Ultrasound registration of the lumbar spine - evaluation of different patient attributes

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Introduction
Avoiding injury of the neural tissue and warranting high spinal stability in vertebral fusion techniques requires precise screw insertion.
Computer assisted surgery in spinal fusion techniques helps to precisely place the screws in the pedicle. However, in navigation systems based on CT or MRI images do not allow real time corrections. Furthermore, the intraoperative imaging systems are expensive and additional radiation is exposed to the patient and surgeon. After successfully establishing an algorithm for the registration of CT-data sets based on ultrasound images in vitro we wanted to evaluate ultrasound registration procedures in different patients finding predictive factors allowing accurate ultrasound registration.

Material and Methods
Eight patients admitted in our department due to lumbar disc herniations for surgery were entered into the study. Preoperative lumbar spiral CT from L3 to S1 was done and patients anthropometric data was obtained. For 3D ultrasound data affiliation a 3.5-MHz curved array probe was used. Assessment of the image quality was measured by using a 5-point rating score. Ultrasound data sets were utilised as 3D gray value data sets for registration. Additionally, pre-processing for bone surface enhancement and extraction of surface points in CT was done. A rigid surface-volume algorithm with six transformation parameters was used for registration.

Results
In eight patients 24 vertebrae were scanned. The patients age was 60 ± 14 years, the mean BMI was 30 ± 3. Skin bone distance was 9 ± 3 cm . Ultrasound quality was assessed as good in 2 patients, as moderate in 2 patients, as fair in 3 patients and as poor in one obese patient. In 21 vertebrae (87.5%) a successful registration with spiral CT-data sets was possible. Three vertebrae could not be registered due to poor ultrasound quality.

Conclusion
3D ultrasound is a diagnostic tool easy to be transferred, allowing real time data acquisition without the disadvantages of CT or MRI based systems.
The limited quality of ultrasound images of the spine makes it currently impossible - compared to brain surgery - to use the native images during surgery. However, in the registration for spinal navigation the image quality is sufficient. Even in patients with apparently bad ultrasound conditions most data sets can be registered with the applied surface-volume algorithm.