Proceedings of the 15th ESVOT Congress

September 15 - 18, 2010
Bologna, Italy
The synthes locking plates

Rico Vannini, Dr. Dipl. ECVS
Bessy's Kleiterklinik, Dorfstr. 51, Switzerland - 8105 Watt

"Synthes-plates" are plates that have been developed and approved by the AO Foundation, which reflects 50 years of leading experience in plate osteosynthesis. Even so the classical concepts of fracture treatment by bone plating as postulated by the founders of AO still hold true, considerable changes have taken place in our understanding how fractures heal under different mechanical and biological environments, how they react to strain and how implants and bone interact. The concept of locking plates is now well established and represents a clear advance in the management of many fractures by plate fixation. Fractures in osteoporotic bone, fractures with short metaphyseal segments and fractures treated with biological fixation are some examples of fractures that are preferably managed with lockable plates nowadays.

Locking plates evolved through the recognition that in order to get a fracture to heal quickly and satisfactorily, it is not always necessary to achieve rigid internal fixation and absolute stability. Anatomic reduction and rigid internal fixation is still required for simple reducible and articular fractures. In comminuted shaft fractures, anatomic reconstruction is not possible or would only be possible with excessive manipulation of the fracture and destruction of the biology. The primary goal of fracture treatment in non-reducible fracture is therefore correct axial alignment of the two adjacent joint bearing surfaces and restoration of length, while preserving the biology of the fracture. Being aware of the importance of biology, the concept of minimal invasive plate osteosynthesis (MIPO) of shaft fractures evolved parallel and became popular and successful.

Minimally invasive surgical techniques have been improved and facilitated by using low contact implants combined with locking screws. The locking plates combine the biological benefits of external skeletal fixation with the post operative management benefits of internal fixation.

With the concept of internal fixators the plate screws are the main load-transferring elements. All the forces are transferred from the bone to the plate across the screw necks. No compression of the plate onto the bone is required to achieve stability. Therefore the blood supply of the bone under the plate is preserved. As it is no longer necessary for the plate to be adapted precisely to the shape of the bone, the need for anatomic plate contouring is eliminated. With locking head screws, there is less risk of screw loosening compared to conventional screws and fracture fixation does not depend significantly on the quality of the bone or the anatomical region of anchorage anymore.

Meanwhile there are a variety of locking plates available. Locking plates refer to those plates that have holes that will only accommodate locking head screws and are therefore used to bridge across the fracture like an internal splint or fixator.

The Synthes LCP is a lockable plate, as it can accept either standard screws and/or locking screws. This "hybrid implant" can, therefore, be used to produce internal splintage with locking screws or - in a more traditional fashion - compression, buttressing and neutralization when standard techniques and screws are employed, as it is needed in reducible simple fractures, osteotomies and complex bone reconstructions. The use of a non-locking screw may also be indicated when angulation of the screw is necessary such as for fixation of a fragment, to assist with fracture reduction or to avoid penetration of a joint surface. This unique feature of the Locking Compression Plate is made possible by a special "Combi-hole" – a combination of the DCU hole for standard screws with a threaded hole for the locking head screw.

THE LOCKING COMPRESSION PLATE: DESIGN AND SIZES

The LC plate has undercuts which result in an identical cross-section area over the entire length of the plate. The LCP has a center towards the holes are directed.

On one end, the tip of the plate is tapered to facilitate closed plate insertion during MIPO and to minimizing impact on soft tissue. This end is also called "slippery toe". The other side of the Vet LCP’s is rounded to accommodate a simple round hole instead of the "Combi hole". This allows to insert the last two screw closer to each other which might allow to insert an additional screw in a short metaphyseal fracture segment.

If a locking screw inserted at a right angle would penetrate the joint surface, this round hole can be used with a regular screw, which can be angulated away from the joint.

