Section: **Ultraschall und Intervention**

ID: 154

Abstract-Title:
FREEHAND ULTRASOUND SUPPORTED AND NAVIGATED IMPLANTATION OF SHOULDER ENDOPROSTHESES

Authors:
U. von Jan[1], D. Sandkühler[2], L. Kirsch[3], H.K. Matthies[1], O. Rühmann[3], H.M. Overhoff[2]
[1] Hannover Medical School, Institute of Medical Informatics
[2] University of Applied Sciences Gelsenkirchen, Medical Engineering Laboratory
[3] Hannover Medical School, Orthopedic Department

Abstract-Text:
Purpose

The use of ultrasound in the shoulder area is nowadays mostly limited to examinations performed by acquiring and evaluating conventional, two-dimensional images in predefined, standardized acquisition orientations. The field of view which is thus provided to inspect the three-dimensional geometry of the joint is greatly limited and high demands are placed on the physician\'s ability to determine the correct position of the scanhead and to interpret the images. When considering ultrasound imaging for use in a surgical planning scenario, e.g. for the implantation of the humeral part of a shoulder prosthesis, the conventional, two-dimensional imaging technique must be extended to three dimensions; a (semi-) automatic segmentation and interpretation, i.e. for determining three-dimensional measures which can be utilized in the planning process as well as during the navigated intervention, is also desired. The determined parameters are then applied in the navigated implantation of the prosthesis according to the patient\'s individual anatomy.

Method

A cadaver study was performed to determine the accuracy of the position of the shoulder prostheses which were implanted with the aid of a navigation system and under freehand ultrasound guidance. Using a tracked conventional ultrasound system, N = 8 three-dimensional ultrasound image volumes of the upper arms of human cadavers were acquired as manually controlled freehand sweeps. In the image volumes, the bone surface was detected by a semiautomatic, locally adaptive segmentation process based on methods available in the Insight Toolkit library. Using the transducer\'s tracking data, the 2-D ultrasound images were automatically classified according to the anatomic region they belong to, i.e. humeral head, shaft or elbow. Since each anatomic region has its own peculiarities, it is possible to employ an optimized, slice-wise segmentation strategy for each. After the segmentation results were subjected to various plausibility tests, in which a small number of slices were rejected, the parameters for the planning scenario could be calculated based on numerous landmark positions. These were either determined automatically by robust approximation algorithms (i.e. sphere-approximation for the humeral head, cylinder approximation for the proximal shaft) or - for more complex

anatomical structures - defined interactively by an expert. The parameters were then used in the subsequent, navigated implantation of the humeral part of a shoulder endoprosthesis. Its position was thus adapted to the patient\'s specific anatomy, which is important since there is a high anatomical variability of the humerus not only between different individuals, but even between the left and right side of the same individual.

Results

Even though a notable decrease in the image quality of the acquired volumes could be observed (compared to live patients), satisfactory segmentation results and surface reconstructions were possible for all of the acquired image volumes. Using the reconstructed surface of the humerus, the necessary parameters for the further steps could be reliably calculated. The interactive planning scenario was based on the parameters of the identified landmarks. By providing 2-D cutting planes as well as different 3-D views of the planned scenario within the user interface, an intuitive simulation of the prosthesis implantation, including the parameters for the individual components of the prosthesis was possible. These could then easily be transferred to the implantation process. The implantations performed in the cadaver study confirmed the good fit of the prostheses implanted according to the planned parameters.

Conclusion

With appropriate data acquisition techniques, 3-D ultrasound volume based surgical planning and navigated implantation offer interesting possibilities. A fully automatic segmentation process and a full fledged and easy to use intraoperative navigation tool are items of ongoing work.

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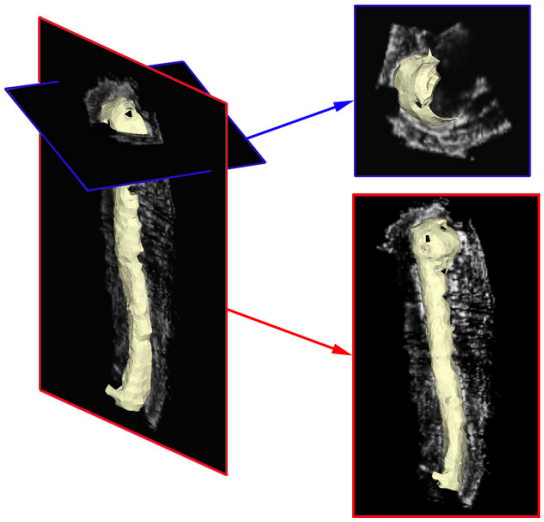

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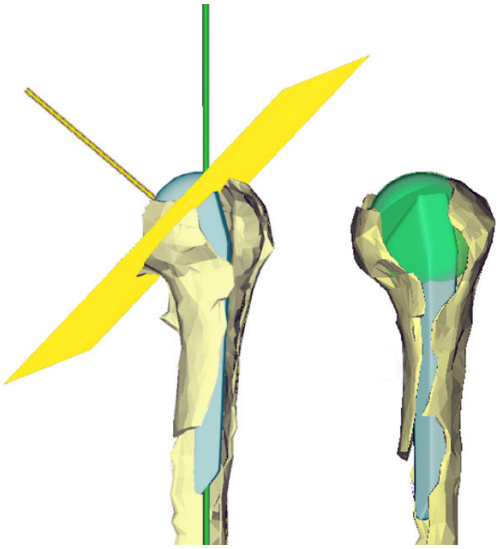

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