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REVIEW

# Evaluation Tools of Shoulder Joint Kinematics - Shape Matching Technique -

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Most early studies used simple radiographs to measure scapular kinematics (Freedman & Munro, 1966). simple radiographs using 2-plane are still used frequently, but there is a limit to evaluate the joint kinematics especially shoulder joint. Now, I would like to take a look at the advantages and disadvantages of several methods that have used frequently.

Techniques

At first, the Cadaver study allows for statcic and dynamic study of shoulder joint motion (Payne, Deng, Craig, Torzilli & Warren, 1996). It is a very useful tool for measuring the approximate change of shoulder joint kinematic. But cadaever study couldnot be studied with the real muscles tone and has a big obstacle to fully reproducing in vivo.

Let's look at the simple radiograph study. It is a very useful tool but cannot simulate the 3-dimentional situation. Although this s can be performed relatively easily compared with other methods, there is a limitation in that dynamic study is not possible and interobserver and intraobserver reliability are large.

Many researcher have used the electromagnetic tracking analysis system (McClure, Michener, Sennett & Karduna, 2001). It enables dynamic analysis of joint motion, However, the electromagnetic tracking method has limitations that it is difficult to measure the shoulder joint motion for the overhead activity of 100 degrees or more due to the skin-bone displacement and the error by the marker being located in the skin (Kolk et al., 2016; Kai et al., 2016).

The recently developed shape matching technique using the 3-D-2-D model registration technique was originally used for in vivo 3-D motion analysis of total knee arthroplasty (Banks & Hodge, 1996).

I will explain how to apply this method on shoulder joint in this section.

The subjects placed their shoulder at the center of a single-plane X-ray system (Infinix Activ; Toshiba, Tochigi, Japan). Fluroscopic images of the subjects were obtained during arm abduction at 30 HZ, as the arm was elevated and lowered from the rest position to the maximum abduction position at a speed of 3 seconds per full elevation motion. All subjects were given a 40-second break for relaxation between each taking fluoroscopy. A total of 3 trials were performed and median values were used for analysis. Fluoroscopic images were calibrated with a calibration file to compensate for the distortions of the geometric images and of the radiographic projection parameters of the object. bilateral CT scans of the humerus and scapulas were taken (SOMATOM Sensation 16; Siemens Medical Solutions, Malvern, PA) at a 1 mm slice pitch (image matrix, 512 × 512; pixel size, 0.9765625 × 0.9765625 mm).

CT images were segmented and 3D models of the humerus and scapula were made with ITK-SNAP (ITK-SNAP; Penn Image Computing and Science Laboratory, Philadelphia, PA). Additionally, a coordinate system was applied to each model of the humerus and scapula using Geomagic conventions (Geomagic studio; Geomagic USA, Morrisville, NC).

The fluoroscopic images were matched with 3 D models of humerus and scapular using JointTrack. (www.sourceforge.net/projects/jointtrack) through model image registration technique.

The scapular kinematic data for the upward, posterior, and external rotations obtained with Euler angle sequences were plotted as a function of the arm elevation and lowering angle.

The scapular kinematic data was interpolated with the best-fitting polynomial function. To find the tendencies for the upward rotation, posterior tilting, and external rotation, we found the best-fitted polynomial curve with quadratic or cubic plots using the moving average method. The scapular rotation angles were plotted in 15° increments of the arm elevation and arm lowering using MATLAB code (MathWorks Inc., Natick, MA, USA). To minimize the influence of different postures among the subjects, the scapular posterior tilting and external rotation angle were shifted to 0° at the starting position. Before shifting, these angles were measured at the resting position.

Recently, a Bi-plane fluroscopy method has been used to reduce errors in out of plane (Bey, Kline, Zauel, Lock & Kolowich, 2008). Shape matching technique has a disadvantage of radiation hazard, and it is difficult to measure the relationship with other joints because the measurement site is confined to one joint only. However, more accurate dynamic kinematic information than other methods can be obtained and the accessibility of researchers can be improved by using fluoroscopy, which is commonly available in hospitals. This shape matching technique is a very accurate method, but it is also an indirect tool. Shape matching technique has recently become popular because it provides a kinematics value that reflects the in-vivo state and can be linked to the clinic. The preoperative and postoperative clinical results are correlated with the kinematic value, so that there is a high expectation that they will be able to measure and compensate for the deficient part in cooperation with the muscles.

## CONCLUSION

Each tools has their own advantages and disadvantages. But many evaluation tools including simple radiographs, cadaever study and electromagnetic tracking system have a big limitation that cannot reproduce 3-dimentional motion. Instead, shape matching technique will be a useful and unique tool to evaluate 3 D shoulder motion and its kinematics values.

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