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Different stabilisation techniques for typical acetabular fractures in the elderly—A biomechanical assessment

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ABSTRACT

Objectives: The tremendous increase of acetabular fractures in the elderly provides new challenges for their surgical treatment. The aim of this study was to evaluate the biomechanical properties of conventional and newly developed implants for the stabilisation of an anterior column combined with posterior hemitransverse fracture (ACPHTF), which represents the typical acetabular fracture in the elderly.
Methods: Using a single-leg stance model we analysed four different implant systems for the stabilisation of ACPHTFs in synthetic and cadaveric pelvises. Applying an increasing axial load, fracture dislocation was analysed with a new multidirectional ultrasonic measuring system. Results of the different implant systems were compared by Scheffé post hoc test and one-way ANOVA.
Results: In synthetic pelvises, the standard reconstruction plate fixed by 3 periarticular long screws and a new titanium fixator with multidirectional interlocking screws were associated with significantly less dislocation of the fractured quadrilateral plate of the acetabulum when compared to a standard reconstruction plate fixed by only one periarticular long screw and a locking reconstruction plate. No significant differences between the different osteosynthesis techniques could be observed in cadaver pelvises, probably due to a heterogeneous bone quality.
Conclusions: We conclude that the plate fixation by positioning of periarticular long screws as well as the multidirectional positioning of interlocking screws account for the most sufficient fracture stabilisation of ACPHTFs under experimental conditions.

Introduction

During the last 30 years, the open reduction and internal fixation of acetabular fractures by standard approaches (Kocher–Langenbeck and ilioinguinal approach) has been greatly improved due to the extensive studies of Judet and Letournel and co-workers[11] as well as the continuous improvement of X-ray analysis and the consequential use of standardised classification systems.[2,7,9,13,14,17,28] Insufficient fixation of acetabular fractures may result in non-unions, while inadequate reduction frequently leads to arthrosis.[17] Thus, surgical reduction of the acetabular joint represents the most reliable possibility to prevent the development of premature arthrosis.[6,19] Today, ORIF of acetabular fractures is performed even in the elderly, although in the 1960s high age was considered to be a contraindication for acetabulum surgery.[10,15] According to epidemiological studies performed by the *German pelvic study group 2* (German trauma association [DGU]/Association for Osteosynthesis [AO]) 14% (118/823) of all pelvic injuries in patients over 65 years are acetabular fractures. Fractures of the anterior column and the anterior wall represent the major part of the acetabular fractures in the elderly (43/118). Particularly, fractures of the anterior column combined with posterior hemitransverse fractures (ACPHTFs) resulting in a protrusion of the femoral head (classification of Letournel; type 62-B3 according to the classification of the AO/ASIF) are prevalent in the elderly.[10]

Surgically, ACPHTFs might be treated by hip arthroplasty[18] or by open reduction (using an ilioinguinal approach) and internal fixation (with a pelvic reconstruction plate).[1,10] To prevent protrusion of the femoral head, a stable fixation of the anatomically reduced fragments is mandatory, but also very difficult because of critical bone quality of geriatric patients.[3,10,15,23] Although biomechanical studies showed that periarticular long screws result in an increased stability of the plate fixation, it has to be considered that the insertion of these screws always bears the risk of penetrating the joint.[24,26] To

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overcome this problem, a pre-bended H-plate might be placed under the reconstruction plate, which could also prevent protrusion of the femoral head.[16] However, the secondary failure of this H-plate is a common complication resulting in non-unions and thus the need for secondary hip arthroplasty afterwards.

So far, no comparative biomechanical data are available for the stabilisation of typical acetabular fractures in the elderly. Therefore, the aim of this study was to evaluate the best implant configuration for the prevention of quadrilateral plate protrusion in ACPHTFs. The use of synthetic pelvises allowed the evaluation of the osteosynthesis techniques independently of individual differences in bone quality. By using cadaveric pelvises the impact of the reduced bone quality on the stability of the different osteosynthesis methods was assessed. Every donor granted permission for scientific use according to the National Institute of Health guidelines.

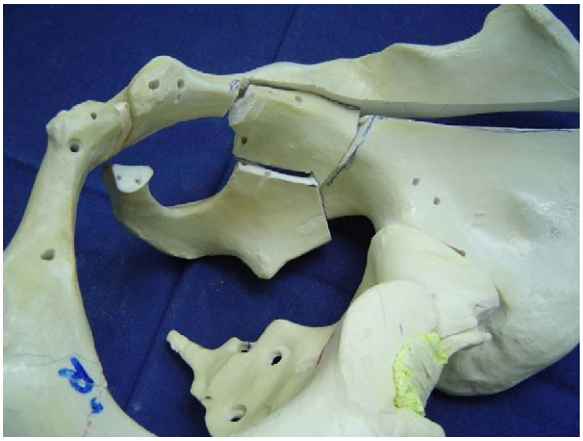

Fig. 1. Fracture model of an ACPHTF displaying a break out of the quadrilateral plate.

