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Fixed angle devices versus multiple cancellous screws: What does the evidence tell us?

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ABSTRACT

Complications, including nonunion and avascular necrosis, are relatively common after internal fixation of a femoral neck fracture. Young patients are particularly impacted by these complications as salvage options often result in a suboptimal functional result. The quality of reduction appears to be of primary importance; however, it is unknown whether the choice of internal fixation affects the incidence of complications. In this article, we present the rationale and evidence for available internal fixation options. Current evidence is insufficient to recommend an optimal method of internal fixation, and this review demonstrates the need for high-quality randomised, controlled trials to study this problem.

Introduction

Intracapuslar femoral neck fractures typically occur from high-energy mechanisms in young patients and low-energy falls in the elderly population. In the elderly population, the focus of treatment shifted away from internal fixation towards arthroplasty after multiple level-1 studies demonstrated improved functional outcomes and reduced reoperation rates in the arthroplasty cohort [1–5]. Since the majority of femoral neck fractures are caused by low-energy falls in the elderly population, higher quality studies of this population have been feasible. In contrast to the relatively robust evidence that guides our treatment in the elderly population, a paucity of high-quality studies exists to guide the optimal device for internal fixation in physiologically young patients.

Implants for internal fixation of intracapsular femoral neck fractures can be divided into 3 groups: multiple cancellous screws, fixed angle devices that allow sliding/compression, and fixed angle devices that do not allow for sliding/compression. Multiple cancellous screws may be placed in a variety of configurations including parallel partially threaded screws, parallel fully threaded screws, and Pauwel screws (a trochanteric lag screw followed by multiple screws parallel to the neck). Fixed angle devices that allow for compression include sliding hip screws and certain intramedullary nails. Fixed angle devices that do not allow for compression are the dynamic condylar screw, proximal femoral locking plates, and blade plates.

The choice of which device to use is controversial with advocates of both cancellous screws and fixed angle devices. When choosing a device, the surgeon must consider the mechanical performance of the implant, the ability of the implant to allow for dynamic interfragmentary compression, and the ease of use and familiarity of the device. Additionally, the surgeon must consider patient and injury factors such as fracture pattern (e.g. Pauwels angle), amount and location of comminution, presence of an ipsilateral femoral shaft fracture, and bone quality. This review focuses on the available biomechanical and clinical evidence regarding multiple cancellous screws and fixed angle devices for the treatment of femoral neck fractures.

Rationale for multiple cancellous screws

Multiple cancellous screws are the most commonly used implant in the fixation of femoral neck fractures [6]. In an international survey, 90% of surgeons preferred multiple cancellous screws in nondisplaced fractures while 68% preferred them in displaced fractures. Advantages to multiple cancellous screws include the relative ease of insertion in comparison to plate and

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screw constructs. Furthermore, cancellous screws can be placed percutaneously, which is particularly helpful if a displaced fracture is to be reduced using an anterior approach (Smith-Petersen) so that a second approach to place the plate can be avoided. Additional advantages of screws over plates include maintenance of bone stock and, possibly, improved rotational strength and preservation of femoral head vascularity [7,8].

Rationale for fixed angle devices

Proponents of fixed angle devices cite the greater strength of these devices (see biomechanical section below), particularly in vertical shear fracture patterns (Pauwel III) and basilar neck fractures. These implants may have a greater ability to resist varus angulation and inferior displacement of the head fragment than traditional inverted triangle screw configurations. Additionally, proponents of fixed angle devices argue that they may have superior mechanics in femoral neck fractures with comminution and in patients with osteopenia. However, these devices are technically challenging to implant and require an open approach specifically for implant insertion with a greater associated blood loss. If an anterolateral approach (Watson-Jones) is used for reduction, then the implant may be placed through the same incision. However, if a direct anterior approach (Smith-Petersen) is used for reduction, then a separate lateral incision is used for implant placement. Similarly to screw configurations, not all fixed angle devices are created equal. This group of implants is diverse, particularly with regard to the amount of interfragmentary compression that is allowed. On one end of the spectrum, the sliding hip screw allows for interfragmentry compression until the screw threads contact the barrel (typically 17 mm slide distance), while proximal femoral locking plates and blade plates allow for no dynamic interfragmentary compression. The dynamic condylar screw and cephalomedulary nails are intermediate in the amount of dynamic compression allowed.