For veterinary use, the plate is produced in stainless steel, but it is also available in titanium. There are all sizes from 1.5/2.0, 2.4, 2.7, 3.5 narrow and broad up to the 5.5 mm in a wide variety of different lengths and shapes.
The profile (thickness and width) of the LCP is similar to a LC-DCP of the same size. Both plates also have similar cross-sectional dimensions through their screw holes. It is therefore not surprising, that the LCP and LC-DCP plates of the same size have similar mechanical performance, i.e. bending stiffness and area moment of inertia. In a mechanical testing model it was confirmed, that there is not any difference in bending stiffness and strength and the selection of the LCP does not compromise the integrity of the implant strength (DeTora and Kraus, 2008).

Any fixation system is as strong as its weakest link. In the case of locking plates, it seems that overall performance is largely influence by the screws. Many screw factors can influence the stability and performance of a locking system: screw design & dimensions, locking stability of the screw head in the plate (loosening) as well as the numbers, placement (monocortical vs bicortical) and orientation of the screws.

The design of the Synthes locking head screws differ from conventional screws, as they are actually more like threaded bolts. The threads are smaller as they don’t have to generate compression between the plate and the bone. The decreased thread diameter allows however for a larger core diameter of the screw, which increases the bending and shear strength while dissipating the load over a larger area within the bone. Also the drive mechanism used for the screw head has been changed to the “Stardrive™”. This screw head design is self-retaining, 65% stronger in insertion torque and therefore more resistant against stripping than the classical hexagonal screw head design. The single lead shaft pitch allows the screw to fully engage in the cortex before locking to plate. As the locking stability of the screw head in the plate is of prime importance, the threads of the head have a conical double lead to facilitate alignment of the screw with the threaded plate hole pitch. As orthogonal screw insertion is a must with locking head screws, a special drill guide is used that is screwed into the locking plate hole to assure correct drilling in regard to the plate hole.

Overall performance of the LCP has been compared to the non-locking LC-DCP systems. It has been shown, that the structural bending stiffness in all loading directions is similar or even slightly stronger in a simple fracture model. Gap bending stiffness for four planes of bending was investigated and the LCP was significantly stiffer than the LC-DCP in the latero-medial plane, otherwise there were no significant differences (Aguila et al, 2005).

In another study with a cadaveric distal humeral metaphyseal gap model, it was shown that the LCP were significantly stronger, than the LC-DCP when loaded in static axial compression. When cyclically loaded in static axial compression, the LCP constructs were significantly less stiff than the LC-DCP constructs. They were also less resistant to torsion over 500 cycles compared to the LC-DCP. Other studies showed however contrary results with no difference between the two plate systems or even greater resistance of the LCP to cyclic torque (Fulkerson 2006, Gardner 2005, Kim 2007, Weinstein 2006).

As the LCP allows for combining locking and non-locking screws, the effect of such combination of locking screws with non-locking screws on stability has been investigated. Initially it has been shown the load carrying capability of a construct with unicortical screws only is at least as strong as a conventional construct with bicortical regular screws. However the concept of using only monocortical screws has been challenged as monocortical screws provide limited torsional stability. Under torsional loads, replacing the end screws of a locked unicortical configuration with bicortical screws significantly improved the construct stiffness: 57.6% increase for the locked screws and 51.6% increase for the unlocked. In anteroposterior (AP) bending, the highest improvement over the locked unicortical configuration came from the locked hybrid constructs (42.9% increase). When compared with the unlocked bicortical configuration, both hybrid constructs provide equivalent stability in torsion but superior stability in AP bending (Roberts 2007).

On the other hand, if a single locking screw is added to an otherwise non-locking construct, it will increase the torque to the offset failure point by 17%. This would suggest that the addition of just one locking screw is able to provide an angle stable construct (Gordon 2010).

Failure to recognize that a lockable plate does not necessarily need to have locking head screws inserted is one of the pitfalls in using these implants. Allowing for using both, locked and non-locked screws, the LCP offers best of both worlds and has revolutionized operative fracture fixation in human orthopedic surgery. If implant cost reach the cost of regular plates it certainly will become a very attractive implant system for veterinary surgeons as well. With it, one implant system could replace all the older conventional plates thereby streamlining the implant inventory dramatically.

REFERENCES