

Review Article

The Talking Knee Is a Reality: What Your Knee Can Tell You After Total Knee Arthroplasty

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This technology has the capability of providing extensive data on gait kinematics that may be used to understand differences in gait patterns and associated clinical diagnoses.

- a Dr. Fred Cushner is a complete knee surgeon specializing in all aspects of knee surgery. His practice offers both operative and non-operative treatment of knee injuries from the sports-related injury to joint replacement. Dr. Cushner has a special interest in cartilage injuries of the knee, as well as partial knee replacements, minimally invasive knee surgery, and revision surgery. Dr. Cushner has written numerous articles and book chapters on bloodless knee surgery and incorporates this research into the care of his patients.

Having extensive experience taking care of both recreational and pro athletes, Dr. Cushner has served as a team physician for the NBA and professional football teams such as the AFL New York CityHawks and the XFL NY/NJ Hitmen.

Dr. Cushner is active in academic orthopedics, having written three orthopedic textbooks, numerous book chapters, as well as over 60 scientific articles. He is a familiar face on the academic lecture circuit, participating both in national and international educational events. Dr. Cushner is a member of numerous educational societies including The Knee Society and the American Association of Hip and Knee Surgery (AAHKS).

His practice philosophy focuses on customized care - matching each patient's diagnosis to their needs and surgical expectations.

[Visit the Open Payments Data Page for Dr. Cushner](#)

[Conflicts of Interest Statement for Dr. Cushner](#)

- b Dr. Peter Sculco specializes in adult reconstruction of the hip and knee, including primary and revision joint replacements. He attended Princeton University for his undergraduate education where he majored in Neuroscience and Art History and was a member of the Track and Field team. He graduated medical school from Columbia University College of Physicians and Surgeons. Dr. Sculco completed his residency at HSS, where he was elected as an Emerging Leader for the American Orthopedic Association. During his training he received the Joseph M. Lane resident research grant of his work on hip vascularity. He received the chief resident award given by the nurses and operating room staff to the graduating resident who best exemplifies professionalism, compassion and interdisciplinary collaboration for patient care. After residency, Dr. Sculco completed his Fellowship at the Mayo Clinic where he received the Mark Coventry, MD Fellows Award in Adult Hip and Knee Reconstruction. Dr. Sculco returned to join the staff at HSS and currently has been recognized at national and international meetings for his academic research in hip and knee reconstruction.

[Conflicts of Interest Statement for Dr. Sculco](#)

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- c William J. Long, MD, FRCSC, is a board certified Attending Orthopedic Surgeon at HSS specializing in adult hip and knee reconstruction, revision joint replacements and sports injuries of the knee.

Dr. Long previously served as an attending orthopedic surgeon at the Insall Scott Kelly Institute for Orthopaedics and Sports Medicine in New York City. He was also a clinical associate professor at NYU Langone Orthopaedic Hospital and assistant program director of the ISK/NYU Adult Reconstruction Fellowship, as well as former director of research at St. Francis Hospital in Roslyn, New York.

Dr. Long completed his undergraduate degree at Queen's University at Kingston, in Ontario, Canada, and his medical degree at the University of Western Ontario. He completed a residency in orthopedic surgery, also at Queen's University, a fellowship in lower extremity adult reconstruction at the Mayo Clinic and a second fellowship in sports medicine and reconstruction at the Insall Scott Kelly Institute.

The author of more than 50 peer-reviewed papers in the last decade, Dr. Long is also editor and author of a number of textbooks on hip and knee reconstruction. He has been an invited speaker at numerous national and international meetings for more than a decade.

Dr. Long is the recipient of the 2019 Frank Stichfield Award from the Hip Society, as well as the first-ever TriOrg grant from the American Academy of Hip and Knee Surgeons and the Hip Society and Knee Society.

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Ultimately, this innovative technology will allow surgeons to use data and analytics to examine differences in recovery between patient groups and thus set better recovery goals.

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Figure 1. CANARY canturio™te (CTE) Implant

WHY WAS THIS INNOVATION INVENTED AND WHY IS IT IMPORTANT?

