

THE IMPACT OF ACCURACY OF COMPUTER-AIDED ORTHOPAEDIC SURGERY ON PATIENT-SPECIFIC BIOMECHANICAL OUTCOMES

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Background

The complexity and frequency of surgical interventions involving bone-preparation gestures such as bone-cutting and positioning implants and prostheses have given rise to an area of research that is of international importance. Since 90s, several assistive technologies have been developed to improve the accuracy of these surgical gestures, with the aim of improving functional outcomes of the procedures. Today, several imaging and optical navigation systems, robots, and 3D-printed mechanical guides are used during procedures such as knee and hip arthroplasties, spinal instrumentation, corrective osteotomies, among others.

The geometrical parameters used to evaluate accuracy of surgical gestures are defined according to patient-specific functional outcomes: measurement of the angular alignment of the leg with the prosthesis in knee arthroplasties, measurement of the mechanical axis of the leg in corrective osteotomies, measurement of the correction of scoliotic spine deformities, etc. However, measurement of these geometrical parameters does not permit a direct assessment of the accuracy of the actual surgical gestures in comparison with the desired gestures. So it is not yet possible to state unequivocally that improvements in accuracy of the assisted surgical gestures significantly impact patient-specific functional outcomes in terms of the restoration of motor skills and biomechanical performance. Doubt is still cast on the real benefits of surgical technologies, hampering their integration and use in routine clinical practice [1].

Recent Advances

In 2004, the International Society for Computer Assisted Orthopaedic Surgery (CAOS-Int), in conjunction with the American Society for Testing of Materials (ASTM), undertook the creation of a new standard for assessing and comparing the accuracy performance of surgical assistance technologies. This standard was published in 2010 as F2554-10 and used the definition of accuracy and precision from the standard E177-08. The F2554-10 standard specifically concerns evaluation of intrinsic performance of assistance systems. In consequence, it is not relevant for directly measuring the accuracy of assisted surgical gestures, so its impact on patient-specific functional outcomes remains difficult to evaluate.

Since 2008, our group has developed quantitative models and research protocols allowing to gather objective data on the accuracy of the actual surgical gestures in comparison with the desired gestures regardless of the assistance technologies that could be used during the surgery [2,3].

Olivier has been working in Computer-Aided Orthopaedic Surgery since studying for his PhD in engineering sciences (2010). Since then he moved from the study of pelvic bone tumor resection to scoliotic spine Biomechanics during a postdoc research position in Montréal (QC), Canada. He is now a Research Associate and is supervising PhD and Master students in engineering, medicine and motor sciences. He is a Visiting Associate Professor at Louvain School of Engineering and Faculty of Motor Sciences. He has published over 20 papers since 2008. He is Secretary General of the Belgian Society of Computer-Assisted Orthopaedic Surgery.

Future directions

We are now focusing on a process of international standardization, in conjunction with CAOS-Int and the International Organization for Standardization (ISO), to propose recommendations allowing the accuracy of assisted surgical gestures (as the difference with the desired gestures) to be clinically correlated with the patient-specific functional outcomes in terms of the restoration of motor skills and biomechanical performance. We are organizing an international workshop agreement (IWA) process to produce a document entitled "Guidance Principles for Defining and Measuring Accuracy in Computer-Assisted Orthopaedic Surgery". The IWA kick-off meeting and first workshop session is scheduled at the 16th annual congress of CAOS-Int in Osaka, Japan, in June 2016.

By investigating new methods for measuring surgical accuracy as well as human movement, we aim to demonstrate the changes in motor skills and biomechanical performance in patients who have undergone computer-aided orthopaedic surgeries, and correlate these changes with improvements in accuracy of the assisted surgical gestures. Optimizing accuracy and reliability of measurement technologies of surgical accuracy and human movement should help to assess the impact of the accuracy of assisted surgical gestures on the restoration of motor skills and biomechanical performance.

References

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2. Cartiaux et al., J Bone Joint Surg Am, 92:2076-82, 2010.
3. Cartiaux et al., Ann Biomed Eng 42:205-13, 2014.

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