Surgical Conditions of the Spine Mini Series

Session Three: Spinal Fractures and Luxations

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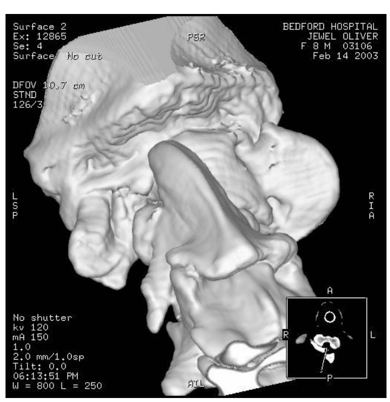

Atlantoaxial Instability

Atlantoaxial subluxation was first reported in dogs in 1967. Since this time, several congenital and developmental deformities of the AA joint have been documented to cause instability of the vertebral column predisposing to AA subluxation particularly in young, small-breed dogs. Possible congenital or developmental anomalies of the AA joint include dysplasia (34% of dogs), hypoplasia or aplasia (46% of dogs), dorsal angulation, and separation of the dens, as well as absence of the transverse ligament. Any abnormality of the dens will predispose to instability of the AA joint due to its important role in the normal stability of this joint; however, up to approximately 24% of dogs with AA subuxation will have a normal dens. Recent additions to this list of anomalies associated with AA subluxation include incomplete ossification of the atlas and the presence of block vertebrae.

Incomplete ossification of the atlas has been documented in 5 dogs with 4 of the dogs exhibiting concurrent atlantoaxial subluxation associated with a relative dorsal displacement of the axis. The authors suggested that this vertebral anomaly may be a contributory factor to subsequent vertebral instability because there may be associated deficiencies of the atlantoaxial ligaments or their attachments allowing laxity of the joint.

Block vertebrae have been reported in association with AA subluxation in 2 dogs. Block vertebrae are rare but well-known congenital vertebral deformations involving the fusion of two or more vertebrae. This vertebral deformity may occur at any level of the vertebral column and is usually considered an incidental radiographic finding; however, block vertebrae may contribute to clinical signs of spinal cord disease in some animals. In the 2 dogs reported with concurrent AA subluxation, the authors hypothesized that congenital vertebral fusion created a ‘fulcrum effect’ that predisposed the dogs to traumatic AA subluxation.

Small breeds of dog including Yorkshire terriers, Chihuahuas, Miniature poodles, Pomeranians, and Pekingese are most often affected by the congenital and developmental anomalies that predispose to AA instability and potential subluxation. This is mainly because the dens is prone to maldevelopment in miniature breeds due to aberrations of physeal growth plate closure. However, atlantoaxial subluxation due to congenital vertebral anomalies has also been reported in large breed dogs. Atlantoaxial subluxation due to congenital vertebral anomalies in cats is very rare.

Traumatic AA subluxation can occur in any breed and age of dog. Traumatic AA subluxation results from forceful overflexion of the head, which may tear the ligaments or cause a fracture of the dens or dorsal arch of the axis. Considerable impact may be required to cause such injuries in a normal AA joint and so many times even traumatic AA luxations are associated with an underlying congenital defect and instability of the joint.

The instability of the AA joint associated with congenital anomalies or subsequent to trauma, allows excessive flexion of the joint and causes spinal cord compression and concussion from the dorsally displaced cranial portion of the axis in relation to the atlas. Spinal cord trauma secondary to an acute episode of subluxation has the same underlying pathophysiology as that related to acute disc extrusion and acute vertebral fracture luxation elsewhere in the spinal column.

Clinical Signs

Instability of the AA joint alone is not associated with clinical signs. The severity of the clinical signs depends on the degree of injury to the spinal cord following an episode of subluxation.

