STUDIES ON LUMBAR SPINAL PLATE FIXATION BY VENTRAL APPROACH IN DOGS

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By

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CERTIFICATE

This is to certify that the thesis entitled ***"STUDIES ON LUMBAR PLATE FIXATION BY VENTRAL APPROACH IN DOGS"*** submitted by **Mr. D.N. SRINATH, MVHK 1165** in partial fulfilment of the requirements for the award of **MASTER OF VETERINARY SCIENCE** in **VETERINARY SURGERY AND RADIOLOGY** of the Karnataka Veterinary, Animal & Fisheries Sciences University, Bidar is a record of bonafide research work carried out by him during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

Bangalore
Date: December, 2013

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Affectionately Dedicated to

Dear wife **Ramya,**

Loving son **Arjuna Sharma**

&

All family members

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Introduction

I. INTRODUCTION

Spinal injuries are encountered frequently in small animal practice. Posterior paresis or paralysis due to spinal injury is devastating for animal and also to the owner. The emotional attachment of the owner to the pet and the agony of the animal because of neurologic dysfunction are the strong reasons for the surgeon to put up best efforts for treatment of spinal injuries.

The causes of traumatic spinal injuries can be broadly classified in to internal and external trauma. Internal trauma of the spinal cord results from intervertebral disc diseases, pathological fractures, congenital vertebral anomalies or instability. Whereas external trauma results from automobile accidents, falling from heights, attack by human and animals, and projectiles like bullets hitting the spinal column (Shores, 1992). Internal trauma results in concussive or compressive injuries of the spinal cord because of the protruded or extruded disc material, fractures or luxations. The external trauma causes vertebral fractures, subluxations, luxations or fracture-luxations resulting in severe compressive trauma to the spinal cord.

Among spinal injuries lumbar spinal injury is more common (Bagley *et al.*, 2000). Lumbar spinal disorders mainly include intervertebral disc diseases, discospondylitis, ischemia, myelopathy, lumbosacral stenosis and trauma leading to fracture and luxations. An increased incidence of fracture-luxation has been reported at the junction between mobile and immobile segments of the spine such as thoracolumbar and lumbosacral junction due to stress concentration (Carberry *et al.*, 1989). The neurological dysfunction of lumbar spinal disorders ranges from pain, ataxia, paresis to paraplegia, loss of bladder and bowel control to absence of deep pain sensation. History, clinical signs, physical, orthopedic, neurological, radiological, myelographical and laboratory investigations serve as diagnostic tools for confirming the site of lesion (Wheeler and Sharp, 1994).

Conservative and surgical options are two approaches to the treatment of spinal disorder depending on degree of trauma and extent of damage. Conservative treatment involves external immobilization in the form of splints and bandages, cage confinement, exercise restriction and steroid administration (Bruce *et al*., 2008). The surgical treatment involves the reduction of vertebral segments, decompression of spinal cord and rigid stabilization of vertebral column. The various Surgical techniques described for stabilization of vertebral column fractures and luxations includes, internal fixation methods such as Wiring (Gage, 1968), Vertebral body plating (Swaim, 1971), Dorsal spinal plating (Gage and Hall, 1972), Dorsal Spinal stapling (Swaim, 1975), Modified Spinal stapling (McAnulty *et al.*, 1986), Composite fixation with pins or screws and PMMA (Blass *et al*, 1988), dorsolateral pinning for lumbar spine stabilization (Riaz, 2004) Modified Spinal stapling with tension band wiring (Voss and Montavon, 2004), spinal stapling with hemilaminectomy (Chandy and Vasanth, 2006[d]), spinal plating without laminectomy (Nagaraja *et al*., 2007[a]), vertebral stabilization by novel fixation locking plates (SOP) (Mckee and Downes, 2008) and the external fixation methods includes Kirschner-Ehmer device (Shores *et al*., 1989) and spinal arch External Skeletal Fixation (Wheeler *et al.*, 2007).

