

3D kinematics of surgeons' upper-arm rotation in laparoscopy

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1. Introduction

In order to foster safer workplaces and to cope with Work-Related Musculoskeletal Disorders (WRMSDs), an ergonomic intervention is required for managing the biomechanical risk factors that appear during laparoscopic surgery tasks. In this sense, surgeons who perform laparoscopy are concerned as a high-risk occupational group for developing WRMSDs as a direct consequence of the postures that they sometimes have to adopt during operation. There are many tracking systems able to track surgeons' motion during laparoscopic activities. Advances in the use of the inertial measurements units (IMUs) for motion capturing make IMUs systems more suitable than 3D photogrammetry for tracking surgeons motion in the operation theaters, as there is no markers occlusion problem [1].

2. Methods

The XSens MVN BIOMECH system (Enschede, The Netherlands) was utilized during laparoscopic surgery to obtain body segment's pose information from inertial units (Figure 1). The pose data were stored as .MVNX files and were post-processed with the Visual3D software (C-motion, Inc., Germantown, MD, USA). The defined segments' local reference systems (LRS) axes X - Y - Z corresponding to mediolateral - anteroposterior - longitudinal directions, respectively. The Z - X - Z Euler sequence of rotation was used allowing the analysis of the upper arm - to - thorax posture adopted by subjects in terms of clinically interpreted position and orientation. Thus, the posture of the upper arms was defined with respect to the trunk, considering posture as the position and orientation of body segments. For every segment of the mechanical model defined, where LRS are fixed, the well-known Euler's sequence of rotation is used to obtain the posture of the upper arm with respect to the trunk:

- 1st rotation with respect to Z axis, where upper-arm rotation takes place (azimuth angle). The 'azimuth angle' defines the plane of elevation.
- 2nd rotation with respect to X axis, where upper-arm elevation takes place (elevation angle).
- 3rd rotation with respect to Z axis, where upper-arm external/internal rotation.

"Data smoothing" was carried out by generalised cross-validation using quintic splines. The R statistical software was utilized to obtain descriptive statistics and to compare the upper arm posture between the conventional axial-handled laparoscopic needle holder (Group L) (Karl Storz) and a robotic handheld laparoscopic needle holder (Group R) with ergonomic handle (DEXTM, Dextérité Surgical).

3. Results

The pair movement of the surgeons' upper arm with respect to the trunk during the laparoscopic operation was analysed and the differences between the two operation tasks were compared. Results revealed that surgeon's upper-arm posture is different between the two tasks.



Figure 1: Experimental set up showing a subject at the operation theater.

4. Discussion & Conclusion

In real operation conditions the use of reflective markers is not an option. IMUs can be an alternative option.

References

- [1] Andreas Skiadopoulos, Carlos Espino Palma and Kostas Gianikellis., "3D kinematics of surgeons' upper-arm rotation in laparoscopy," 5^o congreso nacional de biomecánica, Espinho, Portugal, 8 e 9 de Fevereiro, 2013.