Neck pain is the single most common sign associated with AA subluxation, being seen in most dogs with traumatic lesions and 30-60% dogs with congenital lesions. The associated neurological deficits are determined by the degree of damage present in the cord following both the concussion and residual compression. The neurological deficits can range from mild postural reaction abnormalities (56%) to tetraplegia (10%); overall, gait dysfunction has been reported in upto 94% of dogs. These deficits can appear asymmetrical in addition to appearing worse in either the pelvic limbs or the thoracic limbs. In the rare cases which present with tetraplegia, progression of the clinical signs to a state of clinical respiratory compromise and even arrest should be considered possible. Severe signs can be present in some dogs in the absence of notable compressive disease. The use of magnetic resonance imaging has confirmed the presence of significant parenchymal pathology, including hemorrhage, in such dogs. Abnormalities of posture such as torticollis can be seen in dogs with AA subluxation due to concurrent syringohydromyelia, vestibular dysfunction or associated with the underlying pain. Occasionally, dogs will present with intracranial signs which are purported to be related to extension of parenchymal pathology into the brainstem, basilar artery compromise, concurrent hydrocephalus, and other incidental diseases prevalent in toy-breed dogs such as hepatic encephalopathy. Seizures may be seen in historical association with AA subluxation but it is likely that these represent an inciting cause of the subluxation in a dog with a pre-existing instability.

Specific diagnosis

The diagnosis of AA subluxation should be considered for all dogs with C1-C5 lesion localizations especially in young toy-breeds. Differential diagnoses for this condition in such patients include meningo-myelitis, syringohydromyelia and discospondylitis; disc extrusion would be less likely in dogs less than 12 months of age although should always be considered if there has been a history of trauma.

Atlantoaxial subluxation can be diagnosed from survey radiographs of the cervical spine although extreme care must be taken when restraining and moving dogs in which this disease is suspected. Unsedated views may be attempted and are especially advised if the dog may have a fracture. If the animal is sedated or anesthetized, the head and neck should be supported in slight extension to avoid further spinal cord injury. On lateral radiographs an increased space can be seen between the dorsal lamina of the atlas and the dorsal spinous process of the axis. In severe cases, malalignment of the bodies of the atlas and axis is clearly visible. Objective parameters which take into account the normal range of motion of the atlantoaxial joint have been recently reported. An angle between the atlas and the axis of less than 162° is more predictive of instability than a decrease in atlantoaxial overlap. Without objective measurement, it is possible that some dogs are incorrectly diagnosed.

The presence and size of the dens can be evaluated most accurately on VD views; this can also be well evaluated on oblique radiographs. These views are preferable to open mouth views which place the patient at severe risk of cord trauma. If there is no evidence of subluxation on the lateral views, the neck can be carefully flexed to see if there is instability (the space between the dorsal lamina of the atlas and the dorsal spinous process of the axis should be evaluated). It is preferable to do this with fluoroscopy so that the movement can be monitored to prevent accidental iatrogenic subluxation; this can provide a rapid diagnosis in a conscious dog. However, flexion of the AA joint when the dens is dorsally deviated risks severe iatrogenic trauma to the cord.

Myelography is occasionally performed to confirm spinal cord compression associated with the AA subluxation but involves more risk than anesthetized radiographs and adds little benefit.

Computed tomography and MRI can add vital information which helps with decision making regarding treatment of the individual patient. Computed tomography can assist with identification of dens conformation, dens or vertebral fracture presence and surgical implant placing. Three dimensional CT reconstruction of the AA joint can add an extra level of understanding to the diagnosis which can assist with surgical decision making. An MRI can provide additional information regarding cord pathology such as hemorrhage or edema and syringohydromyelia which might be important for prognosis.

Conservative Treatment

The aim of conservative treatment is to stabilize the AA junction while the ligamentous structures heal. Non-surgical treatment of AA subluxation, including strict cage confinement for 6 weeks, analgesia and a rigid cervical brace has been successful in some patients; however, nonsurgical or conservative approaches are likely to result in recurrent or progressive clinical signs.

The splint must immobilize the atlantoaxial junction and so the entire wrap must come over the head cranial to the ears and go back to the level of the chest. The splint is usually manufactured out of fiberglass cast material, incorporated into a bandage and applied ventrally with neck held in extension as it is secured in place with cast padding and elasticized wrap. The splint must extend from the rostral extent of the mandible to the xiphoid. The splint should ideally be changed once a week while the dog is sedated or under anesthesia to avoid the development of pressure sores associated with migration of the splint under the bandage. Repeat cervical radiographs can be taken while the splint is in place and preferably after each successive re-wrap. Complications associated with the use of a splint and neck wrap include recurrence of disease, corneal ulcers, migration of the splint to become ineffective, moist dermatitis and decubital ulcers, hyperthermia, respiratory compromise (dyspnea, aspiration), anorexia, otitis externa and the accumulation of food between the splint and mandible.