All these techniques were performed by dorsal approach and involves dorsal and middle compartment of the spine. These techniques of dorsal approach has some disadvantages like, heavy musculature attachments, need for heavy dissection with resultant muscle damage, bleeding, cavitation and seroma formation , difficulty of reducing fractured vertebral bodies.

Considering all the above factors the idea of ventral approach to the lumbar vertebrae was conceived. This technique of mid ventral approach to the spine is expected to have several advantages like minimal bleeding, better visualization of fracture site, easy reduction of fracture and more working space.

With this back ground the present study was undertaken with the following objectives.

1. To record the occurrence of traumatic posterior paralysis in dogs.
2. To standardize the technique of ventral approach for stabilization of lumbar fractures in dogs.
3. To evaluate the healing process by clinical and radiographic methods.
4. To study haemato-biochemical parameters before and after surgery.

Review of Literature

II. REVIEW OF LITERATURE

The available literature related to studies on lumbar spinal fixation by ventral approach in dogs is reviewed under the following heads:

2.1 Etiology and occurrence of spinal injury

2.2 Pathophysiology of spinal injury

2.3 Diagnosis of spinal injuries

2.3.1 Clinical examination

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2.1 Etiology and Occurrence of spinal cord injury

Pritchett (1938) reported spinal fracture due to automobile accident in a one year old cross breed female dog and recorded the spinal lesions by autopsy.

Gage (1968) reported tetraplegia in a nine month old female miniature dachshund due to fractures of odontoid process and portion of vertebral body of C_2 vertebra.

Brown *et al*. (1977) recorded 10.2% of recurrences in thoracolumbar disc disease in a retrospective study of dogs due to laminectomy membrane formation.

Denny *et al.* (1977) reported that the most affected breeds with cervical spondylotic myelopathy are believed to be adult Doberman Pinchers and young Great Danes.

Feeney and Oliver (1980) noted that most spinal fractures occurred at the junction between a moveable segment of the spine and an adjacent stable segment like thoracolumbar and lumbosacral region in dogs.

Ball *et al*. (1982) reported that Dachshunds were more frequently affected by intervertebral disc diseases especially at thoracolumbar junction.

Hoerlein (1987) reported that cervical spinal cord compression as a result of intervertebral disk disease (IVDD) is a common problem encountered in Chondrodystrophic breeds as they are predisposed to cervical IVDD. Dachshunds and Beagles were over-represented in the category.

Carberry *et al.* (1989) found that among 12 dogs having vertebral fractures and luxations, four (33.33%) were mixed breeds, two (16.67%) were Doberman Pinschers and one each (8.33%) were a Collie (8.33%), a Yorkshire Terrier (8.33%), a German Shepherd Dog (8.33%), a Miniature Poodle (8.33%), a German Short haired Pointer (8.33%) and an Alaskan Malamute (8.33%). The age of occurrence ranged from four months to nine years. The body weights ranged from 4.5 to 35 kg.

McKee (1990) observed that among 41 dogs and 10 cats with traumatic spinal injuries, the age of the animals ranged from 4 weeks to 15 years. Fifty per cent were less than two years old and seven of the 41 dogs were mongrels and five of the 10 cats were shorthaired. Four of the 22 males were castrated and 12 of the 29 females were spayed. Out of 41 dogs and 10 cats, 30 were hit by car, six injured by dog fight, two were due to tree or weight falling on spine, two were injured due to running through fence, two were due to greyhound racing. Among remaining four, one was injured due to jumping from owner’s arms, one got caught in the door, one was injured during leash training and one was kicked by kangaroo. Five out of them were injured due to unknown reasons.

Selcer *et al.* (1991) studied 211 animals with vertebral fractures and luxations and the results on the possible causes of vertebral fracture included: motor vehicle trauma (n = 189), 89.5%; bite wounds (n = 8), 3.8%; gunshot (n = 6), 2.8% and miscellaneous or unknown causes (n = 8), 3.7%.

McKee (1992) reported that the commonly affected site of thoracolumbar disc protrusions in dogs, was T_{12}/T_{13} (33%) and with T_{12}/T_{13} to L_1/L_2 accounting for 75 percent of all protrusions.

