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Orthopaedics

Locking Plates – How to Use Them
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The basis of plating, as originally described by the AO, has been: 1) anatomic fracture reduction and fixation, 2) rigid fracture stability (compression or splinting), 3) preservation of the blood supply to the soft tissues and bone through careful handling and gentle reduction techniques, and 4) early and safe mobilization of the area. These AO principles have evolved, whereby the current approach is to maintain the blood supply to the soft tissues and bone as the most important aspect of fracture care. Therefore, the principles now are re-stated as: 1) mandatory atraumatic reduction and fixation techniques: reduction of long bones need not be anatomic, but need axial re-alignment (length and torsion) in the diaphysis and metaphysis; however, anatomic reduction is mandatory for intra-articular fracture in order to restore joint congruency, 2) appropriate construct stability must be re-established: absolute stability of joint surfaces; relative stability of diaphyseal fractures, 3) atraumatic soft-tissue technique with appropriate surgical approaches, and 4) early active mobilization.

Conventional Plating – anatomic fracture reconstruction. Because conventional plating relies on the friction generated between the plate and bone, accurate plate contouring is required to match the anatomic bone contour. In conventional plating, even if the bone fragments are correctly reduced prior to plate application, fracture dislocation will result if the plate does not exactly fit the bone as the screws are tightened a loss of reduction may then occur (loss of primary reduction). Furthermore, under an axial load postoperatively, if the shear forces are greater than the frictional forces between the plate and bone, loss of the fixation may occur due to toggling of the screws (loss of secondary reduction). Again, because the plate is compressed to the bone surface, the periosteum is compressed under the plate area, reducing or even interrupting blood supply to the bone. The result can be delayed bone healing due to temporary osteoporosis underneath the plate. Finally, in cases with decreased bone quality, such as osteoporotic bone, screws cannot be tightened sufficiently to obtain the compression needed to support the bone. This may cause loosening of the screws and loss of stability, with ultimately a loss of the reduction. Despite these purported limitations, standard plating achieves good results in good quality bone, and in fractures traditionally fixed with lag screws to achieve direct bone healing.

Locked plating – bridging fracture reconstruction. In this method, screws lock to the plate, forming a fixed-angle construct. Bone healing is achieved indirectly by callus formation. Once the locking screws engage the plate, no further tightening is possible; therefore, the implant locks the bone segments in their relative positions regardless of the degree of reduction obtained. Contouring of the plate minimizes
the gap between the plate and the bone; however, an exact fit is not necessary for implant stability. This feature is especially advantageous in minimally or less invasive plating techniques because these techniques do not allow exact contouring of the plate to the bone surface. By locking the screws to the plate, the axial force is transmitted over the length of the plate and the risk of a secondary loss of the intraoperative reduction is reduced. Finally, locking the screw into the plate does not generate additional compression; therefore, the periosteum will be protected and the blood supply to the bone preserved. A fixed-angle construct provides advantages in osteopenic bone or multifragmentary fractures where traditional screw purchase may become compromised.

The major change in the theory of fracture fixation occurred with development of locked bridging internal fixation with the PC-Fix® (Synthes®). When using this implant and the theory of “bridging plate osteosynthesis,” fracture union occurred by secondary, rather than primary bone healing as with rigid internal fixation. This initial locked plate design created the first screw-plate single composite beam construct, much like a conventional external fixator. An improved locked plating system for metaphyseal fractures subsequently was developed—the Less Invasive Skeletal Stabilization system (LISS®, Synthes®). Several experimental studies demonstrated the increased stability and benefits of preserving fragmentary blood supply using the LISS® system. Further refinements to the PC-Fix® concept led to the design and manufacture of the locked compression plate (LCP®, Synthes®). The LCP® provided angular and axial stability, which again decreased or eliminated the need for exact plate contouring, thereby minimizing the risk of primary loss of reduction. Additionally, the combination screw-hole continued to allow conventional screw fixation, thus enabling the surgeon to apply the most appropriate fixation method.