Indications for surgery

The goal of surgical treatment is to stabilize the AA joint thereby preventing further spinal cord damage. Although the surgery will by design reduce the compressive component of the disease, it will not address any underlying parenchymal disease resulting from the concussion associated with this disease. Surgery should be considered in all dogs as it holds the potential to fuse the AA joint permanently and reduces the chance of catastrophic recurrence. The historical indications for a conservative approach, besides systemic health and economic factors, have been clinical signs of cervical pain only, dogs with mild neurological deficits, and dogs with no radiographic abnormality of the dens. Additional indications for a temporary conservative approach may be very young patients which will benefit from further growth prior to surgical correction and patients with severe neurological dysfunction which may show signs of improvement thereby clarifying the prognosis for the owner.

Specific surgical technique(s)

Ventral Approach to the Atlantoaxial Junction

The animal is positioned and prepared as for a routine approach to the cervical spine and the midline skin incision is performed cranially from in front of the larynx to extend to the level of C4 caudally. Separation of the underlying fascia reveals the sternohyoid muscles as above and their separation will help identify the cranially situated larynx and thryroid gland. The sternothyroid muscle can be seen inserting on the thyroid cartilage and should be sectioned just below this insertion being cautious of the underlying vascular bundle; this should be reattached at the end of the surgery and so should remain identifiable. Careful retraction of the trachea, esophagus and thyroid gland should be maintained manually until the longus colli muscles are elevated as for the ventral slot approach described above, at which point selfretaining retractors can be applied. The underlying joint capsule and articulation of C1 and C2 can be visualized at this time.

Ventral Techniques

Dogs are positioned in dorsal recumbency with a towel placed on the table underneath their neck to extend the spinal column. The neck can also be placed within a vacuum pad to ensure that there is limited movement. The thoracic limbs are extended caudally and tape wraps should secure the limbs and the rostral skull. A routine approach is made to the ventral aspects of C1, C2 and cranial C3. Care should be taken to avoid damage to vital structures such as the recurrent laryngeal nerve and the vascular supply to the thyroid gland. The ventral aspects of C1 and C2 should be cleaned of muscle and the joint capsule should be exposed as far laterally as possible. The joint capsule can be incised and the articular cartilage scarified from the surface of both caudal end plates. This can encourage fusion of the joint which is the primary long term goal of the fixation; this can be assisted by the use of autogenous cancellous bone graft obtained from the humerus.

To secure the joint and vertebrae in appropriate alignment while inserting implants, thereby protecting the cord from repeated concussion, it has been recommended to use a 1.5 or 2.0mm cortical bone screw inserted into the caudal body of C2 as an anchor around the head of which cerclage wire can be twisted and caudo-ventrally retracted, elevating the bone ventrally toward the operator. Screw length is best estimated from CT or MRI scans. The vertebral body of the axis may be fixed with micro Halsted forceps, positioned in the middle of the lateral section of the body if preferred to the above technique. Maintaining bone stability by using a lever type instrument inserted in to the joint toward the spinal cord is another option but is dangerous

Odontoidectomy can be performed from a ventral approach and may be necessary if there is fracture or nonunion of the dens.

Transarticular Lag Screws or Pins

Once the vertebrae have been aligned and are temporarily secured by the above mentioned methods, a 1.5mm hole for a 1.5 mm cortical lag screw is drilled in the cranial section of C2 beginning on one side of the vertebral body just behind the bony cranial wall. Subsequently, the C1 hole for the screw is drilled using a 1.1mm drill; the drill is directed craniolaterally, approximately 30º from midline to reach the largest portion of the bony lateral part of the atlas. The drill hole is tapped with a 1.5mm tap. A similar technique has been described using Kirschner wires or pins (0.045” or 0.062”). The optimum angle for the pin is obtained by directing each pin toward the medial border of the respective alar notch and maintaining the tip of the pin as far ventral as possible.

