



Orthopedic hardware and equipment for the beginner. Part 2: Plates and screws

Greg Harasen

The surgical repair of fractures is a relatively new discipline tracing its roots back less than 150 years. A scientific approach to the understanding of bone healing was not addressed until after World War II when the published work of Belgian surgeon, Robert Danis, ignited an interest in a group of Swiss orthopods who formed the *Arbeitsgemeinschaft für Osteosynthesefragen* or AO group in 1958. The research pursuits of the AO group lead to a better understanding of the physiology of bone healing, the description of principles for anatomic reduction and rigid internal fixation of fractures, and the development of surgical implants and instruments which included the forerunners of modern bone plates (www.aofoundation.org). The veterinary offshoot of the original AO group, AOvet, was formed in 1969 and continues to work closely with the parent group in research and education of surgeons.

The fruit of the AO research and its expansion by countless surgeons and researchers has been the wide array of plates and screws available to veterinary surgeons today.

Bone plates provide a frame to which the fractured bone may be attached facilitating anatomic reduction of the bony column in some cases and, if the implant is selected and applied correctly, neutralization of the forces acting on the fractured bone during the healing process.

Bone plates can differ in 4 primary ways:

1. **Composition:** most bone plates for veterinary use are made of 316L stainless steel. Titanium implants are somewhat more malleable than stainless steel and are more inert with respect to tissues; however, they are significantly more costly and so have limited use in veterinary orthopedics. A few bone plates made of metal alloys have been found on the veterinary market, with the most common recent example being the tibial plateau leveling osteotomy (TPLO) plate marketed by Slocum Enterprises (1).
2. **Size:** The size of a bone plate refers to its length and thickness as well as the size of screw that can be accommodated in its holes. The latter factor is what gives most bone plates their names. For example, a 10-hole 3.5-mm bone plate refers to a plate with 10 holes that can accommodate screws

with an external diameter of 3.5 mm. At least one manufacturer has named their plates based on length in millimeters; however, veterinary orthopods are nothing but creatures of habit, and this innovation has generated more than a few complaints! 3.5-mm plates are the most commonly used bone plates for small animal fracture repair. Other common plate/screw sizes are 2.0 mm and 2.7 mm; 1.5 mm, 4.5 mm, and 5.5 mm plates and screws are also available but have limited application in most small animal cases (2).

3. **Design:** T-plates, L-plates, semicircular or acetabular plates, and TPLO plates are variations from the standard straight plate. They allow contouring of the implant to a specific area of the bone and the placement of more screws in a limited area than would be possible with a straight plate. Recent variations in plate profile include the limited-contact dynamic compression plate (LC-DCP) in which some of the peripheral metal on the underside of the plate has been “scaloped” away between plate holes to decrease the surface area of the plate that is in contact with the bone. This is done out of concern for the effect of extensive plate contact on perisoteal and endosteal blood supply (2,3). Other “streamlined” plate designs include the reconstruction plate which has much more metal removed in between holes allowing maximum “contourability” of the plate at the expense of implant strength, and the more recent “string of pearls” (SOP) which provides the flexibility of the reconstruction plate in a much stronger package (2,4).

The dynamic compression plate (DCP) features an oval plate hole that is sloped from one end of the hole to the other. By offsetting the placement of the screw toward one end of the hole or the other it is possible to exert compression or distraction at the fracture site. A neutral or central screw position within the hole splits the difference and provides neither distraction nor compression. Locking plates (LP) have threaded holes that, when paired with a special screw that has matching threads on its head, will produce a plate-screw construct that “locks” together. Locking plates act like an external skeletal fixator construct in that the plate does not have to be as closely contoured to the bone’s surface and the screws act like fixator pins within the bone. The result is a very rigid construct that is relatively easy to apply (2,4). Round plate holes can still be found in some applications with the most common being in the veterinary cuttable plate (VCP). This is a plate that is 50 holes in length. One

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size can accommodate 1.5 mm or 2.0 mm screws while the larger one holds 2.0 or 2.7 mm screws. The surgeon can cut off whatever length is required for the particular case using a wire cutter. The VCP has many advantages including that multiple lengths can be stacked one on top of another for added strength, there are relatively more screw holes per unit of length than conventional plates (which can be a disadvantage in some cases!), and the plate is relatively inexpensive compared to most other styles of plate (2).

