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ScienceDirect
Clinical Biomechanics 23 (2008) 1012–1017
CLINICAL BIOMECHANICS
www.elsevier.com/locate/clinbiomech

Minimally invasive screw plates for surgery of unstable intertrochanteric femoral fractures: A biomechanical comparative study

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Received 13 August 2007; accepted 23 April 2008

Abstract

Background. This study presents the first biomechanical comparison of two minimal invasive screw plates used in the treatment of intertrochanteric fractures of the femur.

Methods. Six fresh cadaveric pairs of human femur were included, following dual energy X-ray absorbsiometry analysis to obtain two cohorts of homogenous femurs. In each pair, unstable four-part trochanteric fractures were created and reduced. In each cohort, one femur was randomly selected to undergo instrumentation using one of the two minimal invasive devices, and the other femur was instrumented using the other device (minimally invasive screw system (MISS) or per cutaneous compression plate (PCCP)). Femurs were positioned at 25° of adduction in order to simulate the anatomical loading during one-legged stance. Biomechanical tests were performed using a single vertical compressive load applied on the femoral head. Cycling loading was applied with three-dimensional fracture motions with stereophotogrammetric analysis and global displacement analysis throughout the cyclic test. Intact femurs after cyclic loading were tested to failure. Failure mode was diagnosed with macroscopic or radiographic analysis.

Findings. Significant difference were detected between PCCP and MISS in sliding of the lag screw. Global vertical displacement of the femoral head during cyclic loading was higher for the PCCP. No statistically significant difference was noted in three-dimensional inter fragmentary displacement and load to failure between these two devices. Failure mode in both devices mainly consisted in fracture impaction, but no cut-out was noted.

Interpretation. PCCP and MISS appear to be mechanical devices that may improve clinical outcomes and reduce the risk of co-morbidities associated with unstable trochanteric fractures without increased risk of mechanical failure.

Keywords: Intertrochanteric fracture; Minimally invasive surgery; Sliding hip screw; Biomechanical study

1. Introduction

Proximal femoral fracture (PFF) remains a subject of great interest. This is because there have been recent developments in regards to optimising treatment and design of new prosthesis. Minimally invasive (MI) surgery has been shown to reduce operative blood loss, surgical time, pain and hospital stay (Bellabarba et al., 2000; Dipaola et al., 2004; Gotfried et al., 2000). These factors are particulary important for elderly patients, in whom surgical treatment that allows early weight-bearing can reduce complications (Langlais et al., 2005).

At present, sliding hip screws (SHS) are still widely regarded as the most conventional devices for fixation of intertrochanteric femoral fractures and are associated with failure rates between 5% and 20% (Ahrengart et al., 2002; Baumgaertner et al., 1998). Surgical fixation of femoral intertrochanteric fractures can be undertaken with standard devices (SHS or trochanteric nails) using a MI approach (Alobaid et al., 2004), specifically designed MI implants (Gotfried et al., 2000) or MI surgical techniques

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doi:10.1016/j.clinbiomech.2008.04.018

(Moroni et al., 2005). Recently, Gotfried et al. (2000) published the first clinical and biomechanical results of the PCCP (percutaneous compression plate), a MI sliding screw plate implant, used for pertrochanteric fractures, with favourable clinical complications rates and biomechanical results (Gotfried et al., 2002). In contrast to the PCCP, no other MI screw plate devices have been previously tested or implanted. A new MI screw plate implant, the MISS (Lépine, Lyon, France), has been developed that has several differences as compared with PCCP in terms of implant characteristics (double small diameter screw fixation into the femoral head for PCCP, on larger for MISS) and required surgical approach. The goal of this study was to analyse the biomechanical behaviour of these two minimally invasive screw plate implants before any prospective clinical comparison.

2. Methods

Two minimally invasive screw plate devices were tested in this study. The percutaneous compression plate (PCCP) (Fig. 1) is composed of a plate fixed using three femoral shaft screws 4 mm in diameter. Femoral head fixation using the PCCP is achieved with two dynamic neck screws that are fixed with a double barreled screw on a plate at 135° neck–shaft angle. Two separated percutaneous portals permit assembly of the device. The second implant, the MISS (Fig. 2), is also composed of three independent parts, consisting in a five hole titanium plate fixed using 5 mm diameter shaft screws and a single femoral head screw measuring 14 mm in diameter with a 25 mm screw head length and a total length between 60 mm and 110 mm. The screw is fixed with an eccentric screw barrel measuring 40 mm long at a 130° femoral neck–shaft angle. Assembly within the patient uses a single minimally sized incision for the shaft screws. Fracture compression is realised with the screw-driver of the neck screws for the PCCP and a compression screw that can be removed for the MISS. Compared to conventional sliding hip screws, those two devices use a surgical approach with smaller incisions and a sparing muscle approach, without detachment of the vastus lateralis.

Twenty femurs (10 pairs) were harvested from fresh cadavers of un-embalmed donor patients. Ages ranged from 65 to 85 years (mean 74 years) and consisted in eight males and two females. Femurs were stripped of all soft tissues, stored in moistened towels, and kept frozen at −20 °C. They were thawed at room temperature before device implantation and mechanical tests. Radiographs in two planes were taken in order to exclude pairs of femurs presenting with evidence of bone defects. Femoral neck–shaft angles and femoral neck lengths were measured and compared with X-ray length measures. Dual energy X-ray absorbsiometry (DXA) was performed and measured on usual data and especially on the femoral head that was measured with a 4 cm^2 surface. In order to obtain two homogenous cohortes of femurs, two pairs were excluded because of bone density mismatch. Seven pairs were included and randomly assigned in two groups to be treated using either the MISS or the PCCP. Unstable four-part intertrochanteric fractures, as described by Kaufer et al. (1974), were created in each specimen using an oscillating saw. The reproducibility of this fracture method was tested prior to use on two excluded pairs of femurs. All femurs were instrumented following the recommendations of the respective implant manufacturers under radiological image intensifier control. Six pairs were finally included for

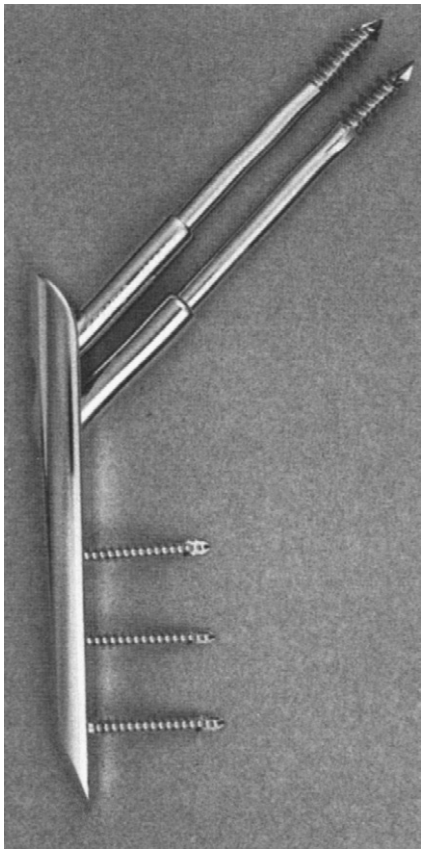

Fig. 1. The PCCP implant.

Fig. 2. The MISS implant.