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Biomechanical properties of a posterior fully threaded positioning screw for cannulated screw fixation of displaced neck of femur fractures

Thomas K. Schaefer [a], Christian Spross [a], Karl K. Stoffel [b], Piers J. Yates [a,*]

[a] Department of Orthopaedic Trauma, Fiona Stanley Hospital, Perth, Western Australia Australia
[b] Department of Orthopaedic Surgery, Kantonssptial Baselland, Switzerland

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ABSTRACT

Objectives: Displaced intracapsular neck of femur fractures (NOF) in younger patients are usually fixed with partially-threaded cannulated screws. However posterior comminution may lead to construct failure. We hypothesised that a posterior fully threaded positioning screw would enhance stability.
Methods: A total of 16 left composite femora (Sawbone) were used for testing. To mimic a subcapital fracture with posterior comminution, a subcaptial osteotomy was performed and a posterior wedge was resected from the neck. Group A ($n = 8$) was fixed using 3 partially threaded cancellous screws. In Group B ($n = 8$), a fully threaded positioning screw instead of a partially threaded was used posteriorly. The specimens were tested for bending (antero–posterior = A–P) and axial stiffness. Finally, they were axially loaded up to failure or up to 10,000 cycles and the final displacement was measured at the site of the resected neck. More than 5 mm of displacement was considered as a failure of the construct.
Results: Group B showed significantly higher average A–P stiffness (665 ± 17 N/mm compared to 414 ± 41 N/mm, $p = 0.0004$); whereas axial stiffness did not significantly differ between the two groups ($p = 0.301$). In Group B, the mean final displacement after cyclic axial loading was 0.51 ± 0.13 mm and none of the specimens failed, whereas 7 of 8 constructs failed in Group A ($p = 0.001$).
Conclusions: This biomechanical study points out a potential benefit of replacing the posterior partially threaded cancellous screw with a fully threaded positioning screw in subcapital NOF with posterior comminution. The construct with the fully threaded screw significantly improved the A–P stiffness and reduced the collapse of the fracture.

Introduction

Intracapsular neck of femur fractures (NOF) are commonly encountered in modern trauma [1]. In the elderly, most of them result from low energy falls and osteoporotic bone and the threshold for either primary total- or hemiarthroplasty is usually low. However, in younger patients, most of the NOF result from high-energy shear loading and thus are often displaced and less stable after reduction [2]. The standard treatment of these fractures is either CRIF or ORIF with 3 partially-threaded cannulated screws [2–5]. The screws should be positioned in a triangular configuration with the widest possible spread in the lateral view [6] and with the apex pointing inferior to avoid stress raiser in the subtrochanteric region [7].

However, loss of fixation after CRIF of NOF with 3 partially-threaded screws is reported to be up to 39% within the first 3 postoperative months [6]. Furthermore, posterior neck comminution is a frequently encountered fracture pattern and may be one of the reasons for later loss of reduction due to further posterior collapse of the femoral head [8].

The partially threaded screws allow compression at the fracture site, which is usually helpful for healing. However, in case of posterior comminution, we question this benefit. Thus, we hypothesised that replacing the posterior partially threaded cancellous screw by a fully threaded positioning screw might improve the stability of the posterior neck comminution while still allowing some compression in the anterior-inferior region. A clinical example is shown in Fig. 1. As there is only limited data about the use of partially- or fully threaded screws for the

* Corresponding author at: Department of Orthopaedic Trauma, Fiona Stanley Hospital, 102-118 Murdoch Drive, Murdoch, Western Australia 6150, Australia. Tel.: +61 8 9 431 2719; fax: +61 8 9 431 2701.
E-mail address: piersyates@hotmail.com (P.J. Yates).

