Validation of new 3D glenoid version measure on truncated scapulae for TSA planning

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Introduction: For any image guided surgery, independently of the technique which is used (navigation, templates, robotics), it is necessary to get a 3D bone surface model from CT or MR images. Such model is used for planning, registration and visualization. For Total Shoulder Arthroplasty (TSA), there are many challenges. The glenoid version assessment is crucial in this procedure. Several recent studies focused on the 3D orientation of the glenoid face. New methods to compute 3D version angle of the glenoid have been proposed [1,2]. These methods proposed different definitions of the glenoid plane and only used 3 points to define each plane on the 3D model of the scapula. In practice, patients often come to consultation with their CT-scans. In order to reduce the X-ray dose, the scapulae are often truncated on the inferior part or medial side or both. In these cases, the referential scapula plane defined in the cited methods cannot be calculated because it is based on specific points on the scapula. Therefore, the patient will need to do another CT-scan which is not acceptable. We hypothesized that a new plane definition, of the scapula and the glenoid, that takes into account all the 3D points, would have the least variation and provide more reliable measures whatever the scapula is truncated or not. The purpose of the study is to introduce new fully automatic method to compute 3D glenoid version for TSA preoperating planning and test its results on artificially truncated scapulae.

Material and Methods: Volumetric preoperative CT datasets have been used to derive a surface model shape of the shoulder. The first step of this planning software is fully automatic segmentation method [3,4]. The second step is a full morphological analysis of the bony anatomical structure. The glenoid surface is detected and a 3D version and inclination angle of the glenoid surface are computed. We propose a new reference plane of the scapula without picking points on the 3D model. The method starts by computing the mathematical skeleton of the scapula using the wide known mathematical morphology techniques. In the second step we use the least squares techniques to fit a plane to 3D points of the skeleton. Specific software has been developed to apply the plane fitting in addition the automatic segmentation process. The software automatically detects the glenoid surface and fit least squares plane in the same manner. The glenoid version is defined by the angulation between the scapula and the glenoid plane. The plane found is very robust because it is based on a cloud of 3D points representing the finest form of the scapula and not only 3 points like in the traditional method.

An orthopedic surgeon defined the traditional scapular plane based on 3 points: the center of the glenoid, the most medial point of the spina scapula and the inferior scapular point. He applied the measures on 12 patients. The manual process has been repeated 3 times and the intra-class correlation coefficient (ICC) was calculated to compare the results with our automatic method. To validate the reliability of the new plane relating to truncated scapulae, we have measured the 3D orientation variation on 37 scapulae. Nine iterations have been applied on each scapula by cutting 5mm of the scapular inferior part. We run the same procedure on 7 scapulae by cutting the medial side with same number of iterations and same cutting width.

Results: The ICC of the scapula plane orientation for the three orientation components (x,y,z) were 0.98, 0.99 and 0.89 respectively. The reliability results applied by cutting the inferior side show good results
with means: 0.01±0.01 mm, 0.01±0.01 mm and 0.02±0.02 mm for X,Y,Z respectively. For the medial side, the results are 3 to 4 times higher because of the important cut volume but they are still acceptable, means: 0.05±0.02 mm, 0.04±0.03 mm and 0.02±0.02 mm for X,Y,Z respectively.

**Conclusions:** New referential scapular plane has been proposed to compute 3D glenoid version. The method is fully automatic and doesn’t need manual positioning of points on the 3D points. The orientation of the new plane is correlated with the standard scapular plane. The new plane has potential utility to define reliable measures because there is no sensitivity to anatomic landmarks definition. The study showed that plane orientation is reasonably constant while truncating the scapula body till 45mm of cut on the inferior and the medial side. This is the only study that proposes a reference plane for truncated scapula.

**References**


