The infraacetabular bone corridor: a three-dimensional CT-based visualization of a safe pathway for long screws

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Introduction: Acetabular surgery is one of the most challenging fields performed in skeletal trauma. This fact may be due to extensive surgical soft tissue dissection and the complex pelvic anatomy. When closed fracture reduction is successful or possible with limited surgical dissection, percutaneous insertion of long "strategical screws" can achieve sufficient fragment fixation. In several fracture patterns infraacetabular (IA) screws interconnecting the anterior and posterior column can enhance biomechanical stability. However, the small isthmus of Köhler´s "teardrop" aggravates accurate screw insertion and is associated with a high risk of screw malposition.

Objectives: The aim of this study was to analyze if a sufficient secure pathway for a 3.5 mm infraacetabular screw regularly exists in human pelves. Furthermore, spatial shape analysis should declare the optimal screw entry area and the location of critical regions related to anatomical bone structures. Computation of a custom made software algorithm should allow automatic visualisation of virtual 3-D corridors within the infraacetabular region based on pelvic multislice CTscans.

Methods: 3-D corridors for a 3.5 mm cortical screw were computed as a sum of all possible trajectories through the infraacetabular region using a custom made C++ software algorithm. Eleven routine CT datasets of intact human pelves (male=8, female=3) with an image resolution of 512 x 512, a slice distance of 0.6 mm and the kernel B45f were used for further data processing. First, semiautomatic segmentation was performed with the software Amira® (Visage Imaging, Berlin, Germany) to create binary pelvic 3-D images. Second, pelves were spatially aligned in a 3-D coordinate system using representative bone landmarks. Additionally, limiting anatomical structures were marked by mouseclick to exclude later computation of unfavorable screw trajectories. Last, 3-D infraacteabular corridors were generated fully automatically by the program script. Measuring data namely screw entry and exit area, corridor volume and isthmus cross-section were calculated by the script.

Results: Computation of secure 3-D bone pathways as the sum of all usable innerbony trajectories for a 3.5 mm cortical screw consistently resulted in dumbbell-shaped infraacetabular corridors with oval footprints. In every pelvis corridors existed bilaterally. Mean volume was 15 ± 6.3 cm³. The limiting isthmus projected to Köhler´s "teardrop" with a mean cross-section of 69 ± 29.5 mm². The screw entrance area projected to the iliopectineal eminence laterally to the pelvic brim with a size of ø 291 ± 143.5 mm². The bony exit area on the ischial tuberosity showed a mean size of 360 ± 145.8 mm².

Conclusion: Three basic conditions were identifed to define three-dimensional corridor shape namely individual pelvic anatomy, implant geometry and implant penetration depth. The introduced computer-based workflow allows automatic 3-D visualization of the infraacetabular corridor even in high numbers in routine CT datasets of the pelvis. It improves surgeon´s visual thinking and allows precise pre-operative planning of acetabular fracture fixation with an infraacetabular screw based on routine CT datasets. Before mentioned corridor dimensions can be calculated in an output file for further statistical radiomorphometric analyses. Furthermore, 3-D corridor datasets can be stored as DICOM Files. Prospectively, implementation of automatic corridor calculation can enhance performance of computer-assisted surgery.

References

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