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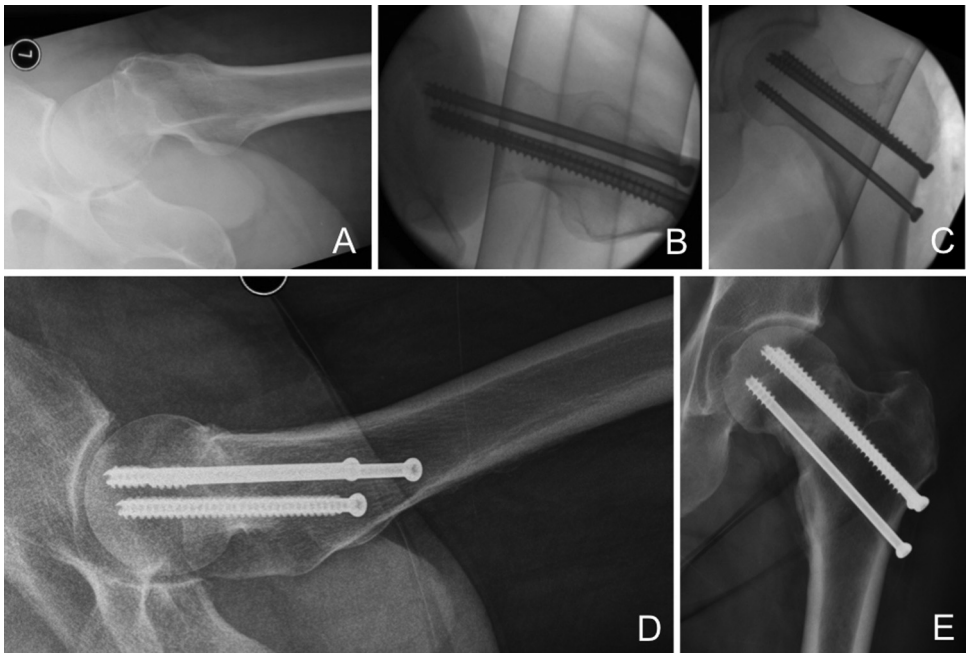

Fig. 1. Clinical example: a 60 y.o. patient with a dorsally displaced NOF (A) treated with a fully-threaded posterior positioning screw and two partially-threaded screws. Figures B and C are intraoperative views after closed reduction and fixation. Figures D and E were taken 6 months postoperatively and show a healed fracture. The effect of "guided fracture collapse" can be observed as the two cannulated screws slipped back, whereas the positioning screw stayed in place and no secondary dorsal displacement occurred.

treatment of NOF, we conducted this biomechanical study to assess their influence on stiffness and stability.

Materials and methods

A total of 16 left fourth-generation artificial femurs (Sawbones, Pacific Research Laboratories, Inc., Vashon, USA) were used for this study.

Preparation of specimens

The distal third of the femurs was cut off to allow better fixation for later testing. To assure comparable screw placement in all specimens, we installed a 2.8 mm guide wire in the central (factory pre-drilled hole along the anatomical axis of the neck) hole of the necks of the Sawbones. From there, the standard parallel K-wire guide was used to place three 2.8 mm K-wires for the screws. The first was placed at 6 (inferior screw), the second at 11 (anterior screw) and the third at 2 (posterior screw) o'clock position. The wires were over-drilled with a cannulated 5 mm drill bit. Standard 7.3 mm cannulated screws (Synthes, Oberdorf, Switzerland) were used for fixation (100 mm inferior, 90 mm anterior and posterior). The screws were removed and a subcaptial osteotomy was performed to mimic the fracture. Then, by cutting a 1 cm bone block out of the posterior neck, the posterior comminution was simulated (Fig. 2A). Finally the screws were reinserted.

In Group A, all screws were partially threaded according to the standard fixation method. All screws were tightened with 4Nm torque (torque wrench) to achieve equal compression at the fracture site.

In Group B, a fully-instead of a partially threaded screw was used posteriorly (2 o'clock position). The partially threaded inferior and anterosuperior screws were inserted first and tightened with 4Nm torque as above. The fully threaded posterior positioning screw was inserted last and only "two-finger" tightened.

Biomechanical testing

Biomechanical tests were conducted using a Zwick/Roell Z020 biaxial materials testing machine (Zwick GmbH & Co, Ulm,

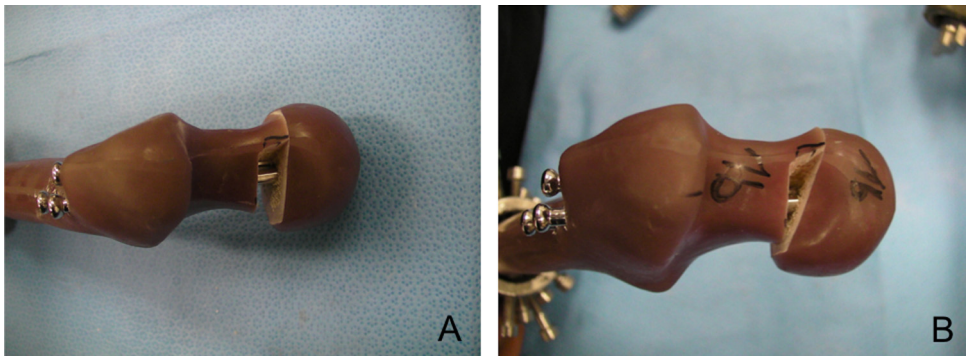

Fig. 2. Resection of a 1 cm bone block of the posterior neck to mimic the dorsal comminution of the fracture (A). Figure B shows a failed construct after cyclic loading (>5 mm displacement).