

Editorial

"In My Experience...From the Shadow of Giants, My Journey Through the World of Knee Arthroplasty"

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Keywords: Knee, Arthroplasty, replacement, mentors

<https://doi.org/10.60118/001c.133787>

Journal of Orthopaedic Experience & Innovation

Vol. 6, Issue 1, 2025

The author reviews his forty-year experience with knee arthroplasty.

I am sitting here today reflecting on my journey through orthopedic surgery. It is amazing how almost 40 years have gone by since I completed my residency and what I have seen, and what I have experienced. When I first started my orthopedic residency, I never thought I was going to become a knee surgeon and really focus on total knee arthroplasty. My original intention was to become a spine surgeon. It is surprising how things changed during those early years. During my orthopedic residency at Lenox Hill Hospital in New York, I was fortunate enough to meet Dr. Norman Scott, who introduced me to Dr. John Insall, one of the early pioneers and designers of knee arthroplasty. Once I met John Insall, I knew spine surgery was out, and knees were in. So, following my orthopedic residency in 1987, I accepted the Knee Fellowship at The Hospital for Special Surgery with Dr. Insall. This was when I realized I was stepping into the shadow of a giant in the field of knee surgery. He had such an impact in total knee design with the evolution of the total condylar knee to the posterior stabilized knee implant. His impact on knee arthroplasty, extended beyond design and into instrumentation, surgical technique, research and academics. With an inquisitive mind, he was always reaching out to his colleagues around the world for their thoughts and insights. Standing beside him in my early years, I realized that he surrounded himself with other giants in the field, such as Chit Ranawat, Dick Scott, Tom Thornhill, and Ken Krackow, to name a few. In the early shadows, I would listen to conversations with Al Bernstein and Peter Walker, influential engineers who were making great strides in total knee arthroplasty design. This was my early beginnings to my career.

Over the years, almost as an apprentice to John Insall, I watched and became involved in the evolution of total knee design. Early on, the move was from monolithic components to modular ones with more sizes to better address the variation in patients' anatomy. The goal was to provide an inventory of sizes that would negate compromise and provide a better outcome. It was also during this time in the late 1980's and early 1990's that there was a big debate on whether to retain the posterior cruciate ligament (PCL). John, as we all know, was on the side of PCL substitution, while others like Dick Scott retained the PCL. I remember the banter back and forth on the podium, but as a disciple of John Insall, I continue to be proponent of PCL substitution with the posterior stabilized knee implant. Through the Insall legacy of total knee design, I became involved in the high flexion knee and the gender solution. This was a transformative time as attention was given to not only more shapes and sizes, but the social and cultural needs of patients undergoing total knee arthroplasty. Realizing the morphologic difference in the male and female anatomy, implants were introduced that addressed the differences in the aspect ratio, with narrower femoral components for the female patients, while maintaining the same antero-posterior dimension. This is now carried over to contemporary designs that afford more choices with less surgical compromises. It is amazing that since the introduction of total knee arthroplasty with only 3 or 4 sizes, we now have a vast inventory of anatomically shaped implants that better match individual patient anatomy. With the increased inventory of sizes, the whole concept of anterior referencing and posterior referencing has changed. The cruciate retain-

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ing surgeons tend to anterior references since they want to have a very predictable anterior femoral resection, a variable posterior resection to help improve flexion. Posterior stabilized surgeons want to have very predictable resection of the posterior condyles to maintain flexion stability, because, once you release the PCL, the flexion space opens a few millimeters. Now, with more shapes and sizes with 2 mm increments, surgeons can anatomically reference, with both predictable anterior and posterior resection. This allows a better match the anatomy of the femur, maintaining the posterior condylar offset and avoid femoral notching.

Beyond the introduction of more shapes and sizes, I witnessed a transformation in the bearing surfaces. As mentioned earlier the original debate was to either retain or substitute the PCL. This was almost a religious experience with staunch proponents on both sides. The intent was to design a knee that closely replicated the normal knee kinematics. In my mind the posterior stabilized knee design always had more reproducible knee kinematics, and to this day is my implant of choice. But, over the last few decades, these implants were not the only options. We saw the introduction of mobile bearing designs, which have become less popular and more recently the medial pivot, medial congruent and ultracongruent designs that are more guided motion knees. It appears that these implants are becoming more popular as surgeon are trying to restore normal knee motion with a more natural feel. My issue is that all knee designs are not the same, and surgeons should choose an implant that provides them with the best results for their patients. It is truly about the reproducibility of the results, which I believe is influenced both by the implant design and surgical technique.

