

Clinical Gait Analysis and Mapping of the Bony Fusion following Sacrectomy: A Case Report

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Introduction: Total en-bloc Sacrectomy with wide oncological margins impacts the load bearing ability of the spinopelvic complex and the mobility of patients after surgery. The closed-loop technique (CLT) uses a single U-shaped rod to restore the lumbo-pelvic junction. This technique uses a non-rigid construct to avoid the stress shielding phenomenon and to promote bony fusion between the lumbar vertebrae and the pelvis. So far, the relationship of any spinopelvic reconstruction method and the fusion process has not been studied. In this study, a computational method was established to map the bony fusion at the level of the construct in addition to assessing the mobility of the patient based on the 6 years follow up (FU) clinical data.

Materials and Methods: Post-operative CT scans were collected from a male patient who underwent total sacrectomy at the age of 42 due to chordoma. CLT technique was used to reconstruct the spinopelvic junction. The 3D geometry of the implant construct was defined. In order to investigate the bony fusion, a single axial slice-based voxel finite element (FE) mesh was defined. The Gray scale values were determined and using linear empirical equation the bone mineral density (BMD) values for each mesh element was assigned using a ten-color coded category (1st category=0 g/cm³, 10th category=1.12 g/cm³). To demonstrate the cyclical loading of the construct at 6-year FU, the patient underwent a gait analysis session. The patient completed five walking trials mounting the Vicon plug-in-gait marker setup. Marker trajectories were acquired using a 6-camera motion analysis system (VICON MXT40, UK), and ground reaction forces using a force platform (AMTI OR6, USA) to calculate the joint kinematics and kinetics. Mean and standard deviation of data per gait cycle were then calculated over the 5 available repetitions per side and compared to normative data.

Results: The developed method was able to map the bone remodeling at the fusion site. The volume distribution over time in the different BMD categories were determined and visualized. The highest BMD value volume on the first post-op CT was 0.04 cm³, 0.98 cm³ at the 2-year FU and 2.30 cm³ at the 6 years FU. The resulting gait was slow and slightly asymmetric with increased support on the left leg and a reduced propulsion power at the hip and ankle. Joint mobility was close to normal at all the joints, distally in particular.

Conclusion: CLT provided strong lumbopelvic bony fusion within 2 years. Independent gait function was maintained, and load bearing abilities restored. The study results and the measurement method can be used for validation of complex patient specific FE models which can be useful for individualized preoperative surgical planning. Due to its relative simplicity, it is suggested to apply the developed measurement method for the scientific and clinical analysis of other surgical procedures for the reconstruction of the lumbo-pelvic junction after sacrectomy.