SYNTHESES® LOCKING COMPRESSION PLATE (LCP) SYSTEM
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Key Points
- The LCP can be used in compression, neutralization, or buttress functions.
- Methods of application include locking (internal fixator), non-locking (standard) and hybrid fixation.
- The LCP is well suited for MIPO applications.

The advent of internal fixation with bone plates and screws represents a tremendous advancement in the methods of fracture fixation. During this era, the emphasis was on anatomic reconstruction and rigid internal fixation. Although these principles are applicable to a great number of fractures, not all can be treated in this manner. In fact, the disruption of the soft tissue envelope required to perform an anatomic reconstruction of a highly comminuted fracture and ensuing disruption of healing potential can contribute to nonunion. Gradually, a shift in philosophy has occurred, and now the emphasis is on preservation of fracture biology, with spatial realignment of the major bone segments; this technique is known as biological osteosynthesis.

LCP Implant Design
The LCP features a uniquely designed combination hole that accepts standard bone screws as well as locking screws, and allows the plate to be used as a conventional plate (compression), a locking plate (internal fixator principle) or as a combination of both principles. The ends of the plate have a “slipper toe” design that facilitates tunneling the bone plate under soft tissues in a minimally invasive manner. The underside of the plate has scalloped undercuts similar to the LCDCP, which creates a uniform area moment of inertia to minimize stress concentration at the plate hole, as well as mitigate disruption of extraosseous blood supply. The locking screws are designed to tolerate the shear loads resulting from angle stable fixation. The core (diameter of the screw between threads) is larger than standard bone screws, with a smaller thread profile. In addition, the pitch of the screw is smaller, and matches the pitch of the thread on the head of the screw. The smaller pitch minimizes the distance the screw travels prior to the threads of the screw head engaging the bone plate; this diminishes plate compression onto the bone surface. Finally, the locked screw has a conical, double-lead thread design that facilitates alignment with the threaded plate hole, and ensures that the screw thread engages the plate thread with no more than one-half turn.

Biomechanics
The design goals of the LCP are to increase the stiffness of the construct while maintaining the biological fracture environment. There are distinct differences between the design of conventional bone plates and locking plates. Conventional plates depend on friction at the plate-bone and screw-bone interfaces to maintain fracture fixation. These implants fail due to cortical screw toggling which leads to screw loosening and loss of
Figure 1: Locking plate combi-hole with locked screw (center) and standard screw (right).

Figure 2: Locking screw (left) and standard cortex screw (right).

plate-bone fixation. Therefore, the system depends on each screw’s resistance to loosening and pull-out strength.

The LCP is a fixed angle construct that does not rely on friction at the plate-bone and screw-bone interfaces. Rather, the system relies on friction at the threaded screw-plate interface. Once the screw is locked into the plate, the fixed, angle stable design converts shear stress into compressive stress at the screw-bone interface. The load
applied to the limb is redirected such that it is perpendicular to the screw axis. The redirection of stress explains why locking screws are designed with smaller threads, since they do not generate compression between the plate and the bone. However, they have a larger core diameter which ensures greater bending and shear strength and dissipates the load over a larger area of bone. In addition, the screws feature the new StarDive head that withstands 65 percent greater insertion torque than conventional hexagonal drivers. The StarDrive is also self-retaining, thus the screw stays on the screw driver without a holding device.

In conventional plating, it is critical to contour the plate accurately to optimize plate-bone frictional forces, and mitigate malreduction during plate application. In contrast, the locked plate does not need to be precisely contoured. During application of a locked plate, the fracture must first be reduced and then conventional screws are placed if used at all. Next, the locked screws are added for the fixed construct stability. Unicortical locked screws have two points of fixation, one in the bone and the other in the bone plate, and therefore they resist axial load to failure better than standard unicortical cortex screws in bone, which may be prone to loosening.

**Biomechanical Studies**

The LCP was compared to a variety of standard and locking plates in both bending and torsion; individual plates, as well as plate constructs were tested in these studies. The bending stiffness and bending structural stiffness of the LCP was not significantly different from the LCDCP or DCP when tested as a plate alone, or as a synthetic bone-plate construct gap model. Torsion testing also revealed that there was no significant difference in yield torque, yield angle, or stiffness between the LCP, DCP and
LC-DCP. A study comparing the mechanical behaviors of semi-contoured LCP-rod fixation and anatomically contoured LCDCP-rod fixation also revealed no difference in construct stiffness, and no implant failure following 63,000 cycles. These findings are not surprising, since these plates are similar in cross sectional area, and thus similar in area moment of inertia. Although the plates differ in their fixation to bone, the inherent strength and stiffness of the bone plate itself is similar between the three, and the methodology of these studies was essentially a test of bone plate strength more than plate-screw-bone interaction. Thus, considering acute load to failure in bending and torsion, the LCP can be used in a similar fashion as the DCP and LC-DCP in clinical practice.

Clinical Performance

To date, there are no randomized clinical trials in human or animals comparing the LCP plate to conventional plates (DCP and LC-DCP) in patients with similar fractures. The plates have been studied and compared in vitro (human and animal) and in case series’ and these studies form the basis for LCP principles and indications. The reported indications for LCP application include patients with poor quality bone (osteoporosis, osteomyelitis), complex periarticular fracture, particularly when contouring may be difficult in the metaphyseal area, fracture configurations in which it is difficult to achieve the minimal number of conventional screw cortices, periprosthetic fractures, cases in which only bridge plating is possible or indicated, nonunions from failed fixations in which cortex or cancellous screw are stripped or have backed-out, and polytrauma cases in which the fractures cannot be anatomically reconstructed. In vitro studies in bone models do show that locked screw constructs fail at higher loads than cortex screws and their advantage is magnified in osteoporotic bone.

Several technical details remain to be elucidated in the application of the LCP to veterinary patients including, the ideal number of locked screws on either side of the fracture, the number of unicortical versus bicortical screws necessary to achieve adequate stability, indications for and magnitude of plate contouring required, the effects of combining conventional screws and locked screws in the same construct, indications for double plating or adding additional implants, such as intramedullary pins, and the potential advantageous biological effects on fracture healing when LCPs are placed in a minimally invasive fashion.
References


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