

A NEW METHOD TO TRACK THE SCAPULA DURING ACTIVE GLENOHUMERAL MOVEMENTS

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INTRODUCTION

Studying the 3-D shoulder kinematics in-vivo can provide vital information in the analysis of a number of clinical disorders. However, the thick layer of skin overlying the scapula means that all skin-based techniques underestimate the actual bone movement. The scapula palpator device was developed in an attempt to reduce the problem of skin deformation [1]. To date, the palpation method has only been used to capture static positions of the scapula at various fixed points in the shoulder range.

The accuracy of the static palpation method has been validated against a bone-based measurement technique [2]. However, the nature of the method means that its accuracy is dependent on the ability of the investigator to locate the bony landmarks. Inter-investigator variability is a reported source of error when this method is used [3]. Guidelines on how to use the method to obtain accurate scapular measurements have not been provided in any previous studies. Despite this, the method has been employed by many subsequent shoulder studies. Furthermore, no studies have looked at improving intra-investigator and inter-investigator variability nor at the effect of applying unequal or high pressure levels on the three tracked bony landmarks which might modify the scapular motion.

However, the main problem with using this technique remains its limited use as a static device. Studies employing alternative technologies have compared dynamic to static scapular kinematics for a number of slow movements. The conclusions of these studies are ambiguous and it is still not clear whether dynamic and static shoulder kinematics are the same.

The aim of this study was to develop a technique using the palpation method to dynamically measure the movement of the scapula during slow active glenohumeral movements. In addition, to assess the effect on scapular kinematics of allowing the investigators to regulate the pressure applied on the three landmarks. This method can then be used to extract accurate glenohumeral and scapulothoracic kinematics.

METHODS

A scapula palpator was modified by attaching pressure sensors to the tips of the three probes. This was done to allow the measurement of contact pressure between the three probes and the skin overlying the scapula. An optical motion tracking system was used with retro-reflective markers on the thorax, scapula palpator and humerus. Subjects were seated comfortably on a stool; the position of the stool was adjusted so that an elevation in the scapular plane corresponded with the arm pointing to a line on the floor. The subject followed the line on the floor and the wall using a laser pointer attached to the subject forearm; this helped keep a consistent movement and reduce motor noise.

A total of 8 subjects and 3 investigators participated in the study. Subject performed slow, controlled bilateral abduction in the scapular plane. Three sets of measurements were taken using each of the following methods: (1) Markers directly

attached to the skin overlying the scapula. (2) Markers attached to the scapula palpator, and the palpator used to track the scapula without consideration of contact pressure. (3) The palpator was used with pressure sensors providing real-time feedback to the investigator. The investigator used the feedback to maintain low and equal pressures on the three probes (Figure 1). This was then repeated by two other investigators for the same subject.

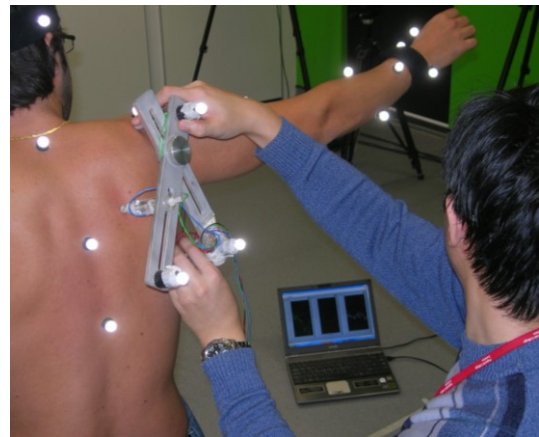


Figure 1: Method (3) tracking the scapula with the palpator and direct pressure feedback on the screen

RESULTS AND DISCUSSION

The skin method (1) measured less scapulo-thoracic rotations than the palpator methods (2) and (3). The ranges of motion measured by the palpator methods are comparable to results in the literature.

A paired T-test was used to compare the intra-investigator standard deviations between methods (2) and (3). Method (3) was found to produce significantly reduced intra-investigator standard deviations for the scapular upward rotation ($p < 0.01$) and the scapular internal/external rotation ($p < 0.01$) than method (2), the scapular tilting also had a significant reduction in standard deviations ($p < 0.05$) in low angles of glenohumeral abduction (i.e. less than 70°). However the method did not improve the inter-investigator errors, and there was a consistent difference between the investigators.

CONCLUSIONS

The palpation technique is difficult to achieve and it is important that the operation of the investigator does not splint or modify the physiological scapular motion. Using pressure feedback improves the repeatability of the palpation technique which could also be applicable to static measures of the scapula. However, different investigators could introduce consistent errors to the measurements.

REFERENCES

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