Training outside the OR: A Simulator for Sacro-Iliac Screw Insertion

Raphael Rush1,2,3, Howard Ginsberg1,2, Richard Jenkinson2,1, Cari Whyne1,2,3

1Orthopaedic Biomechanics Lab, Sunnybrook Health Sciences Centre, Toronto, ON, Canada; 2Orthopaedic Surgery, Sunnybrook Health Sciences Centre, Toronto, ON, Canada; 3Surgery, St. Michael’s Hospital, Toronto, ON, Canada
cari.whyne@sunnybrook.ca

Introduction: The human pelvis presents consistent and predictable fracture and dislocation patterns when subjected to blunt trauma. The treatment of these injuries has evolved dramatically over the last 20 years with a clearer understanding of the anatomy and biomechanics of the pelvis. Where non-operative treatment once predominated for all patterns of pelvic ring injury, trauma surgeons now regularly treat some of these injuries with operative stabilization. The evolution of orthopaedic instrumentation combined with more sophisticated radiologic techniques has permitted this more aggressive approach, producing more reliable and improved outcomes. Minimally invasive approaches to pelvic stabilization require high levels of expertise to avoid damaging critical structures adjacent to regions of thin bone. Surgeons who perform the operation must be able to visualize the procedure from several perspectives simultaneously, i.e. inlet, outlet, and at times lateral views using 2D intraoperative imaging, which may expose both surgeon and patient to heavy doses of radiation. Complication rates in minimally invasive pelvic stabilization are low and highly avoidable, but complications are severe when they occur. One of the most important aspects of avoiding complication lies in understanding the variability of sacral anatomy.

Current teaching technique involves bringing trainees into the operating room to “learn by doing.” Minimally-invasive reduction using SI screws, however, is not a common operation, providing little opportunity for training to take place outside of a few major centres. This makes SI-screw insertion a prime candidate for simulator-based training. Surgical simulators are being integrated into both training regimens and preoperative planning activities. While laparoscopic surgical simulators have been widely deployed for such uses, existing simulators for minimally invasive procedures into complex bony structures (i.e. screw insertions) have not been widely deployed in orthopaedic training. The objective of this work was to develop a versatile simulator for minimally invasive screw insertions which yields an accurate 3D visualization of the anatomy and the surgical insertion of sacro-iliac (SI) screws into the pelvis.

Materials and Methods: We designed a simulator for visualization of screw insertion using patient-specific anatomical CT data (Fig 1). The simulator was designed in TCL (Tool Command Language) atop the Amira simulation package (Amira 3.1.1, Mercury Software). CT scans of 3 patients and one cadaver were anonymized and the bones segmented according to user-defined thresholds to generate a 3D surface of the pelvis. The user can rotate the viewing field to select both inlet and outlet views of the pelvis; these views are recorded by the program for use throughout the simulation. Using the inlet and outlet 3D views, insertion points are selected for SI screw fixation. A computer-generated K-wire is translated to the chosen insertion point, manually angled, and inserted into the bone. The depth of the K-wire allows the user to determine the appropriate screw length. After screw selection, the screw can be inserted into the pelvis along the K-wire track. Once insertion is complete, the user can inspect CT scans overlaid with the screw surface or turn the 3D pelvis’ surface transparent to determine accuracy of screw insertion. A rudimentary tool exists to automatically measure screw/pelvis intersection. Pilot usability tests of the simulator were conducted with an orthopaedic fellow training in complex pelvic and acetabular care.

Results: The simulator was found to provide a realistic 3D representation of the pelvis and the SI screw insertion technique. 3D reconstructions of the pelvis provided increased familiarity with the procedure and allowed visual correlations to be made with 2D CT slice views, and inlet and outlet x-ray perspectives.

Discussion: The development of a simulator for SI screw insertion using patient-specific CT scans provides a novel opportunity for preoperative planning and orthopaedic training. Pilot work suggested that the tool may be highly useful in increasing familiarity with screw insertion, improving 3D visualization of the pelvis, and in training surgical fellows and residents to perform SI screw insertion.

The simulator as developed represents a substantial improvement over previous work, both in providing patient-specific anatomical data and in providing a more realistic portrayal of the procedure itself. In the future, we hope to improve both 3D display (e.g. using 3D visualization techniques like virtual-reality glasses) and the user interface itself. Further work will measure the effectiveness of such simulation as a training tool for screw insertion into this and other complex bony structures, and in improving planning, confidence and screw-insertion-performance among residents or fellows learning these techniques.


Poster No. 1049 • 54th Annual Meeting of the Orthopaedic Research Society