Pins and PMM

Kirschner wires or acrylic fixation pins (0.035” to 0.062”) can be placed in both C1 and C2 ventrally with subsequent incorporation within PMM. Following bone grafting and vertebral re-alignment, the pins are directed perpendicular to the median plane and transverse plain into each of the pedicles of the atlas with a pin driver. Transarticular pins are also placed as described above. Pins are then placed into the caudal body of the axis at an approximate 30° angle to the transverse plain. All the pins are cut 1 to 2 cm ventral to the bone surface and the tips of the pins are bent prior to the all being embedded in PMM. Following prolonged saline irrigation, the longus colli muscle can be closed but this is often not possible. Placement of a biological membrane (e.g., Vet BioSISt®) over the fixation apparatus may encourage local muscle healing and protect the local tissues (esophagus, trachea) from fibrous adherence.

Screws and PMM

Cortical bone screws can be placed into the medial aspect of each wing of the atlas caudal to the transverse foramen in a craniolateral direction. Screw sizes should be chosen based on the size of the dog but 1.5 to 2.0 mm diameter and 10-20 mm in length are usually appropriate. A third screw can sometimes be placed in the middle of the ventral body of C1 depending on the size of the patient; this screw can be inserted at 90º to the bone surface and should not break through the second cortical surface. This portion of the atlas is frequently entirely cortical in nature.

Two ventral C2 screw patterns have been described. In the first pattern, 4 cortical screws are placed into the body; one screw is placed into the middle of the caudal aspect of each of the cranial articular surfaces of C2 at the insertion point of the longus colli muscle and are directed craniolaterally at 30º to 40º. The second pair of screws is placed at the base of the transverse processes of C2 or C3 and directed laterally at 30º to 40º to the midline. Using this technique, Steinman pins or K-wires can be used to bridge the screws; the pins or wires are positioned parallel to mid-line and secured by orthopedic wire to the screws. This entire apparatus can be encased in PMM; as for all ventral techniques, the minimum amount of PMM necessary to cover all the screws should be used as it can cause significant compression of the surrounding soft tissues. A second pattern uses just 2 cortical screws, one of which can be the screw which facilitates secure re-alignment described in the technique overview section above. This latter technique additionally differs from the first screw and PMM technique by using transarticular 0.035-0.062" threaded or non-threaded Kirschner wires to secure the joint and subsequently incorporating all of the screws and the wires into PMM.

Surgical complications

Complication rates have been reported to be as high as 71% for dorsal fixation techniques and 53% for ventral fixation techniques.

Neurological deterioration – surgical manipulation of the joint has a risk of further injuring the spinal cord at the site due to repeated concussion. This has been reported to be associated with both dorsal and ventral techniques. Iatrogenic damage to the spinal cord is also possible due to erroneous implant placement.

Respiratory system compromise – As with all ventral cervical spine surgeries, there is a risk of laryngeal paresis due to retraction related trauma to the recurrent laryngeal nerve. Additionally, there may compression of the trachea by the implants and PMM, which has been reported to cause tracheal necrosis. If this does not cause dyspnea, it may cause an excitement related cough in some dogs. This can also result from prolonged traction of the trachea during surgery. It is unfortunate that any respiratory pathology often compounds an already present brachycephalic airway syndrome or collapsing trachea in many patients due to the nature of the dog breeds predisposed to AA subluxation.

In severe cases, the dyspnea may need to be managed with a temporary tracheostomy tube. Fatal respiratory arrest is rare but central nervous system trauma experienced during the surgery can be responsible. Death following peri-operative aspiration pneumonia has been documented in some dogs.

If external coaptation is used pre- or post-surgery, the dog must be monitored extremely closely for the first few hours as there is a risk of respiratory compromise if the bandage material had been placed too tightly.

Implant failure – migration or fracture of the implants can occur in ventral and dorsal surgeries although seems to most commonly affect the trans-articular K-wires, and can occur months after the procedure; however this tends to occur within the first 3 weeks after surgery. Transarticular lag screws can also be subject to failure especially during the implantation procedure, as the small volume of axis bone available for screw engagement and the 'target' area for screw positioning does not permit any error.

