Biomechanical Evaluation of Multiple Screw Fixation Techniques in Anterior Cruciate Ligament Tibial Avulsion Fractures

Il-Kyu Park[1,2], Seonjin Shin[2], Tae Soo Bae[3], Chang-Hoon Jeong[1,2], In-Beom Kim[2], **Dai-Soon Kwak**[2]
[1]Dept. of Orthopedic Surgery, Bucheon ST. Mary's Hospital, Bucheon, South Korea
[2]Catholic Institute for Applied Anatomy, The Catholic University of Korea, Seoul, South Korea
[3] Dept. Biomedical Engineering, Jungwon University, Goesan, South Korea

Email: daisoon@catholic.ac.kr

Summary

Under load-to-failure conditions, the repair of tibial eminence fractures using multiple 4.0 mm cannulated screws while sparing the growth plate demonstrated a biomechanical strength comparable to that of the suture fixation technique. However, under cyclic loading conditions, the growth plate sparing repair with multiple 4.0 mm cannulated screws showed superior biomechanical performance when compared to both suture and single-screw fixation techniques.

Introduction

Two primary methods for fixing tibial spine avulsion fractures in children are suture and screw fixation. Previous biomechanical studies have compared these techniques, but there is no clear consensus on which one is superior. Bong found that suture repair had a significantly higher initial ultimate strength (319 N) compared to screw fixation (129 N) ($p = 0.0038$) [1]. Tsukada, however, reported a small but statistically significant increase in anterior tibial translation after suture fixation (2.2 mm) compared to screw fixation (1.0 mm) ($p < 0.05$) [2]. Mahar found no significant mechanical difference between the two methods [3]. More recently, some studies have shown good results with multiple screw fixation. However, there are no biomechanical studies that compare different numbers, thicknesses, or configurations of screws for fixation. This study aims to compare the biomechanical stability of tibial eminence avulsion fractures using suture fixation and various screw techniques, including differences in number, thickness, and configuration of screws.

Methods

Skeletally immature porcine knees were randomly divided into six treatment groups: (group 1) suture (Orthocord) fixation, (group 2) a single 4.0 mm screw fixation, (group 3) two 4.0 mm screws placed in parallel, (group 4) two 4.0 mm screws placed divergently, (group 5) three 4.0 mm screw fixation, and (group 6) a single 4.5 mm screw fixation (Figure 1). Type III tibial eminence fracture fragments were created in a consistent manner. Following fracture fixation, biomechanical testing was performed using both cyclical (5-50N 10 cycle, 50-100N 500 cycle) and load-to-failure protocols by applying an anterior shear force to the tibia.

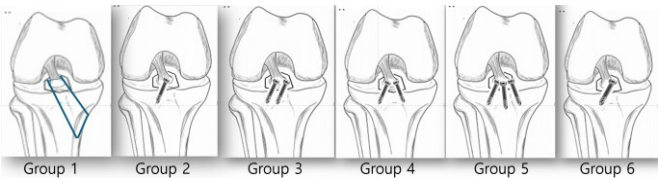

Figure 1: Specimen groups configuration

Results and Discussion

In load-to-failure testing, the groups with single screw fixation (group 2 and 6) exhibited significantly lower mean peak failure loads (229.9 N and 179.1 N, respectively) compared to group 1 (397.9 N), group 3 (329.3 N), group 4 (381.6 N), and group 5 (428.7 N). No significant differences were observed between groups 1, 3, 4, and 5. In cyclical testing, groups 3 (1.42 mm), 4 (1.42 mm), and 5 (0.99 mm) showed significantly less mean total displacement after 500 loading cycles, compared to the other groups (group 1, 3.46 mm; group 2, 3.18 mm; group 6, 2.78 mm) (Table 1).

Table 1: Test results of multiple screw fixation

	Cyclic Disp. [mm]		Max. Load [N]	
	mean	SD	mean	SD
Intact	0.67	0.10	1059.44	311.84
Group 1	3.48	1.12	397.82	126.35
Group 2	3.18	2.08	229.86	93.54
Group 3	1.42	0.74	329.33	56.30
Group 4	1.42	1.33	381.55	104.18
Group 5	0.99	0.33	428.68	129.44
Group 6	2.78	2.28	179.07	27.66

Conclusions

Fixation with two or three screws for type III tibial spine avulsion fractures in children is biomechanically superior to suture fixation in terms of total displacement after cyclic loading tests, while showing similar results to suture fixation in the peak load-to-failure test.

References

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