

Abstract

Introduction: Vertically unstable sacral transforaminal fractures can be stabilized both with a transiliac internal fixator (TIFI) or iliosacral screws (IS).

Goals: 1. comparison of radiological and clinical results between dorsal pelvic segment stabilization with TIFI, IS respectively, 2. evaluation and comparison of biomechanical parameters of TIFI and IS construct.

Material and methods of clinical study: Prospective study, both TIFI and IS group had 32 patients, the most of injuries were assessed as type C1.3, only patients with a high-energy mechanism of injury were included. Radiological results were evaluated according Matta, clinical results according Majeed score, Pelvic Outcome Score. Categorical data were evaluated by two-sided Fishers exact test or Pearson's χ^2 test, continuous data by Student's t-test, a test result with $p < 0.05$ was considered as statistically significant.

Methods of biomechanical study: Using CT images, finite element model of the pelvis was developed. Pohlemann type II fracture was simulated and fixed either with TIFI or two IS. The sacral base was loaded vertically (250-500 N), displacement magnitudes on medial and lateral fracture surface and the maximum bone stress were calculated. The intact pelvis was used as a reference. Stiffness was determined by linear regression of load and displacement, computed stiffness ratio %. Von Mises stress was expressed as % ratio, evaluation of colour mapping was also performed.

Results: In TIFI the mean posterior dislocation was 2.2 mm, in IS 1.9 mm ($p = 0.58542$). Pelvic Outcome Score in the TIFI group: excellent 28 %, good 12 %, fair 48.0 % poor 4 %, in the IS one: excellent 11.1 %, good 22.2 %, fair 66.7 % , poor 0.0 % ($p = 0.51731$). According to Majeed score in TIFI were obtained these results: excellent 56.0 %, good 16.0 %, fair 20.0 %, poor 8.0 %, in IS: excellent 50.0 %, good 27.8 %, fair 11.1 %, poor 11.1 % ($p = 0.70187$). Within the total, average Majeed score was 80.64 points in TIFI, 80.67 in IS ($p = 0.99654$). In a sub-analysis for unilateral transforaminal fracture (Pohlemann type II) average score of TIFI was 82.8 points, in IS one only 53.5 points, differences were statistically significant ($p = 0.04517$). TIFI was without intraoperative complications, in IS was one injury to the superior gluteal artery (3.1 %) and two iatrogenic neurological injury occurred (6.3 %, $p = 0.23810$). TIFI was extracted without complications, in the IS group postoperative bleeding from the inputs of screw occurred in 3 patients (20.0 %, $p = 0.22414$), complete extraction of screws and washers was successful only in 7 patients (46.7 %), in 6 patients washers were left in situ (40.0 %), inability of IS removal occurred in 2 patients (13.3 %). When comparing the number of complicated extraction differences were highly statistically significant ($p = 0.00220$). The mean stiffness ratio medially in TIFI was 75.22 %, in IS 46.54 % ($p = 0.00005$), laterally in TIFI 57.88 %, in IS 44.74 % ($p = 0.03996$). Von Mises stress ratio of TIFI was 139.27 %, of IS 565.35 % ($p < 0.00001$).

Conclusion: TIFI implantation is preferred in transforaminal and central sacral fractures where unlike iliosacral screws, TIFI is coupled with a low risk of excessive compression of the sacral foramina and development of iatrogenic neurological injury. Differences of clinical and radiological results between TIFI and IS stabilization were insignificant in the overall comparison, but in case of unilateral transforaminal fracture, superiority of TIFI stabilization was shown in Majeed score evaluation. IS were associated with a higher rate of complications not only in primary implantation, but also in their removal. Significantly higher stiffness and lower bone stress was found in TIFI model. TIFI provides a lower risk of over-compression of the fracture line in comparison with IS, especially in the region of the first sacral foramen, particularly with comminutive zone. The TIFI thus exhibits both clinical and biomechanical superiority for fixation of transforaminal fractures and represents a reasonable alternative to existing types of minimally invasive fixation.