Pelvis tumor resection: 3D preoperative planning and navigation validation using a virtual specimen

RITACCO LE, MILANO FE, AYERZA MA, MUSCOLO DL, FARFALLI GL, APONTE-TINAO LA

Preoperative Planning and CAS Unit, Informatics and Health Department, Hospital Italiano de Buenos Aires, Buenos Aires, Argentina

lucasritacco@hotmail.com

Introduction: Three-dimensional preoperative planning and bone tumor resection by navigation have been used in the last ten years. According to literature this workflow increases the “accuracy”. However, there are few and not completely clear reports describing accuracy in preoperative planning and navigation. The objective of this preliminary study was to determine the accuracy of osteotomies planned and guided by navigation in pelvis tumor resection. We assume that the surgical specimen scanned and 3D reconstructed is an acceptable method to determine the accuracy qualitative and quantitatively of a virtual planning and navigation

Materials and Methods: A total of four patients were evaluated between May 2010 and February 2011, age range: 6-38, 17.4 mean; 2 males and 2 females. There were 4 malignant tumors: Malignant Schwannoma (1), Ewing’s tumor (1) and Chondrosarcoma (2).

Images acquisition protocol: All anatomic regions compromised by the tumor were preoperatively CT scanned (Mutislice 64, Aquilion, Toshiba Medical Systems, Otawara, Japan). Magnified slices with 0.5-mm thickness were obtained using a soft tissue algorithm, matrix 512 x 512 pixel. Magnetic resonance images (MRI) of the corresponding region were acquired using a 1.5-T unit (Magnetom Avanto, Siemens Medical Solutions, Erlangen, Germany). Slices with 1-mm thickness were obtained using T1 or fat suppressed-weighted sequences in order to optimize visualization of the signal intensity from bone tumor, matrix: 256 x 256 pixel.

3D-Preoperative planning: Image fusion was applied to CT and MRI studies in order to determine bone cortex and intra-extraosseous soft tissues tumor extension. Once the fusion was obtained, osteotomies were planned taking into account the tumor extension in a three-dimensional virtual scenario.

All patients were planned for two uniplanar osteotomies (intercalary resection). Minimal margin was determined in each plane by measuring the closest proximity between malignant tumor and osteotomy plane.

These studies allowed the visualization of the tumor and the application of a virtual osteotomy. Simulation was carried out by using computer-aided design (CAD) software, Mimics software (Materialise, Leuven, Belgium).

Operative Procedure and Navigation: Three-dimensional preoperative planning was obtained in CAD format. Next, 3D models were exported to CT data sets in Digital Imaging and Communications in Medicine (DICOM) format and uploaded to navigator (3D OrthoMap navigation software v1.0, Stryker Navigator, Freiburg, Germany). Using navigation tools: navigated pointer, camera and infrared tracker devices applied to the patient, allowed to the surgeon establish a correspondence between 3D images and real bone with direct vision of the monitor.

In this manner, surgeons were guided in the operating room by navigation to execute the intercalary osteotomies which had been previously planned.
Surgical Specimen Virtualized and Measurements: Once osteotomies were performed, the tumor surgical specimen obtained was CT scanned and 3D reconstructed similarly to what was done previously to surgery to CT images protocol acquisition preoperatively in patients.

The three-dimensional virtual surgical specimen (3DVSS) obtained after tumor resection, was superposed on the three dimensional preoperative planning (3D registration). Distances between the osteotomy planned and the plane created by the saw blade in 3DVSS (aligned on preoperative planning model) were measured. 3DVSS and preoperative osteotomy planes were converted to point cloud model. A point cloud model is a virtual tool capable of consider only the points of a surface. This method helped us to determine a region of interest in order to calculate distances point to point between preoperative planned osteotomies and final osteotomies obtained in the surgical specimen 3DVSS.

Results: The correlation between the osteotomies preoperatively planned and the osteotomies achieved by navigation was in a global mean of 0.73 millimeters (SD: 3.14) in a total of 6 planes evaluated.

Conclusion: According to clinical relevance, this work demonstrates the acceptable accuracy in preoperative planning and navigation. Furthermore, we demonstrate the usefulness of three-dimensional models from surgical specimen when surgeons need to determine quantitative and qualitative accuracy of 3D planning and navigation procedure.