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"Precision Metrics in Orthopaedics: Developing Improved Patient Assessment Technologies and Processes to Optimize Care"

Total hip and knee arthroplasty are very successful surgical interventions for end stage arthritis. These procedures are generally very successful and satisfaction rates and outcomes are very good. Partly because of the historic success of these devices, hip and knee arthroplasty are now being applied to younger, and unfortunately, heavier patients. These patients are also more active with higher loads placed on the joints. Patient expectations are also higher. As such, there has been a need to innovate and develop new prostheses. However, because patients receive such a profound improvement in health outcomes and quality of life after hip and knee arthroplasty, it is difficult for them to subjectively report differences in outcomes between design changes in the prostheses. Subsequently, there has been a proliferation in new arthroplasty technology, usually with an associated increase in price, all in an effort to improve long-term survivorship. This has introduced a paradox as conventional measures cannot determine a difference in outcome and instead it is left to the surgical community to follow the patient long-term and report on the long-term survivorship. This often takes ten to fifteen years and at the end of the cycle the technology has changed.

If there are to be significant advances in hip and knee arthroplasty, especially for younger and more active patients, more precise, reliable and responsive outcome metrics are required. These include tests such as gait analysis, muscle firing patterns and radiostereometric analysis (RSA). With RSA, small tantalum beads are placed in the bone and prosthesis at the time of surgery. Using stereo x-rays immediately after the surgery and in follow-up, micromotion of the prosthesis in relationship to the bone is detected with a resolution of 0.08 mm. This test is highly predictive at an early stage of long-term survivorship. As such, new technology can now be assessed in the short term on as few as 25 patients. As such, the outcome of new implants can quickly be ascertained and the penetration of inferior technology can be prevented. More excitingly, it is the combination of these precision metrics that allow us to consider a more patient specific approach to hip and knee arthroplasty. Gait analysis and muscle firing patterns before surgery have been predictive of the RSA migration patterns. Hence it is likely that with further research we will be able to use existing implants but implant them in a precise fashion using computer assisted or image based surgery that is ideal for the individual biomechanics of the patient. This has the promise to improve patient satisfaction and function as well as extending the life expectancy of the implant. The net effect is better outcomes with significant savings to the health care system.

Milestones:

1) Determine the relationship between various pre-operative gait factors and RSA migration patterns
2) Determine the relationship between various pre-operative muscle firing patterns and RSA migration patterns
3) Develop a one time RSA test that can predict an implant at risk of failure
4) Develop surrogates for this technology using smart phone technology
5) Develop a valid and predictive remote sensing application for smart phones that incorporates the knowledge from this project