Ullman and Boudrieau (1993) noticed that among six dogs with L_7 vertebral fracture, two (33.33%) were mixed breeds, two were Golden Retrievers (33.33%) and one each (16.67%) were a Labrador retriever and a Collie.

Yovich *et al.* (1994) reported that Dachshunds predominated with 51 percent of 61 dogs with thoracolumbar disc protrusions though a total of 17 breeds were represented among the patients. Corgi breed of dogs was the second with 9.8% and German Shepherd dogs represented only 3.3 percent of the cases. They also found that among the 61 dogs, 32 were males and 29 were females. The affected age group ranged from 01 to 11 years with 56% of dogs being five to seven years old.

Scott (1997) observed that the most common site of disc extrusion was T_{12}/T_{13} followed by T_{13}/L_1 intervertebral disc, which together accounted for 65 percent of the cases. The incidence of thoracolumbar disc disease was highest in the miniature Dachshunds (18) followed by crossbred dogs (3) among a total of 40 dogs. The age of incidence ranged from 2 to 14 years. Twenty-six males and 14 females were affected.

Aithal *et al.* (1999) recorded more fracture incidence in males than females and attributed more incidences in males due to more aggressiveness and tendency to wander more, thus making them more vulnerable to fracture than females.

Jeffery and Blakemore (1999) stated that acute spinal cord injury in dogs results from external trauma such as road traffic accidents, fall from heights and internal trauma such as acute intervertebral disc extrusion.

McKee *et al.* (1999) stated that degenerative intervertebral disc disease is a common cause of back pain because of thoracolumbar spinal cord injury in dogs. The discs that have undergone degenerative chondroid or fibroid metaplasia may cause clinical signs in one of two principle ways – extrusion of the nucleus pulposus or protrusion of the annulus fibrosus.

Lanz *et al.* (2000) stated that fractures or luxations of the vertebral column usually occurred near the junction of a mobile and an immobile (a kinetic and a static) vertebral segment. In dogs and cats these areas included lumbosacral, thoracolumbar, cervicothoracic, atlanto-axial and atlanto-occipital junctions.

Davis and Brown (2002) stated that the thoracolumbar disc extrusion was the most common cause of pelvic limb paresis in dogs.

Macias *et al*. (2002) reported that among 99 dogs with thoracolumbar disc diseases, 69% were affected at T_{12}/T_{13} and $L_2/L_{3.}$ The author also reported that annular protrusions in the thoracolumbar spine were most commonly recognised in large breeds and multiple protrusions were common.

Seim (2002) stated that the vertebral fusion is performed in dogs to stabilize acute fractures and luxations of the vertebral column and chronic instabilities like canine cervical spondylomyelopathy [CCSM]). CCSM encompasses multiple different disease entities, including chronic degenerative disc disease; congenital osseous malformations; vertebral tipping; hypertrophy of the ligamentum flavum and vertebral arch malformations and ‘‘hourglass’’ compressions.

Riaz (2004) reported 46 cases of paraplegia in dogs presented to Bangalore Veterinary College Hospital during a study period of one year. German shepherd dogs represented 52.17% of the cases followed by non-descript dogs (21.74%), spitz (13.04%), Dachshunds (8.67%) and Labrador retrievers (4.38%). Males represented 60.86% of the cases while 39.14% were females.

Voss and Montavon (2004) reported in his study of 22 dogs with spinal injury that the fractures and luxations were located between T_{10} and L_6. Body weight of 22 dogs that sustained spinal injury ranged from 1.4 to 45 kg with a mean of 13.3 kg. In 14 (63.64%) of the 22 dogs the lesions were between T_{12} and L_3.

Webb *et al.* (2004) reported that acute spinal cord injuries in dogs and cats might result from intervertebral disc disease, congenital vertebral instabilities, penetrating and non-penetrating traumatic injuries, and acquired conditions causing stenosis of the vertebral canal, intraspinal synovial and ganglion cysts, arachnoid cysts and neoplasia.

Tartarelli *et al.* (2005) noticed in his study of 23 dogs that 17 males and six females were affected with thoracolumbar disc extrusions of which 26 per cent were Dachshunds. The affected age ranged from 4 to 10 years. The mean age at presentation was 5.9 years.

