Section: **Ultraschall und Intervention**

ID: 155

Abstract-Title:
3-D SONOGRAPHY-BASED DETERMINATION OF A PELVIS COORDINATE SYSTEM FOR NAVIGATED ACETABULUM PROSTHESIS IMPLANTATION 3-D SONOGRAPHISCHE BESTIMMUNG EINES BECKENKOORDINATENSYSTEMS FÜR NAVIGIERTE ACETABULUMPROTHESENIMPLANTATIONEN

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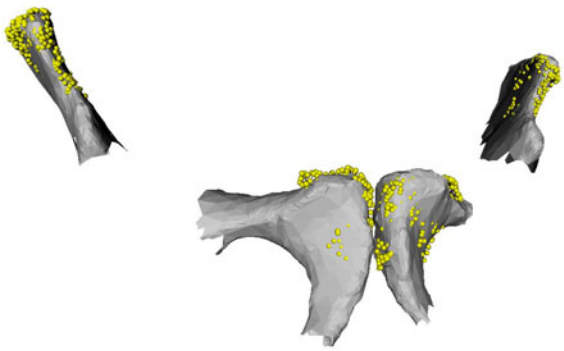
Abstract-Text:
Purpose:
The definition of a reproducible local coordinate system (LCS) is a first necessity for an objective quantification of anatomical relations in bones. At the pelvis the iliac anterior superior spine and the pubic symphysis are accessible percutaneously. Their three-dimensional position estimation by palpating them, leads to systematic errors due to the thicknesses of the tissues between skin and bone. As these landmarks are also visible in sonograms, it is investigated how their spatial positions can be determined more precisely with three-dimensional ultrasound (3-D US).
Method:
3-D US image volumes of the pelvis of 2 healthy volunteers and 10 patients for planned total hip replacement were acquired. For this an ultrasound imaging system with a 5-10 MHz linear probe (Echo Blaster 128 and HL9.0/40/128, Telemed, Vilnius, Lithuania) was used together with an infra-red optical localizer system (CamBar, Axios3D Services GmbH, Oldenburg, Germany). A rigid body defined by 4 reflective spheres was attached to the scanhead. The rigid body`s position is recorded along with the 2-D images during image vs. sensor calibration and image-acquisition.
For landmark's image acquisition the investigator is guided by a Graphical User Interface (GUI). A virtual pelvis model is aligned along manually roughly determined landmark regions. The virtual pelvis model is the result of a coarse shape analysis of 6 CT-scanned pelves. It showed, that by means of projective geometry (scaling, translation, rotation) each of the CT-scanned landmarks regions could be matched with a position error RMS less then 3 mm (fig. 1).
As the rough orientation of the virtual pelvis only serves as hint for the acquisition of US-images, one representative CT-volume was chosen to be manually segmented. The virtual pelvis was generated as surface model of the delineated voxels.
At the iliac anterior superior spine three, at the pubic symphysis two US-image series in typical orientations – visualized in the virtual pelvis model (fig. 2) – are recorded in manually performed freehand sweeps. An US-image series consists of about 50-100 images – a typical example recorded at the iliac anterior superior spine is presented in fig. 3. It is segmented image by image computer-based using a heuristics on bone

representation in US-images. As result of this processing step a common voxel cloud is determined from two resp. three different oriented image series for each of the three landmarks. The voxel clouds show the delineation of the bone surface at the landmark region. Each of the voxel clouds is mathematically matched to a representative model for each landmark.
From these three landmark models the pelvis LCS is determined. The pelvis LCS allows to estimate the anterior pelvic plane. Relative to its orientation the acetabular prosthesis' orientation is quantified by anteversion and abduction angles.
Results:
Image acquisition took less then three minutes, also the image series analysis was performed in less then three minutes. During the segmentation poor US-images were rejected. The segmentation result, the 3-D position of the landmark models, and so the correctness of the determined pelvis LCS are severely dependent on the US-image quality. The GUI guidance proved to support the acquisition of contrast intense US-image series essentially.
Conclusion:
The visibility of the pelvis landmark regions is sufficient to acquire contrast intense US-images under good imaging conditions. Under these conditions the automatic image analysis based LCS definition is a means to determine the anterior pelvic plane precisely. Ongoing work will access the correctness of the landmark's positions e.g. in a cadaver study and the influence of tissue dependent sound velocities potentially causing distance measurement errors.

Figure 1: Matching of two virtual pelvis models (grey surface vs. yellow points) at the landmark regions. The good fit is visually documented.
Figure 2: Orientation of a typical ultrasound image series (red) recorded at the iliac anterior superior spine (blue)
Figure 3: Ultrasound image recorded at the iliac anterior superior spine (blue)

Bild 1/JPG



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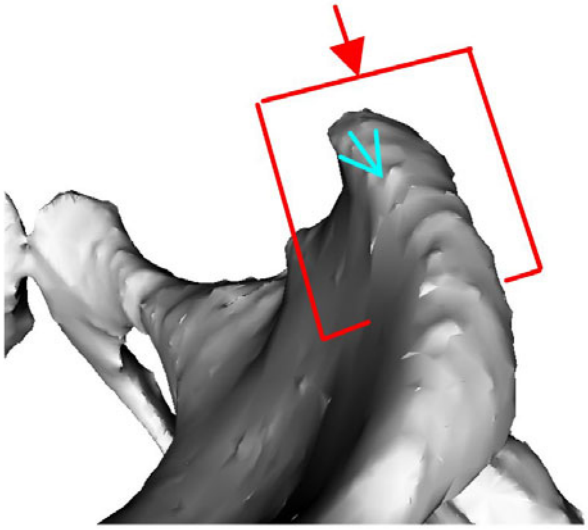

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