OSTEOSYNTHESIS OF THE PUBIC SYMPHYSIS: EXPERIMENTAL-NUMERICAL COMPARISON BETWEEEN TWO FIXATION SYSTEMS

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Introduction

Pelvic fractures, which often result from high-energy trauma, can involve disruption of the pubic symphysis. In these cases, adequate reduction and fixation of the symphysis are crucial for restoring stability and alignment of the pelvic ring [1]. Open reduction and internal fixation with plates has become the preferred standard of care due to its lower rate of complications compared to the other possible approaches [2]. Nevertheless, implant failure rates between 12% and 31%, loss of reduction of 7% to 24%, and revision rates of 3% to 9% have been reported in the literature [3]. Recently, a dynamic fixation approach employing the Endobutton CL device (Smith & Nephew, Memphis, TN, USA) has been proposed for reduction of pubic symphysis diastasis [4]. The aim of this study was to compare the efficacy of the Endobutton CL and the plate reduction techniques for the treatment of open-book pelvic fractures. Experimental tests were conducted to measure the performance of the devices and to assess the validity of a finite element (FE) model developed within this study.

Methods

A total of nine Sawbones pelvis samples were tested: three in a non-reduced open book fracture configuration, three with the Endobutton CL reduction, and three with the plate fixation. The boundary conditions for the tests are shown in Fig. 1a. A compressive uniaxial load was applied on the sacrum under displacement-controlled conditions at 1 mm/min speed up to 3000 N. Nine markers were placed on the specimens' surface and their displacements tracked during the test (GOM Correlate). FE models were developed to reproduce the experimental tests. Elastic isotropic mechanical properties were assigned to trabecular and cortical bone (0.155 and 10 GPa respectively), and to the 316L steel plate (210 GPa). The sacroiliac joints and the experimental boundary conditions at the acetabula were replicated through kinematic constraints and spring elements properly calibrated based on the experimental tests. The Endobutton device was modelled by means of rigid spheres connected by springs.

Results

The Endobutton reduction allowed the highest pubic symphysis opening at the maximum load of 3000 N, with an average of 5.76 ± 0.15 mm. While the fractured specimens yielded an opening of 9.02 ± 0.76 mm, the plate reduction showed a very limited symphysis opening (0.61 ± 0.30 mm). Pelvis stiffness, computed as the ratio between the force registered at the sacrum and the crosshead displacement, was only slightly higher in the case of plate fixation than in the case of Endobutton fixation (682.46 ± 65.27 N/mm against 612.56 ± 28.97 N/mm) when computed at 500 N. Nevertheless, the former showed a 75% increase of stiffness at 2000 N, while the latter showed a more modest stiffness increase, equal to 44%. The FE models achieved a good agreement with the experiments when looking at the displacement of nodes equivalent to the markers tracked experimentally (Fig 1b).

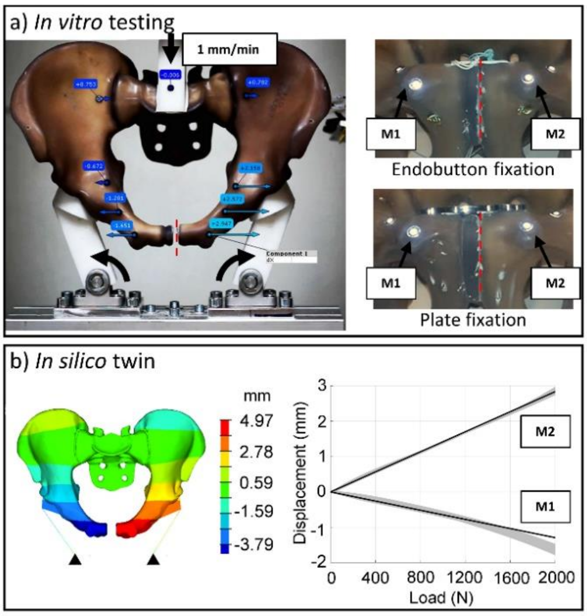

Figure 1. a) in vitro testing of fractured and fixated pelvis; b) horizontal displacement of fractured FE model with comparison of numerical (black lines) and experimental displacements (gray bands) of the two symphysis markers (M1 and M2).

Discussion

The Endobutton fixation allowed a much higher degree of mobility compared to plate fixation. For relatively low loads it proved to be stiff enough to guarantee the diastasis stability. Nevertheless, as the load increased it allowed increased flexibility compared to the plate fixation. The validated FE model will be employed to reproduce more complex physiological loading conditions in order to further compare the two fixation techniques.

References

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