Gonzalez and Olby (2006) reported fecal incontinence associated with epidural spinal hematoma consequent to intervertebral disc extrusion at thoracolumbar region in a seven year old castrated male Great Dane.

Ozak *et al*. (2006) stated that traumatic injuries of the spinal column have been arbitrarily divided into (a) ventral compartment injuries involving the vertebral body, intervertebral disk, dorsal/ventral longitudinal ligaments, and inter transverse ligaments and (b) dorsal compartment injuries involving the lamina, pedicles, dorsal spinal processes, articular processes and various other ligaments.

Nagaraja *et al.* (2007[b]) studied 65 cases of traumatic posterior paralysis in the period of two years and reported that 16 (24.66%) were German Shepherd Dogs, 14 (21.53%) were Spitz, 13 (20%) were non-descript dogs, 6 (9.23%) each were Labrador Retrivers and Dachshunds, 3 (4.62%) were boxers and 1 (1.54%) each Cocker spaniel, Dalmatian, Doberman Pincher, Golden Retriever, Great Dane, Lhasa Apso and Saint Bernard. The authors also reported that 38 (58.46%) were males and 27 (41.38%) were females among the affected dogs.

Wheeler *et al.* (2007) recorded traumatic vertebral column injuries with age range of 6-72 months and weight range of 10-54 Kg in five dogs.

Bruce *et al*. (2008) diagnosed cases of spinal fracture and luxation in dogs and cats and reported that the lesions were located between C_1 to C_5 in 10 cases, C_6 to T_1 in 1 case, T_3 to L_3 in 54 cases and L_4 to L_7 in 36 cases.

Kokila.S (2008) studied cases of 66 dogs with lumbar spinal disorders in various breeds. Among the studied 66 cases, breed wise incidence was Boxer 3.03%, Dachshund 9.09 %, Doberman 6.06 %, German Shepherd Dogs 18.18 %, Great Dane 3.03 %, Labrador Retriver 9.09%, Mongrel 27.28 %, Pekingese 3.03 %, Pug 3.03 % and Spitz

18.18%. The author also reported the percentage sex-wise incidence of lumbar spinal disorders during the period of study as 59.09 % in males and 40.91 % in females.

Suwankong *et al.* (2008) reviewed the medical records of 156 dogs with degenerative lumbosacral stenosis (DLS) that underwent decompressive surgery and reported that 63.5% male dogs and 36.5% female dogs were affected. The authors also stated that GSD was the most commonly affected breed (25.6%) followed by other Shepherd breeds (7.7%).

Bali *et al*. (2009) reported that vertebral fractures and luxations account for 6% of all spinal cord disorders in cats and 7% of all neurological disorders in dogs. Road traffic accidents are the cause of approximately 40% to 60% of vertebral fractures and luxations in dogs & cats. The thoracolumbar (T3-L3) area was the most commonly affected location in both cats (49%) and dogs (58%) while the lumbar region (L4-L7) was second most common in both dogs (24%) and cats (33%). Sacral lesions (S1-S3) were more common in cats (18%) than in dogs (7%), with only small dogs (13%) being affected. Vertebral luxations were significantly more frequent in dogs (20%) than in cats (6%), whereas combined fracture-luxations occurred significantly more often in cats (65%) than in dogs (37%).

Downes *et al*. (2009) reported thoracolumbar disc protrusions in 28 dogs. The age of the dogs ranged from 4 to 12.5 years and body weight from 5 to 51.5 kg. There were 17 males and 11 females. German shepherd dogs and their crosses were the most commonly affected breeds.

Aubrey *et al*. (2010) reported that traumatic spinal cord injury in dogs results from either endogenous or exogenous trauma, such as intervertebral disc herniation and motor vehicle accidents, respectively.

Ayyappan (2012) repoted the causes of spinal cord dysfunction using the acronym 'DAMNIT' as degenerative, autoimmune, metabolic, nutritional, neoplastic, infectious, inflammatory, idiopathic, traumatic and toxic.

