SENSOR-BASED CONTINUOUS ASSESSMENT OF POSTOPERATIVE SHOULDER ACTIVITY

Michiel Herteleer (1), Armin Runer (2,3), Magdalena Remppis (4), Jérôme Schlatter (4), Jonas Brouwers (1), Friedemann Schneider (2), Vasiliki C. Panagiotopoulou (4), Bernd Grimm (5), Clemens Hengg (2), Rohit Arora (2), Stefaan Nijs (1,6), Peter Varga (4)

1. University Hospitals Leuven, Belgium; 2. Medical University Innsbruck, Austria; 3. Technical University of Munich, Germany; 4. AO Research Institute Davos, Switzerland; 5. Luxembourg Institute of Health, Luxembourg; 6. Utrecht Medical Centre, The Netherlands

Introduction

Complex and unstable proximal humerus fractures require surgical treatment, with locked plating being a frequently used osteosynthesis option [1]. The outcomes of fracture treatment could be affected by the postoperative rehabilitation protocol [2], which however remains challenging to assess continuously over longer periods. This study aimed at continuously measuring postoperative shoulder activity over six weeks with sensors and comparing of two rehabilitation protocols.

Materials and Methods

Twenty-six elderly patients (19 f and 7 m, 62.5 ± 8.9 y) having complex proximal humerus fractures treated with locking plating were included at University Hospitals Leuven and Medical University Innsbruck. The two sites, randomized and encoded with H1 and H2, utilized different rehabilitation protocols with 3 weeks slings and immediate unrestricted mobilization, respectively. Shoulder activity was assessed continuously during the first 6 postoperative weeks in two consecutive periods via accelerometer-based sensor (AX3, Axivity) pairs attached on the upper arm of the treated side and on the chest as reference. Patients could follow normal daily activities. The raw data of the sensors was processed via calibration-based corrections, low-pass filtering and time synchronization. Shoulder angle including all directional components was evaluated as the rotation of the arm senor with respect to the chest sensor. Experimental validation indicated 2° accuracy of this method. The evaluation was restricted to upright position of the chest (-30° - 30°) and excluded large accelerations (>1.5g). Shoulder elevation events were defined as peaks of the shoulder angle vs. time data. The daily average angle and total number of events were calculated, and their longitudinal evolution was evaluated in terms of absolute values as well as relative to the direct postoperative period. The effect of rehabilitation protocols was assessed by comparing the results of the two clinical sites.

Results

Total recording time was on average 31 ± 13.8 days, with 22 patients completing both 3-weeks measurement periods. Average shoulder angle of all patients ranged between 9.6° and 31.2°, exhibiting only mild evolution over time, with less than 5° increase over the observation period. The average number of daily

shoulder elevation events were in the range of 547 – 6025, showing an increasing trend for most patients. The two clinical sites showed no characteristic differences in terms of the change in average shoulder angle (Fig 1, top). Results of H2 with immediate mobilization showed clearly increasing trend in the number of elevations vs. no apparent changes for H1 (Fig 1, bottom).
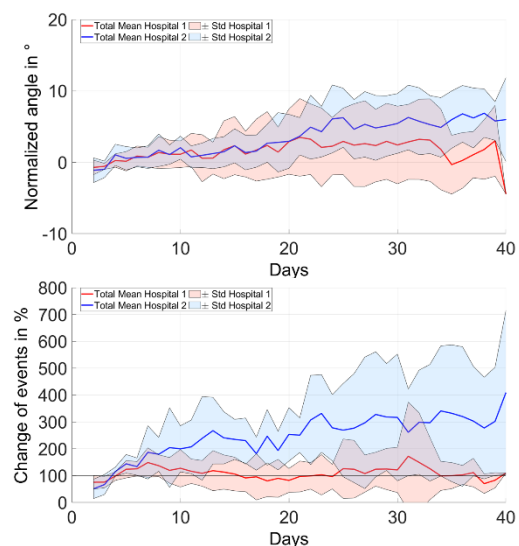

Figure 1: Time evolution of relative changes in shoulder angles (top) and elevation events (bottom) at the two clinical sites utilizing different rehabilitation protocols.

Discussion

Postoperative shoulder activity assessed with sensors over six weeks showed large differences between patients in terms of the average shoulder angle (3-fold) and number of elevation events (11-fold). The latter measure exhibited more characteristic longitudinal evolution and differences between rehabilitation protocols and thus may be a promising parameter of mobility monitoring. Future studies will investigate whether and how the assessed shoulder activity could affect the outcomes of fracture treatment.

References

1. Sudkamp et al, J. Bone Jt. Surg. Am. 91(6):1320–8, 2009.
2. Bruder et al, J. Physiother. 63:205–20, 2017.

Acknowledgements