Biomechanical studies

Biomechanical studies provide important information when choosing an implant for fixation of a femoral neck fracture. Biomechanical parameters such as the overall strength and degree of fragment deformation are important and need to be considered in conjunction with all parameters. While the biologic response to mechanical stimuli is important in many fractures, it is paramount in femoral neck fractures. For instance, in a biomechanical study, proximal femoral locking plates were found to be the only implant that was strong enough for physiologic loading [9]; however, they have performed poorly in clinical practice [10].

The majority of biomechanical studies demonstrate that fixed angle devices outperform multiple cannulated screws. Aminian et al. created a vertically oriented femoral neck fracture in cadaveric femurs and subjected this model to incremental and cyclical loading [9]. These authors reported that proximal femoral locking plates were the stiffest construct and multiple cannulated screws the weakest, while there was no significant difference in stiffness between the dynamic hip screw and dorsal column stimulator implants. Similarly, Baitner et al. reported that sliding hip screws had a higher load to failure and less fragment displacement compared to multiple cancellous screws in a vertically oriented femoral neck model [11]. In basicervical femoral neck models multiple studies demonstrate that a sliding hip screw is superior to multiple cancellous screws [12,13].

Clinical studies: non-comparative

Most commonly used screws are placed in an inverted triangle configuration with partially threaded screws placed at the periphery of the femoral neck. However, the stiffness of the construct can be modulated by using a Pauwel screw configuration or strategically placed fully threaded screws. In a biomechanical study, Pauwel screws, which include a trochanteric lag screw followed by screws placed parallel to the femoral neck, were 70% stiffer than parallel screws [14]. However, in a retrospective review, 23% of patients treated with parallel screws developed nonunion or avascular necrosis compared to 59% of those treated with crossed/Pauwel screws [15]. In a subgroup analysis of the study by Liporace et al., mechanical failure occurred in 60% of fractures fixed with crossed/Pauwel screws compared to 13% of those fixed with parallel screws [16]. Another departure from the traditional inverted triangle configuration is the use of triangular parallel screws, which feature 2 inferior screws and 1 superior screw. Yang et al. found that femoral neck fractures stabilised the triangle configuration and had a significantly higher nonunion rate than those fixed with the traditional inverted triangle pattern [17].

A number of non-comparative studies have reported on the clinical outcomes after fixation of femoral neck fractures with a variety of nontraditional fixed angle devices. A 130-degree blade plate was used to fix 34 femoral neck fractures in young patients [18]. In comparison to historic controls, the 10% incidence of complications (1. nonunion, 2. avascular necrosis) in the study was favourable. However, another length-stable implant, the proximal femoral locking plate, was found to have poor outcomes in a retrospective case series [10]. In this study, the authors reported that 37% of patients treated with a proximal femoral locking plate developed catastrophic failure of the implant. Of these patients, 71% required a total hip arthroplasty and 29% died. The authors hypothesised that the high incidence of failure in proximal femoral locking plates was due to the stiffness of the implant preventing interfragmentary compression resulting in the implant bearing the load. In a study that highlights the importance of patient selection in implant choice, cephallomedulary nails were used to fix displaced femoral neck fractures [19]. The results were primarily driven by patient factors with 100% failure of fixation in subcapital femoral neck fractures in patients older than 60 and no failures in patients younger than 60. It is unclear from the study whether the implant was fixed with a setscrew or allowed to slide freely within the nail.

The optimal amount of interfragmentary compression to achieve femoral neck union without significant shortening is unknown. Zlowodzki et al. reported that a healed yet shortened femoral neck resulted in poorer functional outcome scores compared to patients who healed in an anatomic position [20,21]. Boraiah et al. demonstrated that it was possible to achieve good clinical outcomes with the use of length-stable implants [22]. In a series of 54 patients, fully threaded cancellous screws were used either in an inverted triangle configuration or in conjunction with a sliding hip screw to create a more length-stable construct. In this cohort, 94% of patients achieved union without complications and minimal shortening of the femoral neck was observed.

Clinical studies: comparative

Few comparative clinical studies exist to guide implant choice for fixation of femoral neck fractures. The entirety of the literature is represented by European randomised, controlled trials from the late 1990s and some more recent retrospective cohort studies. The older, more robust randomised studies are limited by the inability to generalise to our young patient population as they were performed on an elderly population with displaced fractures that