Improper pin placement with inadequate bone purchase is the main cause of implant migration. This can be an incidental finding at recheck radiographic examinations or it may become apparent following an onset of recurrent clinical signs or with the appearance of the implant surfacing through the skin or even the mouth. Dorsal repairs using wire can also be associated with the implant breaking. The fixation failure rate may be as high as 25% with dorsal fixation techniques and 18% with ventral fixation techniques. Depending on the time post-surgery when the failure occurred, another surgery may not be necessary as the joint may have already experienced osseous fusion.

Fracture of the atlas or axis –the dorsal arch of the atlas can fracture following a dorsal repair due to the weakness of the thin dorsal bone. Ventral repairs can result in fractures of the cranioventral aspect of the C2 body when a transarticular repair is undertaken due to improper implant positioning or vertebral immaturity or both.

Recurrent Pain – episodic pain has been reported in dogs for several months to life post-surgery and is often a reason for euthanasia of these patients. This can be due to failure of the surgery to decompress the cord and realign the vertebrae or it may be due to fixation failure; neurological status may be improved in some dogs with persistent pain.

Post-operative care

In all cases, lateral and dorsoventral postoperative radiographs are imperative to assess joint alignment and implant placement while the dog is still under anesthesia. Appropriate pain relief should be administered for the first 24-48 hours in the form of opioids with anti-inflammatory doses of corticosteroids or non-steroidals being acceptable after this time. Respiration monitoring should be a priority in all patients for the first 2-3 days; many patients may already have a pre-existing respiratory issue, such as a collapsing trachea, and the stress of the surgery coupled with the location of the implants may serve to exacerbate this.

Although the placement of an external neck wrap has been described post-operatively, the authors believe that this is not necessary if appropriate internal fixation has been achieved, and can result in many complications.

Strict cage restriction is advised for all dogs that have undergone surgery for a minimum of 4 weeks but ideally for up to 8 weeks. A recheck radiographic examination is advisable prior to resuming more normal activity levels; however, owners should be warned to walk the dog with a body harness rather than a neck collar and should discourage any form of jumping activity (i.e., down from a bed or couch) for the rest of its life.

Prognosis / outcome

A good long term outcome has been documented in 10 of 26 (38%) cases managed conservatively and with follow up information available. Dogs that were affected for less than 30 days were significantly more likely to have a good long term outcome when managed conservatively, compared with dogs affected > 30 days.

Peri-operative mortality rate associated with AA fixation has been reported to be between 10-30%. Risk factors affecting surgical outcome in dogs have been identified. Age of onset (<24 months) was significantly associated with greater odds of a successful first surgery and final outcome. Duration (<10 months) and severity of clinical signs was significantly associated with greater odds of a successful final outcome; despite the guarded prognosis for dogs with severe neurological deficits, many dogs that are unable to walk before surgery have a good outcome. Whether a dorsal or ventral procedure is performed does not seem to change the odds of a successful outcome.

The long-term success with dorsal surgical approaches has been reported to be good to excellent in 61% of dogs when all methods of fixation are considered together. Surgical management of AA subluxation by the dorsal wire loop technique has been reported in 27 dogs with an overall success rate of 52%. The dorsal suture technique has been reported in 10 dogs with a 50% success rate. The nuchal ligament technique has been reported in 4 dogs with three dogs having a successful outcome. Six of 8 (75%) toy breed dogs had a good to excellent 12 months outcome when treated dorsally with the Kishigami AATB.[36] One dog did not improve and was euthanized and one dog deteriorated post-operatively.

The long-term success with ventral surgical approaches has been reported to be good to excellent in 47-92% of dogs depending on the method employed. Transarticular pinning alone seems have the least success in comparison to the use of multiple pins or screws and PMM with an overall success rate of 47%; transarticular lag screws alone however have been reported to result in a 90% success rate in one study, but only a 40% success rate in another study when used without cancellous bone grafting. It is debatable as to whether the cancellous bone grafting would have improved the outcome as some cases which have been grafted fail to show evidence of bony fusion 6 weeks after the fixation. The overall failure of fixation rate has been quoted to be as high as 44% with ventral surgery and 48% with dorsal surgery.