Total knee arthroplasty (TKA) surgeries performed in the United States are projected to increase over the next 30 years with TKA annual projections of (in thousands) 1,272 in 2030, and 1,921 by the year 2040 (Inacio et al. 2017; Singh et al. 2019; Sloan, Premkumar, and Sheth 2018). While TKA is generally considered an effective intervention to improve pain and function, 15-30% of patients experience continuing problems, in terms of pain, impairment and functional limitations post-operatively (Anderson et al. 1996; Bourne et al. 2010; Robertsson et al. 2000; Hawker et al. 1998; Noble et al. 2006; Gunaratne et al. 2017; Reichel et al. 2019; Ghomrawi et al. 2020). Revision rates for TKA range from 5-10% of arthroplasties performed, with aseptic loosening as the most common reason for revision (Kutzner et al. 2018; Khan and Thilak 2017; Gøthesen et al. 2013; Sharkey et al. 2014). Understanding that many factors may contribute to aseptic loosening, it has been noted that stability of TKA implants, specifically the tibial component, is crucial to achieving long-term fixation.

While tibial stem extensions are widely used in the revision setting, more recently they have been used in primary TKA to achieve more tibial stability and gain better fixation. The use of tibial stem extensions in primary TKA has been associated with a lower risk of revision for aseptic loosening and an increased survival rate (Steere et al. 2018; Fournier et al. 2020; Hegde et al. 2021; Hinman et al. 2020). Recently, the canturio™te (CTE) with CHIRP System, a novel tibial stem providing additional stability with its 58mm length to the complete knee prosthesis in the same manner as a shorter in length, traditional tibial extension used in primary TKA procedures, received FDA market authorization. Given that the stem and bone engagement is not defined as just stem length, tibial extensions have been categorized as metaphyseal-engaging stems (MES) or diaphyseal-engaging stems (DES) rather than by absolute stem length. MES are tibial stems that are 30-75 mm in length, whereas DES stems are greater than 75mm in length (Hinman et al. 2020). Using a matched cohort in the Total Joint Replacement Registry, Hinman et al. analyzed the use of tibial stems in the three highest volume implant systems and found a lower risk of revision due to aseptic loosening in TKAs performed with an MES tibial stem (Hinman et al. 2020).

Despite major technological advancements since the first recorded TKA surgery, smart technology remains largely absent in manufactured orthopaedic implants. In the literature, studies have used wireless instrumented TKA implants to analyze real measured in vivo data describing the loading conditions of devices (D'Lima et al. 2006; Westerhoff et al. 2012; Damm et al. 2017). The canturio™te (CTE) is a novel tibial stem with an embedded inertial measurement unit (IMU). The canturio™te IMU allows qualified step count and qualified gait movement data to be collected, as well as sensor pairing accelerometers with gyroscopes to provide detailed measurements of limb movement and orientation within a spatial reference frame. The Canary Tibial Extension with CHIRP™ System is intended to provide objective kinematic data from the implanted medical device to assist the patient and clinician during a patient's TKA post-surgical care. The kinematic data is intended as an adjunct to other physiological parameter mea-

