

Postoperative impacts of Reamer-Irrigator-Aspirator (RIA) on femoral strength: A finite element analysis

Ryota Nishida¹, Keisuke Oe¹, Tomoaki Fukui¹, Yohei Kumabe¹, Kenichi Sawauchi¹, Ryowa Mineo¹, Takehiro Konishi¹, Genta Fukumoto¹, Jonathan¹, Hyuma Kondo¹, Takahiro Niikura², Ryosuke Kuroda¹

¹Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine, Kobe, Japan

²Department of Orthopaedic Surgery, Hyogo Prefectural Nishinomiya Hospital, Hyogo, Japan

Email of Presenting Author: ryotanishida18@gmail.com

Disclosures: Ryota Nishida (N), Keisuke Oe (N), Tomoaki Fukui (N), Yohei Kumabe (N), Kenichi Sawauchi (N), Ryowa Mineo (N), Takehiro Konishi (N), Genta Fukumoto (N), Jonathan (N), Hyuma Kondo (N), Takahiro Niikura (N), Ryosuke Kuroda (N)

INTRODUCTION:

The Reamer-Irrigator-Aspirator (RIA) is a procedure to obtain a large amount of autologous bone graft, most commonly from the femur. One of the major complications associated with RIA is postoperative fracture due to decreased bone strength. Although the number of reported cases is limited [1], it is serious issue because it involves fracture of originally healthy bone. While some cadaver studies have reported on post-RIA bone strength, no studies have investigated it using finite element analysis (FEA). The aim of this study is to elucidate the effects of RIA on postoperative femoral strength using FEA.

METHODS:

Quantitative CT-based FEA was conducted using CT images from two patients who underwent RIA in the femur for autologous bone grafting during nonunion surgery. Patient 1: A 60-year-old man who underwent RIA on the entire left femur. Postoperative CT showed no cortical penetration. Patient 2: A 64-year-old woman who underwent RIA on the entire right femur. Cortical penetrations were observed on the posterior aspect of proximal shaft and the anterior aspect of the supracondylar region (Fig.1). We analyzed four loading conditions for each patient: (a) axial loading, (b) lateral fall, (c) direct force, and (d) rotation (Fig.2). Fracture load (or torque) was defined as the minimum load (or torque) at which elements exceeding one shell failed at the complete fracture site. Fracture sites and fracture loads (or torques) were compared between the preoperative and postoperative models.

RESULTS:

(a) Femoral neck fractures occurred in both the pre- and post-RIA models for both patients (Fig3.a). Fracture loads were 6200 N (pre-RIA) and 5800 N (post-RIA) in Patient 1, and 1700 N in both models in Patient 2. (b) In Patient 1, femoral neck fracture occurred in both the pre- and post-RIA models (Fig3.b), with fracture loads of 2350 N and 2250 N. In Patient 2, a trochanteric fracture occurred in the pre-RIA model, and a femoral neck fracture occurred in the post-RIA model; both loads were 800 N. (c) Shaft fractures occurred in both the pre- and post-RIA models for both patients (Fig3.c). Patient 1 showed fracture loads of 3300 N (pre-RIA) and 2950 N (post-RIA), and Patient 2 had 1450 N and 1350 N, respectively. (d) In Patient 1, femoral neck fracture occurred in both the pre- and post-RIA models (Fig3.d-1), with fracture torques of 76 Nm (pre-RIA) and 65 Nm (post RIA). In Patient 2, a femoral neck fracture occurred in the pre-RIA model with a fracture torque of 93 Nm. In the post-RIA model, a complete fracture occurred at the supracondylar penetration site with a fracture torque of 20 N, followed by an incomplete fracture at the proximal penetration site (Fig3.d-2).

DISCUSSION:

In the case of a 60-year-old man without a penetration model, the decline in femoral strength after RIA was limited, and the fracture sites were unchanged between the pre- and post-RIA models. In contrast, in the case of a 64-year-old woman with a penetration model, fractures occurred at the penetration sites under rotational loading with lower fracture torque. Previous reports have identified the supracondylar region and diaphysis as common fracture sites following RIA [1]. Penetration after RIA frequently occurs on the anterior aspect of supracondylar femur [2,3]. Our results, along with these reports, suggest that post-RIA penetrations most frequently occur in the supracondylar region, where they may considerably compromise bone strength and increase the risk of fracture.

SIGNIFICANCE:

This study suggests that early weight bearing may be feasible in non-penetration cases following RIA, as the postoperative decline in femoral strength was limited. In contrast, penetration cases require caution to prevent postoperative fractures.

REFERENCES: [1] Laubach M, et al. Arch Orthop Trauma Surg. 2023. [2] Niikura T, et al. J Orthop Sci. 2021. [3] Metsmakers WJ, et al. Eur J Trauma Emerg Surg. 2019.

Fig.1

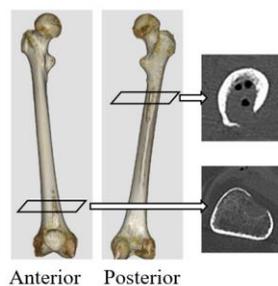


Fig.2

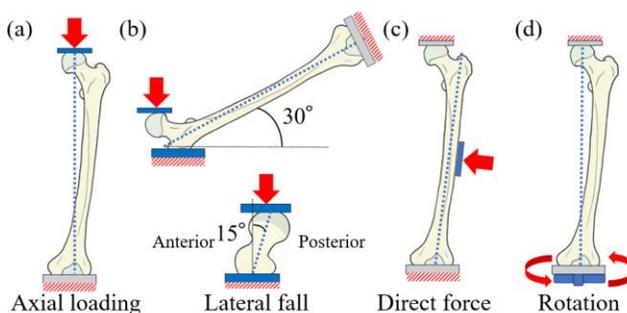


Fig.3