Spinal Fractures and Luxations

Spinal column fractures and dislocations (SCFD) are infrequent. They usually result from severe blunt force trauma such as motor vehicular accidents and falls but may also result from gunshot wounds or other penetrating injury on occasion. Dogs with SCFD may present in a variety of neurological states ranging from paraplegic without pain perception to ambulatory. A dog with SCFD and significant canal displacement may still be able to walk, sometimes surprisingly near normal so caution should always be observed if the possibility of SCFD exists. The blunt force required to fracture or dislocate the spine may easily result in significant injury to other organ systems, some of which may be life-threatening. A thorough examination of the dog without excessive manipulation is in order to identify other injuries. If the dog is stable a limited neurological examination should be performed to assess the lesion location and extent. Tests such as spinal column hyperpathia, dorsal spinous process malalignment, bruising of the skin over the spine, myotatic reflexes, withdrawal reflex, perception of deep pain sensation, anal and bladder tone, and observation of purposeful movement can provide sufficient information to properly stage the extent of the neurological injury.

Following induction of general anesthesia, advanced imaging can be performed. Survey radiographs, if proper collimation, positioning, and technique are followed, provide good information about the extent and location of the SCFD injury but are not as helpful for identifying bone fragments or hematomas in the spinal canal as well as the images obtained with CT or MRI. Radiographs obtained when the dog is awake generally are only useful when there is extreme spinal canal displacement and the primary motive for making the radiograph is to confirm the obvious. Myelography rarely adds useful information and increases the time under anesthesia and manipulation of the dog's spine. The greatest utility of myelography is when the contrast agent diffuses throughout the substance of the spinal cord parenchyma, supporting the clinical diagnosis of myelomalacia (no deep pain perception, excessive pain, labored respiratory character, etc.). It should always be remembered that extreme caution should be exercised when manipulating a dog for any imaging study because the protective effect provided by the spinal musculature is lost under anesthesia, making it easier to further damage the spinal cord when maneuvering the dog to make various views, transfer the dog from gurney to table, etc.

Spinal column stabilization can be achieved with a number of techniques, all with distinct advantages and disadvantages. The author's preferred techniques include spinal rods and segmental wiring, closed or open external skeletal fixation (ESF), and perhaps the new SOP locking rods. Spinal rods and segmental wiring is a variation on the traditional spinal stapling technique except larger rods are used to achieve greater resistance to bending, the primary force acting on most SCFDs. The advantage of this technique is its stability. The disadvantages include the need to open the SCFD site, excessive soft tissue elevation from the spinal column bones, the tedious nature of placing multiple segmental wires and the attendant risk of glove puncture and infection, and the potential for migration of the rods and/or breakage of the segmental wires. External skeletal fixation has recently gained some popularity for the stabilization of SCFD injuries. The technique can be applied either open or closed with fluoroscopic imaging. In either case, the surgeon must have a very good command of the regional anatomy to avoid iatrogenic spinal cord or aorta injury and still achieve proper bony fixation. I prefer to apply the ESF in a closed fashion using fluoroscopic guidance to limit soft tissue insult and spinal cord manipulation unless removal of bone fragments or other material from the spinal canal is necessary. For caudal lumbar SCFD, the caudal ESF pins can be anchored in the ilial wings, lessening the risk of spinal column injury while achieving sufficient stability. The ESF frame is left in place and the pin-skin interface cleaned daily until fracture healing or joint fibrosis has occurred, typically 8-10 weeks.

Although untried at this time, the new SOP locking rods may offer the best solution to stabilizing SCFD injury. The rod resembles a string of pearls (hence the acronym SOP). A screw is inserted through each pearl and locks into place against the rod, providing a rigid construct. The screws are inserted into the vertebral body obliquely in the same direction as ESF pins. The SOP can be contoured in three planes to achieve anatomic reduction. The advantages of the SOP include biomechanical advantage by applying the SOP on the vertebrae and locking the screws to the rod but the need to elevate the paraspinal muscles from the spinal column is a disadvantage.

Surgical treatment is indicated primarily for unstable injuries. Decompression is often achieved after fracture reduction, which is why (hemi)laminectomy is not routinely carried out. However, (hemi)laminectomy is indicated for removal of fragments displaced into the vertebral canal or treatment of disc herniation associated with compression of the spinal cord or nerve roots. (Hemi)laminectomy should be carried out only in association with fracture stabilization and not on its own.