Currently, there are a number of manufacturers that have locking plate systems available. The different concepts between the apparently dissimilar systems in veterinary medicine are presented here: LCP® (SynthesVet®), SOP™ (Orthomed), ALPS (Kyon) and Fixin (TraumaVet). Other manufacturers, for example, Securos™ and NGD have similar properties to the LCP® and will not be discussed.

Locking screws provide the ability to create a fixed-angle construct while utilizing the familiar plating techniques. Locking screws do not rely on plate/bone compression to maintain stability, but function similarly to multiple small angled blade plates. The concept of unicortical screw fixation was proposed, thus further minimizing the damage to the vascularity. From the mechanical standpoint, bicortical screw fixation has been used with conventional plate fixation as both cortices are required to achieve sufficient stability so as to prevent pullout (screw stability and load transfer are accomplished at two points along the screw: the near and far cortices) – thus maintaining friction between the plate and bone. Locking screws are proposed to provide sufficient stability and load transfer only at the near cortex due to the threaded connection between the plate and the screw. This latter concept has been questioned in small animals due to the presence of very thin cortices; therefore, bicortical screw fixation, or double plate fixation (opposite or orthogonal with monocortical screw fixation), is presently recommended.

**LCP® (SynthesVet®)**

The LCP® plates have combination locking and compression holes, or so called “Combi
hole”. This allows the plate to be applied with either fixed angle locking screws in the threaded part of the Combi hole, or standard cortical screws that are placed in the dynamic compression unit (DCU) part of the Combi hole. These plates also have a round “stacked hole” in one or more positions. The round hole limits the degree of angulation and also does not permit any compression to be applied; it is used at the end of the plate where there is limited space to place the Combi hole. The locking hole has threads (with a Morse taper) that match the screw head.

Locking screws have a larger core diameter and finer thread pitch as compared to standard screws; locking screws are designed to resist bending and shear, and do not need to generate compression between the plate and bone. The shape of the plate (and underside) is identical to the standard LC-DCP®, re: undercuts so as to decrease cortical contact of the plate with the bone.

**SOP™ (Orthomed)**

The “String of Pearls” design is a rod with multiple “nodes”. Each node is designed as a sleeve to accommodate the head of a standard screw in a Morse taper design. This results in a friction fit as the screw is driven into the base of the hole and the head of the screw pulled into the plate.

The rod is to enable a more easily follow the bone concept of the dimensional bending so as to more easily follow the bone. Using standard screws was to enable a minimum of new instrumentation and inventory to purchase; however, due to the standard screw design for a locking construct there is a potential weakness. There is no ability to produce compression at the fracture.

**ALPS (Kyon)**

The technical features of the “Advanced Locking Plate System” include increased biocompatibility (cpTi and Ti alloy), use of both standard and locking screws in all plate holes, plate geometry to permit plate contouring in 3-dimensions (in-plane and out-of-plane bending) with specially designed instrumentation that allows bending (in either plane) while preserving the screw-holes such that the
Locking mechanism is not adversely impacted. The principle of application remains accurate contouring to the bone surface and compression of the plate to bone (point contact); however, due to the geometry of the plate, the contact area between the plate and bone is minimized. The purpose of this design is greater construct strength as plate/bone contact minimizes shear loads to the screws and improves torsional resistance to failure.

Locking screw design is threads on the head of the screw (Morse taper) that match the base of the plate hole (allowing a DCU hole to be used above this point with a standard screw).

**Fixin (TraumaVet)**

The locking mechanism of the Fixin device is based on a conical coupling system where the conical head of the locking screw is locked in the corresponding conical hole of a Ti alloy insert that is screwed into the SS locking plate. A standard screw may be used in the hole without the Ti insert.

The hole geometry in the plate does not permit compression to be applied at the fracture. The concept with this implant is bridging fixation (the length of the bone) such that a more elastic stability is obtained. This concept demands that there is a wide distance between the central screws of the plate, thus dispersing the bending loads a wider distance (throughout the length of the plate). Healing is thus more consistently by secondary bone healing (callus formation).

**References**