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STRAIN MEASUREMENT OF SHOULDER CAPSULE USING FINITE ElEMENT METHOD

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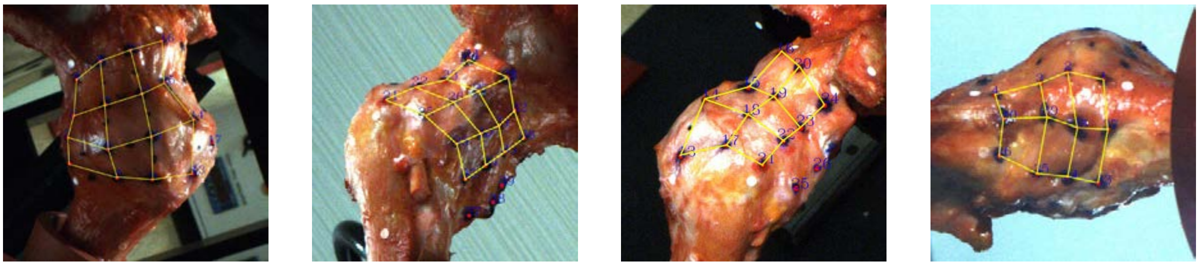
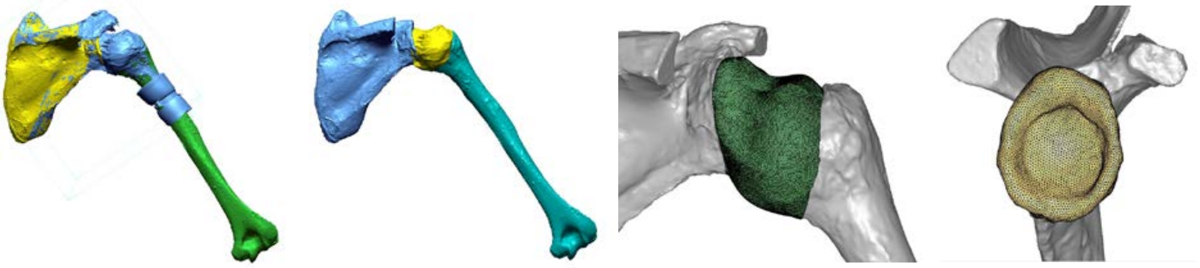
In recent years, many patients suffer from shoulder related disease, for example, dislocations, sprains, tendinitis, bursitis, torn rotator cuffs, frozen shoulder, fractures, arthritis and so on. Of these, especially frozen shoulder is very common in many over-50s and it accompanies pain and the reduced joint range of motion. Clinicians use multiple methods to relieve symptoms such as medication, injection therapy, stretching exercises and joint surgery. In most cases, except for severe condition, stretching exercise is widely used to increase range of motion of the shoulder. But due to the complexity of its motion, sometimes, clinicians have a different opinion for the same symptoms in exercise strategy. And many patients have complaints for over spending a considerable time to do a complicated set of exercise. If a correlation between lesions of the capsule and specific joint motion is known, clinicians could suggest more effective and patient-specific shoulder exercise. Therefore, in this study, cadaveric test was performed to measure the distribution of capsule strain in several joint positions relative to the motion of humerus. And the FE model was developed to analyze invisible area in cadaveric test. For this purpose, the distribution of maximum principal strain and deformed shape of the glenoid capsule was measured for a cadaveric shoulder in several joint positions (0°, 30°, 60°, 90° of glenohumeral abduction and 15°, 30°, 45° of internal/external rotation).



(a) posterior region (b) anterior region (c) superior region (d) inferior region

Fig 1. Captured images for 3D reconstruction to obtain the locations of targets

At each joint position, the locations of the strain markers were recorded using two calibrated cameras. And 3-dimensional reconstruction of stereo images was performed for all joint positions. On average, 6 images were used for reconstruction in each case. With the acquired locations of 40 markers, the maximum principal strain was calculated in the reference and strained configurations at the centroid of elements which were created by four neighboring strain markers. Following that, specimen was scanned by a 3D scanner to obtain geometric data for FE modeling. FE model which includes scapula, humerus and shoulder capsule was developed based on scanned data. FE model was simulated in the same manner as the experiment. Displacements of datum points on the humerus were applied as the boundary condition for positioning humerus to appropriate joint position.



(a) scanned points data (b) surface geometry (c) FE capsule model (d) FE labrum model

Fig 2. FE modeling using 3D scanned point data

To validate the FE model, some additional modeling and simulation was performed. For a direct comparison of strain and deformed shape, the comparable capsule model was developed. This model was modeled with extracted base nodes, which are corresponding to the 40 markers. Obtained displacements of the base nodes from FE simulations were applied to the comparable capsule model for 30° abduction (15°, 30°, 45° of internal/external rotation) case. Then, resultant strain and deformed shape were compared with experimental results. Resultant strain of the comparable model was similar to the experimental results and the tendency of strain and deformed shape variation along with the joint position were also pretty similar. In conclusion, the detailed FE model which can simulate the motion of the glenohumeral capsule was developed and validated based on the experiment. In the future work, FE model could evaluate the strain of the specific area which is hard to analyze with experiment. Based on these findings, it may be possible to speculate the contribution of the capsule area to specific shoulder motion. And it'll be helpful to develop effective treatment methods that can reduce the duration of the patient should be considered for various shoulder diseases.

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