Mini Plate Can Influence the Primary Healing of a Long Bone Fracture Fixed with a Compression Plate

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Introduction: Compressive force generated by a compression plate has been shown to facilitate primary healing of long bone fractures. Reduction forceps or K-wires are used for provisional stabilization of these fractures but may interfere with the installation of plate and screws [1]. Low-profile mini plates have been used by surgeons seeking less cumbersome temporary reduction and easier implant tightening [2]. Its application may enhance or block the compression at the fracture and potentially influence the primary healing. However, this biomechanical effect has never been researched. The purpose of the current study is to investigate whether the application of mini plates and their screw placement (neutral vs. eccentric): 1) interfere with initial compression at a fracture, and 2) influence pressure distribution during a compression plate is applied.

Methods: Transverse fractures were created on 20 Sawbone models (outer diameter 20mm, inner diameter 10mm, and 160mm in length) with a diamond saw. Each specimen was tested under two settings: experimental (with mini plate) and control (without mini plate). The specimen was placed in a horizontal metal groove and one side (static side) was clamped. In the experimental setting, a 2.0 mm 5-hole mini plate (DePuy Synthes Companies) was installed. Based on the placement of cortex screws, the specimens were divided into two groups: in Compression group (10 specimens), screws were placed eccentrically away from the fracture to generate compression. In Static group (10 specimens), screws were placed in a neutral position. Then a 3.5 mm 7-hole dynamic compression plate (DCP, DePuy Synthes Companies) was oriented in parallel and separated by 90 degrees (Fig. 1). Three screws were tightened in neutral positions on the static side. On the compression side, two screws were eccentrically placed and tightened using a torque-limiting wrench under the following sequence: Screw 1 tightened (case S1), then loosened, and screw 3 tightened (case S3), finally, both 1 and 3 were fully tightened (case S1+3). In the control setting, the mini plate was removed and screws 1 and 3 of the DCP were loosened and then tightened under the same sequence as the experimental setting. A Tekscan pressure sensor (model 4000) was placed in the fracture to monitor the compressive force and pressure distribution during screw tightening. Wilcoxon signed ranks test was used to evaluate the compressive forces between the experimental and control settings in each group. Mann-Whitney-Wilcoxon test was used to compare the compressive forces between Compression and Static groups. In statistic analysis a two-sided significance level of 0.05 was selected.

Results: In the Compression group, experimental setting generated significantly higher fracture compression than control setting (p < 0.002, Fig. 2). On the other hand, experimental setting generated lower compressive forces (p 0.05), but in the experimental setting the Compression group had higher compressive forces than the Static group (p < 0.0003). No significant correlation existed between the starting pressure and the final pressure achieved in the experiment (p = 0.4). In the Compression group mini plate significantly increased the contact area compared to those without mini plate (p < 0.01). This
trend was not significant in the Static group. In general, pressure peaks occurred close to the DCP (Fig. 3).

**Discussion:** Compression is essential for primary healing in simple long bone fracture fixation. Sufficient compression across a fracture site improves stability, allows pre-load to exceed dynamic load, prevents micro-instability and resorption at the fracture and, thus, improves primary bone healing [3, 4]. This study demonstrates that mini plates will play a role in determining the initial fracture compression. Eccentrically placed mini plate screws enhance the compression, while neutrally placed screws limit compression in excess of controls. Use of the mini plate also appears to spread the compression into a larger area, possibly optimizing stress distribution. This study, performed on a synthetic bone model, did not investigate the effect of the mini plating on biological bone. Future research may focus on varying the geometric relationship between the mini plate and DCP, as well as determining if the effect is consistent in osteoporotic models or cadaveric specimens.

**Significance:** This study suggested that mini plate may have a significant impact on the compression at the long bone fractures fixed with a DCP. To achieve fracture stabilization and primary healing, physicians may consider using mini plate as an adjunct to increase the compression at the fracture site.
Fig. 2. Compressive forces (in Newton) generated under four conditions.

Fig. 3. Representative example of force distribution across the fracture. A: mini plate, B: DCP.

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