Materials and methods

Specimens

The study was conducted using 6 synthetic (Pelvis 4060, Synbone, Bettlach, Switzerland) and 4 cadaveric pelvises. After resection, the cadaveric pelvises were cleaned from surrounding soft tissue, whereas the anterior, the interosseous, and the posterior sacroiliac ligaments, as well as the sacrotuberal and the sacrospinal ligaments were retained. The pelvises were stored at −32 °C until biomechanical testing.

The age of the donors averaged 79.8 years. Mean body weight was 74.3 kg and mean height was 171.8 cm. Before death, none of the donors was immobilised over a longer time period.

The degree of osteoporosis was determined by dual-energy radiograph absorptiometry (DEXA) (Discovery, Hologic Inc., Bedford, MA, USA) of the according fourth and fifth lumbar vertebra. In addition, a screw break out analysis was performed to determine the biomechanical bone quality. For this, 3.5 mm titanium screws were inserted into the anterior inferior iliac spine (SIAI), the supraacetabular region (SUPRA), and the S1 pedicle (SACRP1). Applying a gradually increasing axial traction (5 N/s), force at failure was recorded for each screw.

Fracture model

Using a well-established single-leg stance model,[4,21,22] the pelvis was positioned in the level of the anterior iliac spine, whereas the symphysis was located orthogonally to the ground. This set-up imitates the physiological pelvic anteversion of 50–60°.

ACPHTF with a protrusion of the quadrilateral plate was accomplished by an osteotomy along pre-marked fracture lines (Fig. 1). The protrusion was indicated by a medial dislocation of the marked fragment. In all cases, the symphysis was fixed ventrally by a 4.5 mm 4-hole low contact dynamic compression plate (LCDCP).

Implants

The acetabular fracture was stabilised using the following implants:

A. Conventional implants
   1. A standard 3.5 mm pelvic reconstruction plate (12-hole) (Synthes, Solothurn, Switzerland), which was applied to the pelvic brim. Using this implant, we performed three test cycles. During the first test cycle, fracture stabilisation was achieved by three periarticular long screws, two placed into the anterior and one placed into the posterior column. After this first test cycle the posterior screw was removed. In accordance, the fracture was fixed during the second test cycle by the two anterior column screws. After this second test cycle we removed additionally the posterior screw of the anterior column. Thus, the fracture was fixed during the third test cycle only by one anterior column screw. Data are presented only for the first and the third test cycle. The rationale of performing these three test cycles was to analyse the impact of the posterior column screw on the stability of the osteosynthesis (Fig. 2).

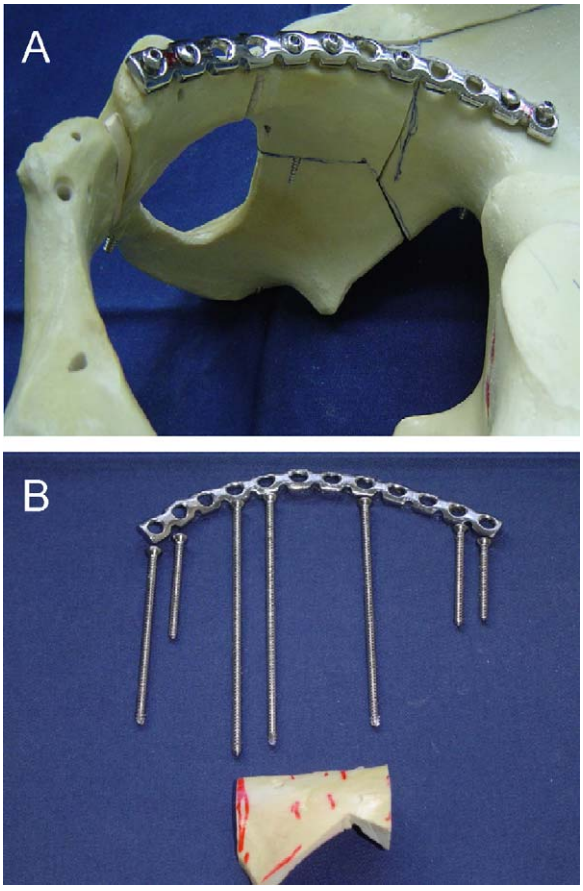

Fig. 2. Reduction and fixation of an ACPHTF (A) using a 12-hole pelvic reconstruction plate (B). The 3 periarticular screws stabilise the quadrilateral plate (b).