2.2 Pathophysiology of spinal cord injury

Hansen (1952) described a Hansen type I disc extrusion wherein the nucleus pulposus was transformed into hyaline cartilage with subsequent rapid mineralization changing from a jelly like consistency to a dry, gritty substance finally leading to rupture of the annulus fibrosus and extrusion of the nucleus pulposus into the vertebral column. In Hansen type II disc protrusion, the nucleus pulposus transformed into a fibro cartilage finally leading to the bulging of disc with partial rupture of the annulus fibrosus.

Prata (1981) considered four factors for spinal cord injury. They were (1) mechanical pressure and distortion of the spinal cord, (2) intrinsic chemical, neuronal and blood from alterations within the spinal cord (3) onset of spinal cord attenuation, and (4) duration of attenuation.

Braughler *et al.* (1984) stated that aberrant post traumatic calcium influxes created microcirculatory vasospasm, altered mitochondrial function and facilitated the production of vasoconstructive prostaglandins and leukotrienes leading to calcium mediated spinal cord neurofilament degradation and progressive axonal degeneration.

Braughler and Hall (1989) stated that there was increased production of oxygen free radicals following trauma or ischemia which was vulnerable to cell membrane phospholipids resulting in cell membrane disruption and formation of lipid peroxides.

Shores (1991) opined that primary spinal cord injury resulted from concussion or compression or combination of both. Consequences ranged from structural changes with minimal dysfunction to laceration and crushing with permanent dysfunction of the spinal cord.

Tator and Fehlings (1991) stated that that systemic, focal, cellular and sub cellular events that occurred after primary injury resulted in various biochemical and pathological changes causing additional functional deterioration and structural integrity of the spinal cord collectively known as secondary injury. It was also stated that following spinal cord trauma, there was loss of autoregulation in the injured cord segment and perfusion pressure became directly related to mean arterial pressure. Additionally, a period of systemic hypotension existed for several hours following spinal cord trauma ultimately resulting in fall in spinal cord blood flow.

Le Couteur (2000) opined that the severity of spinal cord injury due to intervertebral disc extrusion depended on the velocity at which the compressive force was applied, the magnitude of the compressive mass and the duration of the compression.

Kanchiku *et al.* (2001) stated that chronic spinal cord compression may result in cord atrophy with the irreversible loss of axons and supporting tissues.

Pierre *et al.* (2003) opined that spinal cord injury following intervertebral disc herniation was the result of a combination of compressive and concussive injury. Primary concussive injury damaged the meninges, blood supply and neural tissue. Compression resulted from a mass of herniated disc material or hematoma within the vertebral canal or spinal cord swelling within duramater.

Smith and Jeffrey (2006) observed that neuropathological findings were characterized by hemorrhage, infarction and gray matter damage. Detailed analysis of axonal and myelin changes revealed axonal swelling and myelin degeneration, that developed soon after the SCI. In particular, demyelination of axons developed by 2 wks following SCI. In the chronic phases of SCI the spinal cord reveals characteristic central areas of cavitation with peripheral rim sparing of white matter.

Aubrey (2010) while reviewing pathophysiology of SCI stated that the resultant pathology irrespective of the cause of SCI arises from both primary and secondary injury mechanisms. Primary injury is physical injury to the spinal cord and is the result of laceration, contusion, compression, and traction of the neural tissue. Pathological changes resulting from primary injury mechanisms include severed axons, direct mechanical damage to cells, and ruptured blood vessels. Secondary injury is of paramount importance and is responsible for expansion of the primary injury. Secondary injury results from alterations in local ionic concentrations, loss of regulation of local and systemic blood pressure (depending on the level of the injury), reduced spinal cord blood flow, breakdown of the blood-brain barrier; production of free radicals, imbalance of activated metalloproteinases and release of cytotoxic neurotransmitters. The results of both primary and secondary injury mechanisms are conduction block of neuronal impulses resulting from local ionic changes and demyelination, ischemia, necrosis and apoptosis of spinal cord tissue, and characteristic pathological findings.