4. **Application:** Two bone plates may appear to be the same but may be used in very different fashions. In veterinary medicine, none of the long bones are perfect cylinders aligned exactly parallel to the weight-bearing forces applied to them. Consequently, there will be one side of the bone that is under tension from these weight-bearing forces while the opposite side will generally be under the influence of distractive forces. Placing a bone plate opposite to the “tension” side of the bone allows it to convert the distractive forces to compression at the fracture line. In comminuted fracture cases the same plate may be applied in the same place but instead of playing a “compression” role the plate “neutralizes” the forces on the fracture and is referred to as a “buttress” or “bridging” plate. In this application the plate carries most or all of the weight-bearing load during the healing process. This will obviously have implications on the size and type of implant used and may necessitate use of additional implants, such as an IM pin (2).

The 3 main characteristics in screw design are size, thread characteristics, and the manner in which threads are cut into the bone.

The previously described screw sizes refer to the external diameter of the screw threads. Screw threads also differ in their spacing and pitch. Cortical screws are most commonly used in veterinary applications. Their threads are relatively closely spaced and shallower in pitch which makes them best suited to placement in cortical bone. Cancellous screws have wider-spaced, steeper-pitched threads that hold better in softer cancellous bone. Secure meshing between the screw and the bone depends on the cutting of matching threads into the screw hole drilled in the bone. This has traditionally been done with a tap, but self-tapping screws are becoming increasingly popular. Self-tapping screws have a cutting flute at their tip that cuts threads into the bone as the screw is turned into the hole. It used to be thought that manually tapping threads into the bone provided a more secure hole but many recent studies have shown that self-tapping screws are equally secure (5,6). Today, the only thing that stands in the way of the retirement of the “tap” and a complete switch to self-tapping screws is their significantly greater cost compared with conventional screws.

As with any application of orthopedic hardware, the surgeon must strictly adhere to a number of basic principals to increase the likelihood of a successful outcome when using plates and screws. The orthopedic implant is primarily a “force neutralizer” in a fracture situation. The size of those forces varies depending on the size and activity of the patient, how much he is likely to use the affected limb, which bone is involved, the characteristics

of the fracture, specifically, can the bony column be reconstructed and stabilized sufficiently so that it can bear weight or will the implant bear all of the weight, how long will the implant be required before healing bone takes on weight-bearing (admittedly an “educated guess” in most cases). The plate selected must be strong enough to carry the forces applied to it, but it must not be too rigid so as to divert all weight-bearing load from the healing bone. Such a state of affairs produces “stress protection” in which the bone will significantly weaken and demineralize by virtue of Wolff’s Law. Wolff’s Law states that bone will adapt to the load that is placed on it. Weight lifters not only develop larger, stronger muscles but they also develop stronger, thicker bones. Conversely, bed-ridden patients develop thin, fragile bones....as do patients with an overly heavy plate on a fracture. The size of plate selected can be determined by a combination of charts (2), based primarily on patient weight and the bone involved, and consideration of all the patient factors previously discussed, tempered with a healthy dose of experience! The length and shape of the plate chosen must permit a minimum of 3 full screws (or 6 “cortices” of screw purchase within the bone) on either side of the fracture. In some instances, if the available bone in a fragment is limited, 2 full screws may suffice. One wants to fill each screw hole in the plate with a secure screw. In cases where there is not solid bone stock beneath a screw hole and a hole is left empty, a “stress riser” is created. This is a weakness in the fracture repair construct and opens up the possibility of plate breakage. This can be counteracted by choosing a heavier plate or protecting the plate with an IM pin.

Bone plates and screws are seldom removed once fracture healing is complete. While there is evidence that a very small number of patients may develop malignant bone tumors at the site of orthopedic hardware, it is unclear whether this is attributable to the hardware or to the fracture, or both. Potential prevention of this exceedingly rare complication must be weighed against the disadvantages of performing a second anesthetic and surgery on the patient. In general, bone plates are only removed if they cause a problem such as if an infection is present, or if lameness, swelling, or irritation persists over a plate after clinical healing (2,7).

References

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