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Erzeugung von 3D Ultraschall-Bildvolumen zur Anwedung bei Untersuchungen des Schultergelenks

Acquisition of 3-D ultrasound image volumes for application in shoulder joint insoection

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Introduction

A diagnostic inspection of the shoulder is usually performed by taking 2-D ultrasound images in typical sonogram acquisition orientations. The acquisition makes high demands on the physicians experience and moreover only allows for a small field of view. Structures like the acromion, clavicle and coracoid process act as a sound absorber and additionally minimize the field of view. It is expected that the diagnostic quality can be increased by the use of 3-D sonography. It would make the findings less dependent on the investigators experience. Additionally, 3-D image volumes can potentially be used for pre-operative planning like a biokinematically optimized positioning of a shoulder endoprosthesis and for intra-operative control. In this study, we investigated how humeral landmarks can be visualized in freehand acquired 3-D ultrasound image volumes.

Material and Methods

An appropriate image acquisition technique, using a conventional 2-D ultrasound scanhead system (Nemio(TM) SSA-550A, Toshiba, Tokyo, Japan) employing B-mode imaging from 6-12 MHz and an infrared optical localizer system (Polaris(TM), Northern Digital Inc., Waterloo, Ontario, Canada) was specified and developed. The acquisition system was able to sample at least 10 images per second with the corresponding position data for each image. The image series consisted of about 800-2500 2-D images and were visualized as original 2-D and reconstructed 3-D images on a PC screen. After recording, the 2-D images

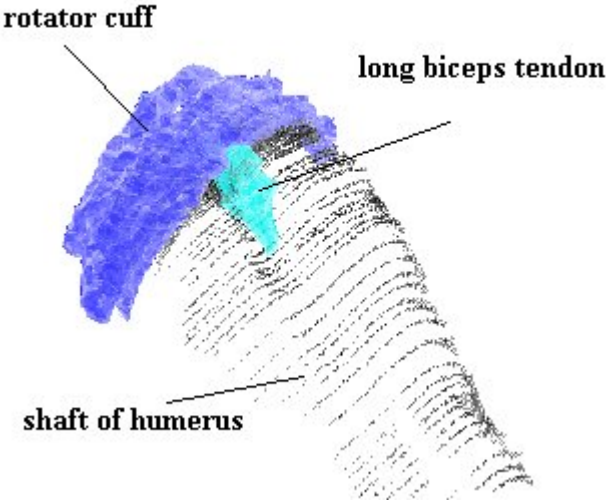
were segmented semiautomatically. A spherical measurement volume with radius120mm is needed to scan the entire shoulder joint. The localizersystem has a measurement volume with radius of up to 500mm. In this volume, the localizer system works with an accuracy of less then 0.2mm. The geometrical correctness of the 3-D image volumes must be determined experimentally using reference structures.

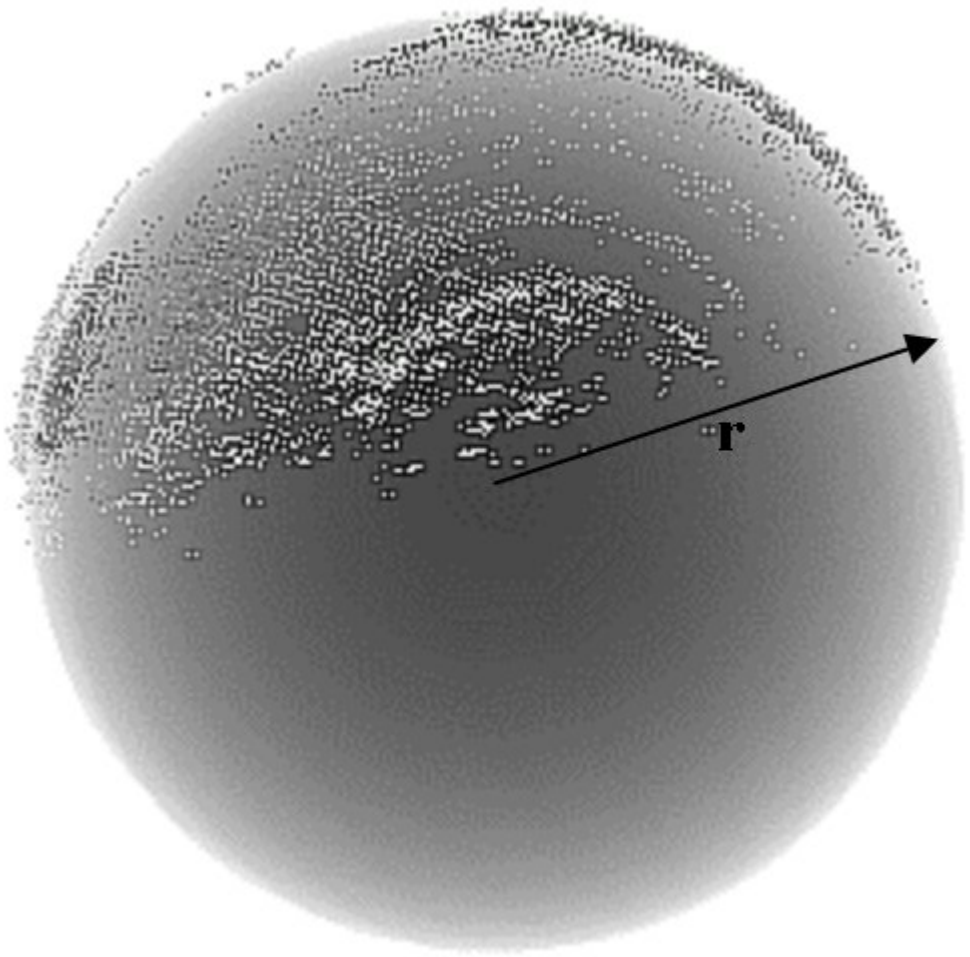
Results

Experiences on healthy volunteers has been carried out. The visualization of these image volumes gave precise insight into anatomical relations. Clearly visible were the lateral humerus, the humeral head, the intertubercular sulcus, the medial, and the lateral epicondyles. In further experiments, the geometric precision of the image acquisition technique was investigated for spherical solid models (radius 14.0 - 18.2mm) which were placed in a water bath. Their radii were calculated from the acquired images after a binarization of the gray scale volume by using a Least Squares fit of the remaining voxels positions to a sphere. The radii matched with an RMS of less than 0.5mm.

Discussion

Visualization of the human shoulder joint from 3-D ultrasound volumes has been proven successful. It can be expected that the entire humeral head would be visible, if the humerus were turned around its longitudinal axis during image acquisition. Segmentation increases the visibility of anatomical structures in the gray scale image volume, it should be performed full automatically in order to avoid a tedious ans error prone manual process.


rotator cuff
long biceps tendon
shaft of humerus



$$r=(18.2 \pm 0.5)mm$$