A novel rat model for nonunion fracture with different mechanical stability

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INTRODUCTION: Fractures can be managed through diverse modalities, including casting, bracing, and surgical intervention; however, even with appropriate therapeutic approaches, nonunion can manifest. Although nonunion can engender persistent pain and impede Activities of Daily Living (ADL), instances of painless non-union preserving ADL have been documented. The origins of pain in the nonunion state remain elusive. Gaining insight into the mechanism underpinning non-union pain could potentially pave the way for novel treatment modalities. The primary objective of this inquiry is to elucidate the mechanisms contributing to the emergence of pain in nonunion. To achieve this objective, several fracture models varying in fixation forces and bone fusion conditions will be established.

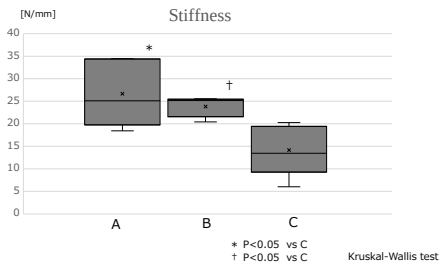
METHODS: Surgical intervention was executed under inhalation anesthesia using Isoflurane. An incision was made on the lateral aspect of the left thigh, allowing for the femur's exposure. Subsequently, a bone saw blade was employed to induce a fracture in the diaphysis. The materials for fracture fixation comprised stainless steel plates and 1.1 mm diameter screws. In instances where bone fusion was not attained (nonunion group), a small rubber sheet segment was introduced into the fracture gap to hinder bone bridging. Furthermore, three groups with distinct fixation forces between bone fragments were arranged using varying fixation techniques at the fracture site. Group A featured the plate affixed to the femur via four bicortical screws, group B employed three bicortical screws, and group C utilized two bicortical screws alongside two unicortical screws. For assessing fixation force, each model was synthesized employing extracted femurs, and a three-point bending test was administered. Periodic radiographs were taken every fortnight over an 8-week postoperative span to monitor bone fusion progress.

RESULTS: Within the context of the 3-point bending test, Groups A and B exhibited a considerably greater stiffness compared to Group C (Figure.1). Radiographic evaluation demonstrated that group A achieved bone fusion within 6 weeks, while the nonunion group exhibited 6 weeks of non-union without fracture site dislocation due to the incorporation of a rubber sheet. Group B did not exhibit bone fusion after 8 weeks of imaging, while Group C displayed minor postoperative fracture site dislocation, yet achieved bone fusion by 8 weeks postoperatively.

DISCUSSION: The results of the three-point bending test unveiled a notable distinction between Group A and Group C, signifying a divergence in fracture fixation efficacy. Imaging corroborated that Group A and C exhibited progressive bone fusion, whereas Group B did not. Group B showed higher stiffness than Group C, but fewer screws were used, which may have been a disadvantage in terms of bone fusion.

SIGNIFICANCE/ CLINICAL RELEVANCE: The model incorporating a femoral plate secured to the femur utilizing four bicortical screws, two bicortical screws, and two unicortical screws presents an innovative approach to representing both union and nonunion scenarios while encompassing variations in fixation strength.

IMAGE:
Figure1. Stiffness assessed by the 3-point bending test



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