Re-embracing External Skeletal Fixation

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With the introduction of locking plates and the advent of angle stable nail systems for use in dogs and cats, there has been a steady decline in the use of external skeletal fixation in small animal practice. Linear fixators were once an integral component of small animal orthopedic surgery armamentarium. For decades the Kirschner Ehmer System was the primary linear system used by veterinarians. While the system had some inherent limitations, acceptable outcomes could be consistently obtained when this system was applied appropriately. The '90s ushered in advances in pin design as well as new linear fixator systems, such as the Securos External Fixator System and the IMEX SK Linear External Fixator System, with design advancements that improved biomechanics and facilitated application. These systems offer a versatile, economical modality for deformity correction and trans-articular stabilization, this lecture will primarily focus on the use of external skeletal fixation in fracture management.

Circular fixators were initially developed by the Russian physician Professor Gavriil A. Ilizarov during the latter half of the 20th century. These are modular systems, which can be assembled in an unlimited number of configurations to stabilize fractures and arthrodeses, perform bone lengthening and bone transport as well as correct angular, translational and rotational deformities. Circular fixator frames consist of a series of complete and/or incomplete external rings that are interconnected by a series of threaded rods. Rings are secured in position along these rods by placing a nut on opposing surfaces of each ring. Unlike linear fixator systems, traditional circular fixators use small diameter wires, rather than relatively larger pins, as fixation elements. The fixation wires are typically tensioned, when using larger diameter rings, to improve the construct's stiffness characteristics. The fixation wires immobilize the bone segments and adequately resist bending, shear, and torsional forces while allowing some degree of axial micro-motion at the fracture or osteotomy site. Axial micro-motion has been shown to be beneficial, creating a mechanical environment conducive to osteogenesis, and enhances fracture healing. Circular fixators are uniquely designed, allowing the frame to be elongated or compressed. Elongation of the frame allows for distraction osteogenesis, a method by which regenerate bone is produced within the developing gap created as the secured bone segments are slowly and sequentially distracted apart during the post-operative convalescent period.

Circular external skeletal fixation has been used in small animals over the past three decades. At the University of Florida, we have used circular fixators to treat a multitude of developmental, traumatic, and neoplastic orthopedic conditions affecting dogs and cats. The most notable of these being limb deformity corrections, particularly antebrachial limb deformity corrections requiring limb lengthening. Pre-operative assessment and planning, a thorough knowledge of the instrumentation and its application and conscientious post-operative patient care are essential for a successful outcome. We have less experience using circular constructs for hind limb (both proximal and distal to the stifle) deformity correction, but when needed these constructs can be used to effectively address challenging cases. We often use circular constructs to stabilize complex fractures of the antebrachium and crus. We also use circular fixators for trans-articular stabilization, particularly in performing arthrodeses. Circular fixator frames which utilize hinges provide the latitude to adjust the angle of arthrodesis during the early convalescent period as well as the removal of all implants following fusion. Finally, oncologic surgeons are now using circular fixators to perform bone transport in limb salvage procedures in dogs with appendicular bone tumors. The use of bone transport can also be used to replace segmental bone defects in dogs and cats with traumatic bone loss or following sequestrectomy.

Hybrid linear-circular external skeletal fixation evolved to simplify construct application and limit post-operative morbidity. While circular fixators are useful for stabilizing distal limb fractures in small animals, morbidity ascribed to wire tract inflammation, especially resulting from wires traversing large muscle masses, is a consistently reported complication. Human patients experience similar wire tract complications, which prompted the use of hybrid constructs which employ half-pins rather than wires as fixation elements in high morbidity locations. In veterinary orthopedics, the term "hybrid fixator" is typically used to describe a construct that is composed of both linear and circular components. Approximately 15 years ago, hybrid rods [variable length connecting elements which have a smooth shaft that accommodates linear fixator clamps and are threaded at one end, allowing the rods to be secured to ring components of fixator systems] became available for use in companion animals (IMEX™ Veterinary, Inc., Longview, TX, USA) which ushered in a new era in veterinary external skeletal fixation.

Hybrid constructs can be applied using either an open or a closed approach. If an open reduction is performed, an intramedullary Steinmann pin or Kirschner wire is often placed as a primary means of stabilization. The fracture can also be partially or completely reconstructed using interfragmentary cerclage and Kirschner wires. Following closure of the surgical approach, the ring components are secured to the distal fracture segment [generally the shorter fracture segment is distal, but in selected fractures the short juxta-articular fracture segment can be proximal] using two or more divergent Kirschner, or preferably, opposing olive wires. A half-pin is then placed in the proximal fracture segment and an appropriate length hybrid rod is secured in one of the holes in the ring [preferably using paired hemi-spherical washers and nuts] as well as the fixation pin. The hemi-spherical washers and nuts allow the hybrid rod to be rigidly secured to the ring with some degree of angulation. Alternatively, articulated posts or a Vari-ball hybrid adapter can be used in lieu of hemi-spherical washers and nuts. Additional [usually one to three] intermediate pin fixation clamps and half-pins are then placed where deemed appropriate. Employing type Ib constructs is mechanically advantageous and is advocated whenever feasible.

If a closed reduction is performed, the ring component is secured to the distal fracture segment via a fixation wire placed in the medial-to-lateral plane. The ring is positioned perpendicular to the anatomic axis of the engaged bone segment and a second temporary fixation wire is placed in a cranial-to-caudal direction to maintain proper ring orientation during reduction and/or as subsequent fixation elements are placed. Use of paired, divergent, opposing olive wires to maximize stability of the bone segment engaged by the ring is highly advocated. A half-pin is placed in the proximal fracture segment and a primary hybrid rod is loosely secured in a hole in the ring which is aligned with the anatomic axis of the fractured bone. The rods are secured to the ring using paired hemi-spherical washers and nuts. The fracture is then reduced by applying traction to the limb segment, ring component, or both. When the fracture is perceived to be aligned, the pin fixation clamp and hemi-spherical nuts securing the hybrid rod to the ring are tightened. Alignment is assessed, using palpation and visual appearance of the limb, and fluoroscopy if available. Adjustments can be made by loosening the assembly elements and applying traction to the fractured limb segment again. Once alignment is considered acceptable, the construct is completed with the placement of additional intermediate pin fixation clamps and half-pins. Again, use of type Ib constructs is strongly advocated.

In addition to decreasing fixation element tract morbidity, hybrid constructs afford additional benefits compared to purely circular constructs or purely linear constructs. Compared to linear construct, hybrid constructs have proven to be useful for managing fractures with short juxta-articular fracture segments because a ring can accommodate placement of multiple divergent wires which provide multi-planer stability. Hybrid constructs simplify pre-operative planning and fixator application compared to the utilization of traditional circular constructs [particularly in small dogs and cats] because hybrid constructs can be applied with a “linear mentality”.

Hybrid constructs also allow utilization of ring components proximal to the elbow and stifle. Half-pins can be used instead of wires as fixation elements when stabilizing proximal limb fractures in larger dogs. Half-pins, mounted on 1/3 arches, are also useful when stabilizing humeral or femoral fractures with short proximal fracture segments. Adjunctive fixator placement to supplement an intramedullary pin, including the use of articulated “tie-in” constructs, is advisable when stabilizing more complex humeral and femoral fractures.

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