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Primary stability of three different iliosacral screw fixation techniques in osteoporotic cadaver specimens—a biomechanical investigation

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Abstract

BACKGROUND: The incidence of osteoporotic and insufficiency fractures of the pelvic ring is increasing. Closed reduction and percutaneous fixation with cannulated sacroiliac screws is well-established in the operative treatment of osteoporotic posterior pelvic ring fractures. However, osteoporotic bone quality might lead to the risk of screw loosening. For this reason, cement augmentation of the iliosacral screws is more frequently performed and recommended.

PURPOSE: The aim of the present biomechanical study was to evaluate the primary stability of three methods of iliosacral screw fixation in human osteoporotic sacrum specimens.

STUDY DESIGN/SETTING: This study used methodical cadaver study.

METHODS: A total of 15 fresh frozen human cadaveric specimens with osteoporosis were used (os sacrum). After matched pair randomization regarding bone quality (T-score), three operation technique groups were generated: screw fixation (cannulated screws) without cement augmentation (Group A); screw fixation with cement augmentation before screw placement (cannulated screws) (Group B); and screw fixation with perforated screws and cement augmentation after screw placement (Group C). In all specimens both sides of the os sacrum were used for operative treatment, resulting in a group size of 10 specimens per group. One operation technique was used on each side of the sacral bone to compare biomechanical properties in the same bone quality. Pull-out tests were performed with a rate of 6 mm/min. A load versus displacement curve was generated.

RESULTS: Subgroup 1 (Group A vs. Group B): Screw fixation without cement augmentation: 594.4 N±463.7 and screw fixation with cement augmentation before screw placement: 1,020.8 N±333.3; values were significantly different (p=.025). Subgroup 2 (Group A vs. Group C): Screw fixation without cement augmentation: 641.8 N±242.0 and perforated screw fixation with cement augmentation after screw placement: 1,029.6 N±326.5; values were significantly different (p=.048). Subgroup 3 (Group B vs. Group C): Screw fixation with cement augmentation before screw placement: 804.0 N±515.3 and perforated screw fixation with cement augmentation after screw placement: 889.8 N±503.3; values were not significantly different (p=.472).

CONCLUSIONS: Regarding iliosacral screw fixation in osteoporotic bone, the primary stability of techniques involving cement augmentation is significantly higher compared with screw fixation without cement augmentation. Perforated screws with the same primary stability as that of conventional screw fixation in combination with cement augmentation might be a promising alternative in reducing complications of cement leakage. These biomechanical results have to be transferred into clinical practice and prove their clinical value.

Keywords: Biomechanical; Cement augmentation; Fracture; Iliosacral fixation; Osteoporotic; Sacrum

FDA device/drug status: Investigational (modified [six 2.0 mm perforations over the first 1/2 of the thread] self-cutting lag screws made of titanium [aap Biomatterials, Dieburg, GmbH]).

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Introduction

Pelvic ring fractures are comparatively rare [1], with an incidence of 0.3–8%, and typically result from high-energy trauma [2]. Because of increasing life expectancy, the incidence of osteoporotic and insufficiency fractures of the pelvic ring is increasing [3–6]. Osteoporotic fractures of the pelvic ring differ substantially from high energy fractures regarding symptoms as well as treatment. Even the patient's own body weight can be sufficient to produce such a fracture [7]. An extreme reduction of bone mass and overstressing of the already weakened bone lead to insufficiency fractures [8]. Insufficiency fractures of the sacrum are already described by Lourie et al. in 1982 [9]. Closed reduction and percutaneous fixation with cannulated sacroiliac screws is a well-established therapy in the operative treatment of osteoporotic posterior pelvic ring fractures [10–12]. If elderly patients with sacral insufficiency fractures suffer from a high pain level, this minimal invasive procedure can help to both reduce pain and to recover mobility [13]. Even in unstable sacral fractures, iliosacral screw fixation is used and can be combined with lumbopelvic fixation to achieve a high biomechanical stability [14–16]. To attain even greater stability for the transverse component, lumbopelvic distraction osteosynthesis is combined with iliosacral screw osteosynthesis, resulting in a clinically sufficient multiplanar stability [16]. However, osteoporotic bone quality might lead to the risk of screw loosening [7]. For this reason, cement augmentation of the iliosacral screws is more frequently performed and recommended [11,17,18]. Cement augmentation is often performed before screw placement [3]. Wähnert et al. developed a new method with perforated screws, which allows the application of cement after screw placement [19] to reduce possible complications such as cement displacement resulting in nerve compression or embolization [13].

