phase of placing final implants that the hallmarks of clinical success are established to include good fit with the bone, optimized lateral offset, and equality of leg lengths.

With the acetabular cup implant positioned and seated, and the femoral broach in place with its associated trial neck and head, the physician then brings the C-arm back into the surgical field and captures an AP hip image that sets into motion a complex algorithm that features edge-detection and positional attributes to assist the physician in real-time with the final implant combination. This OneTrial technology displays a series of digital indicators and measures on the included monitor, enabling the physician to make rapid and precise decisions about component position, neck angle, lateralization, and leg length; and, all parameters are calculated in real-time on the basis of each patient's unique intraoperative anatomic features and needs. The surgeon references the OneTrial technology for an automatically-generated offset and leg length analysis indicating a potential combination of acetabular liner, femoral head, and femoral stem geometries and associated components. Compared to the conventional technique of eyeballing and relying on the feel and behavior of the joint after it has been reduced through the “guess-and-test” method, the JointPoint system represents an extraordinary advancement that is the unrivaled leader in total hip replacement technology.
A 62 year old male patient of average build and activity level recently presented to the orthopedic clinic with advanced osteoarthritis of the right hip, as demonstrated by physical examination and an x-ray study. The patient was counseled as to the potential benefits of a total hip arthroplasty (THA) for pain relief and functional recovery, and the patient was subsequently scheduled for a THA procedure to be performed via the anterior approach surgical technique.

Immediately prior to surgery, the patient reported no illness and a preoperative workup was negative for infection and no remarkable cardiac myopathies were observed. Using standard preparatory procedures which included standard general anesthesia and surgical draping protocols, a mobile fluoroscopy unit (C-Arm) was positioned into the operative field in order to capture a single anterior/posterior (AP) preoperative image that was immediately transmitted via direct upload to a JointPoint™ Software System (Belleair Bluffs, FL). The JointPoint software, utilizing a proprietary suite of edge-detection, relational geometry, and mathematical modeling algorithms, created a “virtual mapping” registration output in order to deliver a baseline patient map intended for use throughout the remainder of the surgical procedure (Image 1).

Image 1: Pre-Operative Virtual Mapping Baseline Data

Referencing the initial pre-operative x-ray output from the JointPoint system, which was captured using a recommended protocol intended to measure true offset and mitigate the distorting effects of anteversion and rotation, it was quickly determined that the patient’s anatomic features and hip disease closely matched the original preoperative plan developed by the JointPoint software, and no further imaging was necessary.

The surgery was immediately commenced and the hip was dissected and the capsule was exposed, minimally resected, and then the femoral head was exposed. The femoral head was resected using a sagittal saw and was removed using a corkscrew t-handle in order to minimally traumatize the wound or surrounding tissues. Using a battery-powered reamer driver and reamers from the Pinnacle® Performance Cup System (DePuy Orthopaedics, Warsaw, IN), the patient’s acetabulum was then progressively reamed in a manner consistent with the surgical technique. The acetabular rim contained typical cartilaginous structures and labral tissue on the periphery, and these were removed using a scalpel and rongeur prior to final reaming. Once reaching a final reamed size of 56mm, a Pinnacle Cup implant with Porocoat porous coating was introduced into the acetabulum using an insertion handle designed for use with the anterior approach surgical technique. Using a series of moderate mallet blows performed in a customary fashion, the acetabular implant was impacted into place until it exhibited satisfactory seating. The C-arm technician was then requested to capture a single AP Pelvis x-ray for the purpose of marking the acetabular geometries (Image 2). Immediately, the C-arm was then re-centered over the acetabular component for an AP Hip x-ray, and the JointPoint software package provided critical positional feedback regarding the abduction and anteversion situation that confirmed proper placement (Image 3).

With the acetabular component satisfactorily fixated and positioned in the acetabulum, the procedural focus then shifted back to the femoral anatomy. Using a femoral stem and associated instruments from the Corail® Stem System (DePuy Orthopaedics, Warsaw, IN), the femur was progressively broached until fit was determined to be stable axially and rotationally with a size 13 broach, which was consistent with JointPoint’s pre-operative indication that the Corail size 13 was likely to be an appropriate size. The final broach size of 13 was reconfirmed and remained incarcerated in the femur, at which point a trial neck component was affixed and a trial femoral head component was assembled in-situ, consistent with JointPoint’s automated preoperative plan.

This is a critical decision-making phase of the THA procedure, as failure to plan and execute an implant combination with proper cup position, lateral offset, and leg length equivalence can lead to serious complications,
unremarkable and wound closure was performed using standard procedures. A single post-operative x-ray was captured in the recovery room that further confirmed the intraoperative data.

**DISCUSSION & CONCLUSION**

Traditionally, surgeons have relied on the “guess-and-test” method when performing total hip arthroplasty with respect to component selection, position, and achievement of optimal offset and leg length. This unassisted method necessarily requires numerous fluoroscopic studies, multiple rounds of implant trialing, and additional exposure to x-rays and anesthesia time. Achieving ideal positioning relies more fully on surgeon experience and judgement, while robots and traditional surgical navigation are generally unwieldy, excessively time-consuming, expensive, and may also require the purchase of “disposables” for each procedure.

JointPoint enables the physician to import preoperative patient information to automatically predict implant combinations, and then with a single low-dose AP x-ray obtains positioning reference and confirmatory anatomic information. With only 3 subsequent fluoroscopic images, the entire procedure can be completed in a manner that is commonly reported as time neutral or time saving while data provided can lead to considerable increases in confidence and potentially improvements in surgical outcomes--particularly those related to common, expensive, and intractable complications such as leg length discrepancy, unusual hip joint laxity, and dislocation.

In conclusion, the JointPoint System provides critical intraoperative mapping and positioning information in a non-invasive fashion with an easy to use interface. The system is part of the natural THA workflow and, importantly, is unique in its ability to deliver value without costly disposables or the need for expensive CAT scans or MRI studies. Finally, the commonly reported time saving aspect of this system makes it highly attractive to high-volume orthopedic surgeons, as well as those surgeons desiring to achieve the best possible outcomes for their patients.
REFERENCES


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