Jefferson *et al.* (2011) Stated that the primary injury consists of the initial traumatic compressive force applied to the spinal cord causing laceration and or intramedullary hematoma formation. The compressive force is typically caused by bone or disc material that enters the spinal canal as a consequence of vertebral fracture or dislocation. The end result of both primary and secondary injury combined together is the gradual expansion of the initial lesion, in a rostro-caudal direction from the epicenter of the initial force, furthering gray matter loss and white matter degeneration, at the expense of neurologic function.

Ayyappan (2012) in a review on spinal trauma and its management in companion animals stated that clinically the severity of neurological deficits correlates with the severity of the spinal cord damage. Initially loss of conscious proprioception is observed. Then, there is progressive loss of motor function, superficial pain and finally deep pain sensation. Patients also may become urinary incontinent.

2.3 Diagnosis

2.3.1 Clinical examination

Gage (1968) reported in nine-month-old tetraplegic Miniature Dachshund following a C_1-C_2 vertebral fracture that the spinal reflexes and muscle tone were near normal and a flexion reaction could be elicited by pinching the toe, but was slow.

Geary *et al*. (1967) diagnosed atlanto-axial subluxation in 10 dogs and reported clinical features varying from pain in the high cervical region to tetraplegia. The motor abnormalities included knuckling of one or more paws, paresis of the hindlimbs and the forelimbs, paralysis of the hindlimbs and tetraplegia.

Gage and Hall (1972) reported a case of caudal cervical subluxation in a dog with clinical features of cervical pain, in-coordination and paresis of all four limbs, knuckling of the front limbs and moderate atrophy of cervical and shoulder musculature.

Griffiths (1972) discussed in detail the clinical examination of dogs with lumbar disc protrusion. The clinical signs consisted of spinal pain, general dullness, reluctance to move, loss or slowness of the tactile placing reflex and paw position sense, hyperaesthesia, locomotor dysfunction varying from mild paresis to paraplegia, loss of the anal reflex, inability to wag the tail and urinary retention or overflow.

Prata (1981) stated that caudal lumbar disk herniations (L3 to seventh lumbar [L7] intervertebral disk spaces) represent a relatively small subset of cases. Disc herniation at this level causes ischemia and compression of the lumbosacral intumescence and frequently is associated with lower motor neuron (LMN) signs. It has been suggested that dogs with caudal lumbar disk herniation and LMN signs may have a poorer prognosis than dogs with UMN lesions.

Moreau (1982) stated that upper motor neuron bladder syndrome resulted from a spinal cord lesion cranial to first sacral spinal cord segment characterized by increased urethral resistance, intravesical pressure and difficulty to express the bladder whereas lower motor neuron bladder syndrome resulted from a first, second and third sacral spinal cord lesion segments contained within the fourth and fifth lumbar vertebrae characterized by hypotonic to atonic urethral sphincter and easy manual expression of bladder.

Braund (1985) stated that clinical signs of upper motor neuron syndrome were spastic weakness or paralysis in pelvic limb, normal pectoral limbs, increased reflexes and muscle tone without atrophy of pelvic limbs, urinary incontinence, increased sensitivity at the level of lesion, reduced sensitivity caudal to lesion and depressed postural reactions in pelvic limbs. The clinical signs of lower motor neuron syndrome were flaccid weakness or paralysis in pelvic limbs and tail, urinary incontinence, flaccid bladder, reduced reflexes and muscle tone with atrophy in pelvic limbs, dilated anal sphincter, faecal incontinence, depressed postural reactions in pelvic limbs and normal pectoral limbs.

Carberry *et al.* (1989) evaluated neurological status in dogs and cats with thoracolumbar fractures or dislocations with respect to the following: 1) ability of the patient to walk, 2) ability to perceive pain caudal to the vertebral lesion 3) presence of voluntary hind limb movement and 4) presence and quality of flexor and patellar reflexes.