For reduction, the intact vertebra adjacent to the fractured or luxated bones is grasped with bone holding forceps. Careful distraction usually suffices to reduce the fracture; however, leverage is sometimes required. Reduction is confirmed by assessing the vertebral processes. When the articular facets on either side are positioned correctly, reduction is considered successful.

Numerous stabilization techniques have been described in the literature. In our experience, vertebral body fixation methods that incorporate as few vertebrae as possible are superior to methods that involve dorsal fixation of the spinal processes over a longer stretch. To ensure optimal stability, collapse of the affected intervertebral space is acceptable or even desirable. Long-term re-evaluations have shown that the intervertebral space becomes smaller again after reduction and spinal fixation when spacers (cage or bone cement) are not used. The resultant instability favours loosening of implants, which have little purchase in the cancellous bone of the vertebrae.

A ventral approach is used in patients with cervical vertebral osteosynthesis and spondylodesis. Fractures of the vertebral body can be stabilized with a plate that is limited to the injured vertebra. Orthopedic wire suffices for fixation of physeal separation of the endplate. Spondylodesis involves distraction and filling of the unstable intervertebral space with bone cement or a cage filled with cancellous bone. The mobile vertebrae are then stabilized with a plate and a minimum of two screws per vertebra. Internal fixator systems with locking screws are advantageous for this because they provide better pull-out resistance and allow mono-cortical seating of the screws. For stabilization of atlantoaxial subluxation caused by fracture or hypoplasia of the dens, or ligament rupture, two transarticular screws are placed in a caudocranial divergent direction using a ventral approach. 3D-reconstruction of computed tomographic images is used to determine optimal screw placement. A T-plate can also be used, although the cranial screws in the ventral arch of C1 do not have much purchase. Another technique involves fixation of the spinal process of C2 to the dorsal arch of C1 using orthopaedic wire or suture material. To prevent compression-associated complications, C2 should not be pulled too close to C1. Lateral removal of the lamina may also be indicated in this procedure. Dorsal fixation cannot be ensured when the dorsal arch of C1 is not completely ossified.

Injuries of the thoracic vertebrae and thoracolumbar vertebral junction require decompression more often because the spinal canal is narrower in these regions. In patients with spondylolisthesis, vertebral body fixation is achieved with cross-pinning of the affected vertebra; threaded Steinmann pins are suitable for this. The pins should cross the intervertebral space as far apart from each other as possible and should engage the entire length of both vertebral bodies. Three vertebrae must be included in the fixation of a vertebral-body fracture. Techniques for this include transpedicular Steinmann pins that are stabilized with bone cement on their free end, unilateral or bilateral plates or a clamp rod internal fixator (CRIF). The disadvantage of plate osteosynthesis is that partial rib resection or luxation is necessary for plate placement on the thoracic vertebrae. Plates can be contoured better on the lumbar vertebrae, although care must be exercised to prevent compression of the nerve roots, especially in the regions caudal to and including L4. Instead of a dorsolateral approach, a ventral approach via laparotomy can also be used for plate placement. In general, bone plates with locking screws are preferred for vertebrae because they provide more angular stability in the soft cancellous bone. However, when planning the operation, it must be remembered that, unlike conventional plate screws, the direction of locking screws is not variable. With dorsolateral fixation, other alternatives to plate osteosynthesis include transpedicular pins and bone cement. A more elegant method is the use of a unilateral or bilateral CRIF, which provides better preservation of the spinal musculature.

Fracture-luxation at the lumbosacral junction seldom results in impairment of hind limb function, but frequently affects innervation of the bladder and rectum. For a better prognosis, the cauda equina should be examined via laminectomy. One transilial pin seldom achieves adequate stabilization. Likewise, screw fixation of the small articular facets is frequently inadequate. Fixation of lumbosacral luxation-fractures usually requires transpedicular pinning and bone cement, or a bilateral CRIF involving the iliosacral region.

The prognosis of spinal injuries depends mainly on the neurological status of the patient, the time between injury and repair and whether optimal stabilization can be achieved with minimally invasive technique. Animals with grade 1-3 injuries usually have a good prognosis for recovery, while the prognosis for grade 4 is less favourable. Grade 5 injuries generally carry a poor prognosis.