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Blending patient-specific instruments with surgical navigation

This work is a retrospective analysis of our 13 years of experience and a prediction of future prospects. A patient-specific instrument (PSI) is typically implemented as a rigid structure with two physically linked elements: a "mirror" or mirror surface that physically mates with an anatomical region; and a means of guiding a surgical instrument, typically a surgical drill. Historically, early PSI's were created from CT scans and manufactured by computer-numerical machining. It is now more common to use additive manufacturing to create a PSI. Although early PSI's provided an improvement technical accuracy, more recent clinical trials are bringing into question the clinical benefit for high volume procedures. We believe that the seeming discrepancy between high technical accuracy and subsequent patient outcomes is attributable to two effects: selection of the procedure and patient for PSI application, and the inability to intraoperatively choose a surgical alternative. Since 2005, we have performed hundreds PSI-guided cases. These have included: hip resurfacing and total hip arthroplasty; post-traumatic total knee arthroplasty; knee osteochondral transplantation in younger patients; radius osteotomy about the wrist; pelvic reconstruction following oncological surgery; peri-orbital tumor access; and many one-of-a-kind, technically difficult, orthopedic procedures. We have found significant longer-term improvements for hip resurfacing, which is consistent with our 20+-year successes in image-guided orthopedic surgery. These surgical procedures share the properties of being technically difficult and in having nearby bone surfaces that are naturally free of osteophytes and periosteum, both of which can physically interfere with the mating process of PSI application. We have found PSI's to effectively solve relatively straightforward navigation problems. The technique relies critically on a high quality CT 3D image that can be easily and accurately segmented. Osteophytes, in particular, have been obstacles in registration regions. Commercially available PSI's may not adequately address this fundamental problem. When physical registration is problematic, the PSI technique must be converted to surgical navigation or to an older, non-navigated technology. We propose to bridge this technology gap by linking the physical registration of a PSI with electromagnetic navigation. In laboratory studies and a pilot cadaveric trial, this hybrid of a PSI with navigation has proven to be as accurate as navigation alone and considerably easier to perform. This technical advance places additive manufacturing of a PSI in a spectrum of technical solutions, potentially broadening the reach and effectiveness of them as implementations of image-guided surgery.

Biography

Randy E Ellis is a Professor at Queen's University at Kingston, Canada. His primary Queen's appointment is at School of Computing, and he is also appointed as a Professor in Departments of Mechanical and Material Engineering, Surgery, and Biomedical and Molecular Sciences. He is the Project Leader of a large multidisciplinary group that investigates advanced health-care delivery. He is Fellow of the American Society of Mechanical Engineering and of the Institute of Electrical and Electronic Engineers. He has published more than 300 refereed scientific contributions and served extensively on editorial boards and program committees of major international conferences.

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