Aim of the study

The aim of the present biomechanical cadaver study was to evaluate the primary stability of three methods of iliosacral screw fixation in human osteoporotic sacrum specimens. Our goal was to compare axial pull-out failure in the following three techniques: screw fixation without cement application, screw fixation with cement application before screw insertion, and screw fixation with a modified, perforated screw and cement application after screw positioning.

Materials and methods

Specimens

A total of 15 fresh frozen human cadaveric specimens were used (os sacrum). Only women donors (mean age 81.47±9.04 years) were selected, and bone density was measured in all specimens separately, which showed substantial osteoporosis (mean T-score −4.45±1.73). Osteoporosis was defined according to the World Health Organization (WHO) criteria—bone mineral density of more than 2.5 standard deviations below the mean of a young healthy reference population of the same gender (T-score). A preliminary computed tomography scan of all specimens was performed to identify any pathologies, especially preexistent sacral fractures or deformities. Soft tissue was removed and the specimens were stored at −20°C until testing. Just before the experiment, all specimens were thawed to a temperature of 37°C in a water bath to achieve realistic conditions of cement dispersion.

Group generation

Matched pair randomization regarding bone quality (T-score) was performed to establish similar groups.

Three operation technique groups were generated: screw fixation (cannulated screws) without cement augmentation (Group A); screw fixation with cement augmentation before screw placement (cannulated screws) (Group B); and screw fixation with perforated screws and cement augmentation after screw placement (Group C) (see Fig. 1).

In all specimens both sides of the os sacrum were used for operative treatment, resulting in a group size of 10 specimens per group. One operation technique was used on each side of the sacral bone to compare biomechanical properties in the same bone quality. This allowed us to establish three comparable subgroups: subgroup 1: screw fixation without cement augmentation versus screw fixation with cement augmentation before screw placement; subgroup 2: perforated screw fixation with cement augmentation after screw placement versus screw fixation without cement augmentation; and subgroup 3: screw fixation with cement augmentation before

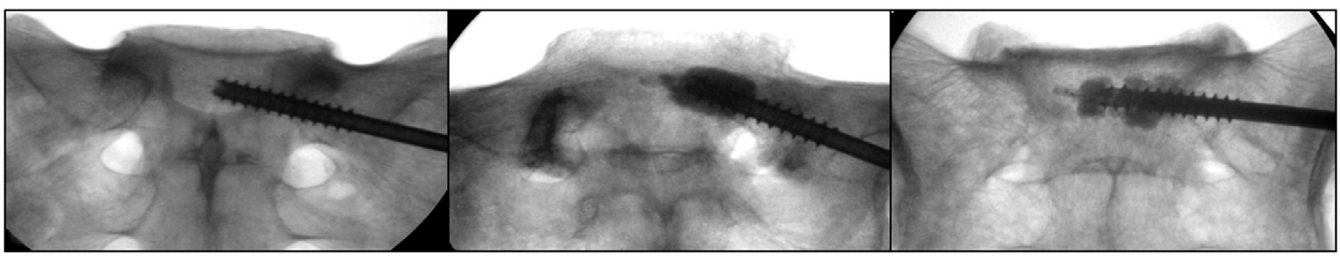

Fig. 1. Radiographics of the operation groups: (Left) screw fixation (cannulated screws) without cement augmentation (Group A); (Middle) screw fixation with cement augmentation before screw placement (cannulated screws) (Group B); and (Right) screw fixation with perforated screws and cement augmentation after screw placement (modified screws) (Group C).