EVALUATION OF BIOMECHANICAL STABILITY OF LOCKING COMPRESSION PLATE SYSTEM WITH BRIDGING TECHNIQUE IN THE PROXIMAL TIBIA

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INTRODUCTION

Minimally invasive plate osteosynthesis(MIPO) with locking compression plates (LCP) has been widely used for the surgical management of comminuted fractures in the tibia[1]. The bridging technique supports the locked internal fixator and induces secondary bone healing. However, large fractrue gap may decrease construct rigidity, thus resulting in nonunion of bone fragments. Biomechanical studies are needed to investigate the relationship between the bridge gap length and the consruct rigidity. In this study, we experimentally evaluated the stability of LCP under various bridging conditions in the proximal tibia with a large defect in the proximal region.

METHODS

The composite synthetic tibiae (Sawbones, USA) were used to simulate proximal extra-articular tibia fractures. And three groups (n=4) of comminuted fracture surgical models were constructed with 13-hole LCP (LCP_PLT, Synthes, USA) according to AO classifications, 41A3. Group 1 has a 3cm-defect while Groups 2 and 3 10.5cm. The bridging defect sizes were chosen to represent two extreme conditions in the gap found clinically based on one of the authors' clinical experience. Groups 1 and 2 were reduced with three screws in a clustered fashion (Fig. 1-a). On the other hand, only two screws were inserted in Group 3 at immediately below the gap and the other at the sufficient distance near the end of the plate to simulate dispersed screw distribution (Fig 1-a). All specimens were fixed on distal epiphysis to evaluate the static stability. They were loaded at 0.2 mm/sec using MTS 858 Bionix (MTS System corp., MN, USA) with a specially-fabricated jig [2].The stiffness and yield load were obtained from load and displacement data collected at a rate of 20 Hz. Simultaneously, axial strains were recorded nearby each LCP holes using Strain Measurement System (AL1600, CAS, USA) (Fig. 1-b).One-way ANOVA was used to evaluate statistical significance of results.

RESULTS AND DISCUSSION

Our results showed that the average structural stiffness in linear region were 156, 133, 126 (N/mm) and yield loads were 760, 637, 623 (N) for Group 1, 2, 3, respectively (Table 1). Larger defect gap size considerably affected structural stiffness and yield load as observed with statistically significant decrease from Group 1 to Groups 2 and 3 (by 17% and 19% in stiffness, respectively, $p<0.05$). On the other hand, there were no significant differences between Groups 2 and 3 ($p>0.05$), suggesting the screw distribution, whether clustered or dispersed, did not affect the construct rigidity. High strains (up to 0.54%) at yield load were found near the proximal LCP (at the hole number 1 and 2) in all groups. In particular, Group 1 showed comparatively higher strain magnitude than the others due to local stress concentration at the plate similar to the reports in literature [3].

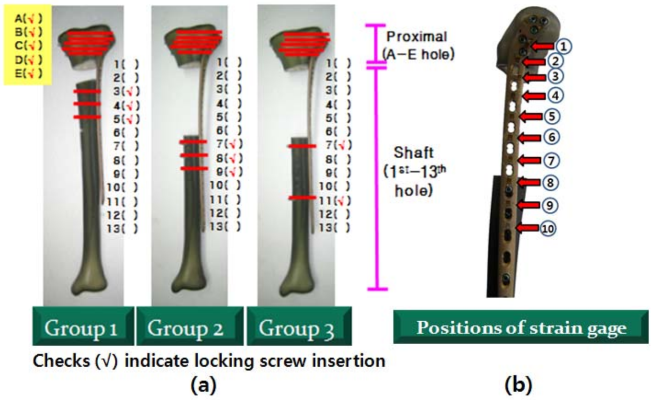

Figure 1: (a) LCP fixed on Composite synthetic bone with fracture gap, (b) positions of strain gauge (indicated with arrows)

CONCLUSIONS

Our study showed that the construct rigidity in the LCP fixation was far more sensitive to the bridge gap length than to the screw distribution. Further studies on extent of gap size and construct rigidity are needed to ensure better surgical management of comminuted proximal tibia fracture.

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Table 1: Biomechanical test results

	Mean stiffness (N/mm)	Mean yield load (N)	Max. strain(%)on LCP
Group 1	156	760	0.54
Group 2	133	637	0.31
Group 3	125	623	0.33

* : p < 0.05

N.S. : No significant difference