Finite Element Analysis of Double-Plate Fixation for Vancouver B1 Femoral Fractures

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INTRODUCTION: Periprosthetic femoral fractures are serious complications of total hip arthroplasty (THA) that often require revision surgery. Internal fixation is recommended for treating Vancouver B1 periprosthetic femoral fractures. Recent biomechanical studies demonstrated that locking-plate constructs provide greater stiffness than conventional cable plating. Nonetheless, single locking-plate fixation may not always offer optimal fixation, and failures or less satisfactory results are often reported. Such cases most likely occur as a result of full weightbearing on the plate system. Addition of an anterior locked-plate to the reversed contralateral locking compression-distal femoral plates (LCP-DF) might be a good choice to improve fixation stability and overcome the weightbearing restriction of using a single-plate system. Therefore, the aim of the current study was to evaluate the potential advantages of a reversed contralateral LCP-DF double-plate fixation procedure for treatment of Vancouver B1 fractures under full weightbearing conditions using finite element analysis (FEA).

METHODS: The stability of LCP-DF double-plate construct was evaluated and compared to that of single-plate construct under full weightbearing conditions (Fig. 1). Both constructs were analyzed under an axial load of 1,500 N by FEA. A finite element pre-processor was generated. To set up the boundary conditions, the cortical and trabecular bones were fixed by glue, with a coefficient of friction of 0.1 and 0.3 used at the bone-plate and bone-screw interface, respectively. These constructs were positioned at 20 degrees adduction in the frontal plane and aligned vertically in the sagittal plane. Thereafter, the constructs were tested under an axial load of 1,500 N (Fig. 2), and the results were then analyzed.

RESULTS: To define areas of high stress and stress shielding with single- and double-plate fixation, von Mises stress distributions at 1,500 N axial loading were determined by FEA. Of note, maximum von Mises stress in the single-plating method occurred at the fracture region of the femur, and the stress areas were present in the center of the LCP-DF plate, with a maximum stress value of 474 MPa. The stress level at the defect region in the double-plate procedure was very low compared to that in single-plating, and there was a high stress level at the distal part of the LCP-DF plate. The maximum stress value was noted to be 164 MPa. (Fig. 3).

DISCUSSION AND CONCLUSION:

Our results showed that the maximum stress level on the lateral plate in the single-plate fixation procedure was higher than the double-plates fixation. This may suggest that the contralateral reversed LCP-DF fixation with single-plate fixation procedure has a high potential risk for implant failure under full weightbearing. Double-plate fixation showed a significant reduction in stress concentration in the lateral plates at the fracture site. Under full weightbearing, the maximum stress level was 164 MPa. The stress level in the plates fell within the fatigue threshold of titanium (ca. 598 MPa), corresponding to approximately 5 years of the normal functioning period.

This is the first study reporting finite element analysis and biomechanical testing of double-plate fixation using reversed contralateral LCP-DF for the stable model of Vancouver B1 periprosthetic femoral fractures. Adding an anterior narrow locking plate significantly reduced the stress concentration at the fracture site of the lateral plate. The present results showed that the double-plate procedure with reversed contralateral LCP-DF significantly increased the strength of Vancouver B1 fractures and provided full weightbearing in the early postoperative period.

Fig. 1

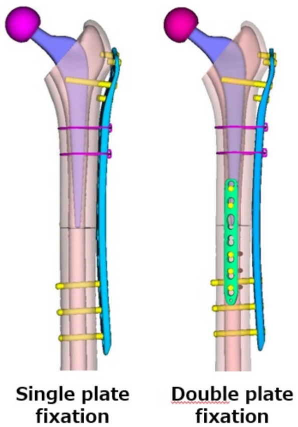

Fig. 2

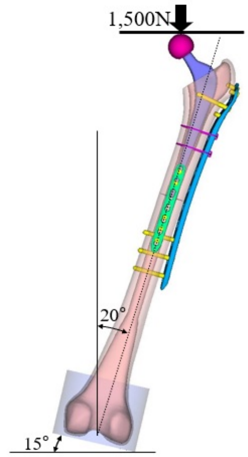

Fig. 3