Griffiths (1989) described the localization of lesions in the spinal cord by dividing the cord in to four regions- C1-C5 lesions showed a UMN syndrome in both fore and hind limbs, C6-T2 lesions showed a LMN syndrome in forelimbs and UMN syndrome in hind limbs, T3-L3 lesions showed no abnormality in forelimbs and UMN syndrome in hind limbs and L4-S3 lesions showed no abnormality in forelimbs and LMN syndrome in hind limbs.

McKee (1990) stressed that dogs with traumatic spinal injury should be assessed on the basis of neurological examination rather than radiographical findings as in some cases there was poor correlation between the degree of displacement of vertebrae observed and the severity of neurological dysfunction recorded.

Bailey and Morgan (1992) stated that at the junction of the major divisions of the vertebral column, a single vertebra (vertebral segment) may assume characteristics typical of either division. The anomalous vertebra has been referred to as a “transitional segment.”

Ness (1994) reported the clinical signs of degenerative lumbosacral stenosis include caudal lumbar pain, pain upon pressure on the LSJ, pelvic limb lameness, reluctance to perform certain exercises, and activities, such as standing up and jumping, hyperesthesia, automutilation, posterior paresis, proprioceptive deficits, tail hypotonia, and urinary and feacal incontinence.

Wheeler and Sharp (1994) explained in detail how physical and neurological examination of a dog with spinal cord injury had to be performed to localize lesions and to help prognostication. They have also explained the method of evaluation of spinal reflexes like panniculus reflex, patellar reflex, flexor reflex, perineal reflex *etc.*

Morgan (1999) stated that not all anomalous vertebral segments are asymmetrical; however, asymmetrical vertebrae have transverse processes that vary in size and shape, thereby markedly altering the sacroiliac attachments. Usually the lumbosacral transitional segment is the first sacral vertebra.

Bergman *et al.* (2000) described Schiff-Sherrington posture as a clinical syndrome in severe cases of thoracolumbar spinal cord trauma in dogs. This posture was seen as rigid forelimb extension with paraplegia of the pelvic limbs.

Gopal and Jeffery (2001) reported the case of a crossbred dog presented with tetraplegia, following a fall. Neurological examination revealed no voluntary movement in any limb. Flexor reflexes in all four limbs were absent, although there was cranial response (whimpering) to sustained severe pressure to the paws of all four limbs. Patellar reflex was intact, but depressed. There was no evidence of pain either in the vertebral column or elsewhere. The lesion was suspected to lie in the cervical spinal cord specifically at the site of the cervical enlargement (5th cervical to 2nd thoracic vertebrae).

Sanders *et al.* (2002) reported a case of intramedullary spinal cord hamartoma at the level of T_6-T_7 vertebral area in a nine-year-old female Golden Retriever with a three-year-old history of progressive hind limb lameness. The dog was paraparetic leading to atrophy of the hind limb muscles; with exaggerated patellar reflexes. Further, withdrawal reflexes of limbs were normal. However, there was mild bilateral atrophy of the quadriceps, semitendinosus and semimembranosus muscles.

Chandy and Vasanth (2006[a]) subjected 18 dogs presented with traumatic posterior paralysis to detailed clinical and neurological evaluation. Authors noted the attitude, postureand gait of the dogs, and presence or absence of conscious proprioception and deep pain sensation in hind limbs. They also noted panniculus reflex, patellar reflex, anal sphincter reflex and flexor reflex.

Chandy and Vasanth (2006[b]) reported that palpation of bladder in cystoplegic dogs was helpful in determining whether the spinal cord injuries were of the upper motor neuron (UMN) or the lower motor neuron (LMN) type with respect to bladder function. The UMN bladders were distended and urine could not be freely relieved from them by pressing them through the abdomen. These animals showed dribbling of urine following over-distension of the bladder, but no free flow of urine was seen. LMN bladders were also distended but could be easily relieved of urine by pressing them through the abdominal wall. These animals showed free dribbling of urine when the bladders were full.

Da Costa *et al.* (2006) performed physical and neurological examination daily and gait monitoring hourly from about 4-12 hours post surgery and then once daily in dogs which underwent a modified thoraco-lumbar dorsal laminectomy for creation of laminectomy defect to evaluate the effectiveness of cellulose membrane (CM) or free fat graft (FFG) on laminectomy membrane formation.