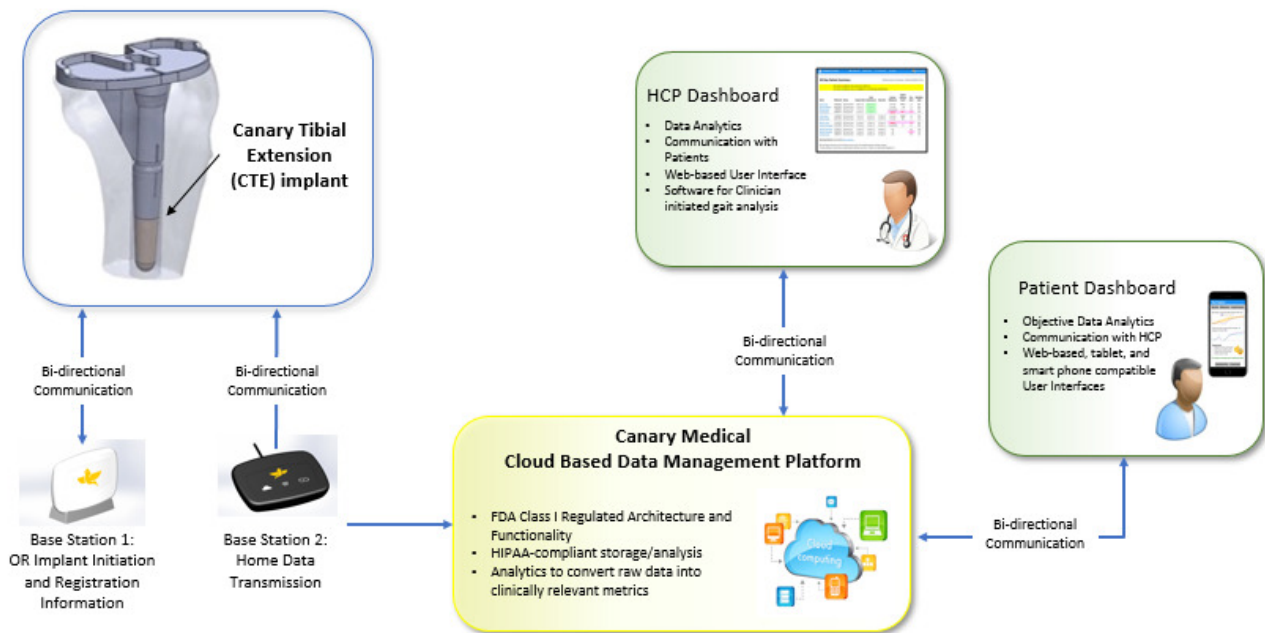


Figure 2. Canary Medical™ CTE with CHIRP™ System

surement tools applied or utilized by the physician during the course of patient monitoring and treatment post-surgery. The intent of the CTE implant design was to offer an implantable sensor capable of monitoring activity and gait that provides consistent data that does not require a patient to actively track or remember to wear a device. Physicians routinely use patient-reported outcome measures (PROMs) to evaluate post-operative function and pain following TKA (Harris et al. 2016; Ramkumar, Harris, and Noble 2015). While various PROMs have been used both pre- and post-operatively in TKA patients, they are limited due to lack of effectiveness, ceiling effects, inaccuracies and patient-reported bias (Dowsey and Choong 2013; Vaughn, Dunklebarger, and Mason 2019; Terwee et al. 2006). Previous studies have assessed the use of activity trackers, and while some are proponents of their use to track patient recovery post-operatively, other studies discourage their use due to variable results. While external smart devices used to monitor recovery post-orthopedic procedures have become increasingly available to patients and clinicians, their widespread adoption remains problematic. Most of these wearable devices consist of measurements from accelerometers to quantify movement, but their accuracy is limited, and patient compliance is an issue; both of these remain persistent obstacles to their widespread adoption. While tracking patient activity is helpful for the clinician, the number of patients providing data decreases linearly with time. In addition, the data specificity associated with wrist-based measurements cannot provide information on TKA kinematic function. External monitoring devices can be used, but in the past have had mixed results due to patient compliance, particularly for monitoring over numerous years. Monitoring allows the clinician to determine if the patient is appropriately achieving their rehabilitative goals and allows the clinician to tailor and adapt the rehabilitation pro-

gram appropriately in response to the patient's progress. The way these sensors have been deployed in TKA research and clinical care has not been fully examined.

HOW DOES IT DO WHAT IT DOES?

The CANARY canturio™te (CTE) with Canary Health Implanted Reporting Processor (CHIRP™) is a tibial extension implant containing electronics and software. Using internal motion sensors (3-D accelerometers and 3-D gyroscopes), the CTE collects kinematic data pertaining to a patient's gait and activity level following TKA. The kinematic data produced by the CTE implant is intended as an adjunct to other physiological measurement tools. The CTE implant is assembled with the Zimmer Biomet Persona® tibial baseplate. In addition to its data collection and reporting capabilities to the physician and patient, the CTE implant provides additional stability to the complete knee prosthesis in the same manner as a traditional tibial extension.

The CTE with CHIRP™ System uses two different external configurations: the Operating Room (OR) and Home "Base Station" units to query the CTE implant (which has an internal radio and antenna) and upload the data collected by the CTE implant to the Canary Cloud data management platform (the Cloud or CDMP). Information from the implant is processed by the system's Canary Medical Gait Parameter (CMGP) software—located in the Cloud—into clinically relevant metrics. The CTE with CHIRP™ System technology package ultimately allows patients and their health care professionals (HCPs) to view the patient's functional activity data which is collected and processed by the system. Patients and HCPs view the information on HCP and patient "dashboards" on the Canary Medical website, which is accessible through the Internet.



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WHAT DO YOU, AS A SURGEON, GET OUT OF THE INNOVATION AND WHAT DOES THE FUTURE LOOK LIKE IN THIS AREA?

Despite over forty years of successful TKAs, it has been reported that up to 20% of patients are not satisfied post-TKA. This technology may provide an opportunity to gain more knowledge and information to help determine the cause of patient-reported pain following TKA. In addition, this technology has the capability of providing extensive data on gait kinematics that may be used to understand differences in gait patterns and associated clinical diagnoses. Ultimately, this innovative technology will allow surgeons to use data and analytics to examine differences in recovery between patient groups and thus set better recovery goals.

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Video 1. The Talking Knee (ZimmerBiomet with Canary Technology)

URL: <https://www.youtube.com/embed/RQe1H4smHOo>



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