While there have been numerous changes in implant designs to better fit the anatomy and provide more normal kinematics, there has been changes in the material properties of the tibial polyethylene from conventional to highly cross-linked polyethylene. While there are proprietary differences in the preparation and anti-oxidative additives, the impact on the market has been significant since we are not seeing the level of polyethylene wear and osteolysis that was prevalent in the 1990's. Beyond the improvements in the tibial polyethylene, there has recently been a shift towards cementless fixation. Like the evolution away from cemented total hip arthroplasty decades ago, there is move towards cementless fixation in total knee arthroplasty. The ability to add porous materials that are osteo-productive and osteo-inductive to the back surface of the tibial and femoral components has provided the ability to achieve immediate and ultimately long-term fixation. Maybe Leo Whiteside was right years ago and we were slow to follow his lead. While there is an increasing trend towards cementless total knee arthroplasty, cement still appears to be the gold standard and most popular mode of fixation, but I believe this may change,

In recent years, there has been a challenge to the philosophy of restoring the mechanical alignment of the knee during total knee arthroplasty. I have always said that every knee has its own identity, both with its bone anatomy and soft tissue stability. There is agreement that there is great

variability between patients' anatomy, which may impact the surgical technique. Since the introduction of the concept of mechanical alignment, I have seen a proliferation of numerous alternative alignment techniques in total knee arthroplasty. In search of improved patient satisfaction, advocates of personalized alignments have reported either improved or comparable outcomes to mechanical alignment, but the true effectiveness of has yet to be established in long term studies. Currently, we are hearing from advocates of kinematic alignment, restricted kinematic alignment, inverse kinematic alignment, functional alignment and personalized alignment, each with their own recommendations for bone resection and joint line obliquity. These surgeons are prioritizing bone resection over soft tissue balance. While these alternative alignments may work for some cases, they may not work for all cases, especially extreme deformity such as a valgus knee, and tend to be impacted by retention of the posterior cruciate ligament. It is also apparent that there are no clear guide rails. It tends to be a bit of a word salad and until we have specific guidelines for special implant designs, as a surgeon who prefers a posterior stabilized knee implant, I will continue to strive to restore the mechanical alignment. I am sure that we will continue to hear more about alternative alignments in the years to come, especially with the rise in robotic surgery.

The introduction of technology into the operating room has revolutionized total knee arthroplasty. When I first started doing surgery in the late 1980's there was very limited instrumentation with limited implant choice. Surgeons were artisans, crafting the knee with rudimentary instruments to get the implant to fit with appropriate motion and stability. Then came intramedullary and extramedullary instruments from Harold Dunn and Kim Bertin, as well as David Hungerford and Kenneth Krackow. The impact was immediate, as surgeons had a more predictable technique to more precisely prepare the femur and tibia with less compromise and greater reproducibility. These instruments were the foundation of modern total knee arthroplasty for years. With the introduction of minimally invasive surgery, these instruments were made smaller to fit within the limited surgical field. Realizing the difficulty with working within a smaller operative field and looking for reproducible accuracy, came the introduction of computer navigation. This led to a focus on preoperative planning and a more personalized approach to surgery. I have watch technology morph from the large computer navigation systems to handheld navigation, to robotic surgery that continues to be increasing in popularity. It is my opinion that robotic surgery is what is also driving the concept of alternative alignments since surgeons can adjust the bone resection by millimeters in their attempts to balance the knee. Robotic surgery is an attempt to quantify the qualitative feel of artisan surgeons with reproducible results. Newer innovative technology is on our close horizon. Augmented reality appears to be the next step, with the ability to both visually and virtually visualize the knee, set your operative plan and execute the procedure with a compact intelligent guidance system. Ultimately this will all be tied to artificial intelligence, which will interpret all the acquired informa-

tion from the preoperative examination and imaging, apply it to the specific characteristics of the knee and recommend a surgical approach that will be executed by the surgeon with a paired guidance system. Until that day, surgeons should learn and evaluate all the new technology but continue to understand the art of manual conventional total knee arthroplasty. They should be artisans who understand the basic principle of total knee arthroplasty but are able to interpret and apply the new technology for better patient outcomes.

While there have been revolutionary changes in total knee design and surgical technique, there has also been a dramatic change in the clinical pathway. When I did my fellowship with John Insall, postoperatively we would immobilize the knee a bulky Robert Jones dressing while the patient stayed in the hospital for two weeks. But look where we are today. We are now performing total knee arthroplasty as an outpatient in ambulatory surgery centers or a hospital-based outpatient department. With the introduction of the enhanced recovery program, patient optimization, improved pain management, and pre-operative education, we can get patients up immediately after surgery and send them home the same day. However, what is important is to pick the right patient for outpatient surgery and it is important that patients are risk stratified, and modifiable risk factors are addressed. There will always be some patients that are still going to need inpatient care. As we move towards a value-based care model in total joint arthroplasty based upon the quality of care and outcomes,

patient optimization and the clinical pathway will be more critical.

Four decades is a long time and it feels like I have experienced the industrial revolution of total knee arthroplasty. From the original total condylar knee implanted with no instruments to the high performing high flexion implants with robotic surgery. We have gone from the Ford Model T to the Ferrari Scuderia in 40 years. Having experienced this journey with my mentors, innovative giants, has made me realize that our goals have not changed. We are striving to provide the best outcomes for our patients, who are now younger, more active and more demanding. Whether their expectations are realistic or unrealistic, we still must understand their goals and align them with our ability to provide them with the best outcome possible. There has been a great deal of change in implant designs with more shapes and sizes, improved materials, changes in fixation, surgical technique and rapid recovery programs, all driven by the same goal of improving patient satisfaction with a normal feeling knee. It may be search for the holy grail, but as I continue my journey out of the shadow of giants, I hope my fellows will be my legacy. I hope they will continue to reflect on history, have inquisitive minds, compassion for their patients and continue to improve innovations in total knee arthroplasty. The journey is not yet over.

Submitted: March 30, 2025 EDT. Accepted: March 30, 2025 EDT. Published: May 12, 2025 EDT.



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