Gonzalez and Obly (2006) performed physical and neurological examination in a seven year old castrated male Great Dane. Heart rate was132 beats/ minute and respiratory rate was 101.8^0 F, mild muscle atrophy in both hind limbs. Neurologic Examination revealed hind limb ataxia during walking. Conscious proprioception was decreased in the left hind limb and mild hyperaesthesia was detected on palpation of lumbosacral region.

Chang *et al*. (2007) reported that if a disc with a normally hydrated nucleus pulposus is placed under a stress exceeding its normal strength, the dorsal annulus fibrosis may rupture and the jelly-like nucleus pulposus may explode into the spinal canal and cause spinal cord contusion.

Mann *et al.* (2007) performed physical examination in 78 dogs with Hansen type-1 interverbral disc disease, which were frequently presented with spinal hyperpathia as the chief owner complaint. Pain on palpation was often elicited during physical examination along with varying degrees of neurological abnormality ranging from spinal hyperpathia to paraplegia and loss of pain perception.

Nagaraja *et al*. (2007[c]) studied 66 clinical cases of posterior paralysis in dogs, presented to the veterinary college hospital, Bangalore over a period of two years and subjected to clinical and neurological evaluation on the day of presentation and at weekly intervals for 8 weeks. The authors opined that detailed neurological evaluation was very helpful in grading of posterior paralyses in dogs, localization of lesion and also indicate the prognosis of the patient.

Simova-curd *et al*. (2008) reported a case of lumbar osteosarcoma in 11 year old chinchilla with clinical signs of progressive weight loss, apathy, anorexia, changes in faecal quality, alopecia on the tip of tail and stiffness of the back legs.

Suwankong *et al.* (2008) reported that pelvic limb lameness, caudal lumbar pain and pain evoked by lumbosacral pressure were most frequent clinical findings in dogs with degenerative lumbosacral stenosis.

Zulauf *et al*. (2008) reported that spinal injuries at the lumbosacral junction in cats are rare. Injuries in this area of the spine possibly result in ischiatic nerve deficits, paralysis of the tail and bladder dysfunction.

Janssens *et al.* (2009) reported clinical signs like pain in the caudal lumbar region and pelvic limb weakness that is manifested as reluctant to rise, climb and jump. Sometimes the animal stands in a kyphotic position in dogs with lumbosacral degenerative stenosis.

Worth *et al.* (2009) reported that degenerative lumbosacral stenosis is characterised by intervertebral disc degeneration, secondary bony and soft-tissue changes leading to compression of the cauda equine a syndrome in dogs in working dogs.

Parent (2010) The author in his review states that the evaluation of gait and posture is pivotal to the localization of the leision in spinal disease. The most sensitive test to evaluate for presence of proprioceptive ataxia remains the gait, not the proprioceptive positioning testing. Regarding posture of the animal he opines that a stiff neck and an arched back in the dog is usally indicative of vertebral column pain. If the arc of the back is centered to the thoraco lumbar region the disease is usually in the T10 to L2 region whereas when the rear end of the animal is kept under, low lumbar or lumbosacral disease is more likely. In the lateral recumbent animal, a Schiff-Sherrington posture indicates a T3 to L5 leison.

Ayyappan (2012) in his review on spinal trauma and its managements in copmanion animals the author states that, following a thoracolumbar disc herniation, symptoms may clinically be characterized by systemic signs of toxemia, a flaccid abdomen, the level of 'cut-off' of the cutaneous trunci reflex response migrating cranially, a shift from upper motor neuron to lower motor neuron signs in the rear limbs, progressive involvement of the forelimbs and eventually respiratory paralysis and death.

Viganò and Blasi (2013) in their review on initial assesment of spinal trauma cases the authors opine that the panniculus reflex is lost approximately one or two segments caudal to the spinal lesion, and whilst it may be used to precisely locate lesions between T1 and L3, it is not reliable for more caudal lesions. They have also mentioned that a double spinal cord injury can be difficult to recognize: e.g. a lesion at the level of the caudal lumbar vertebrae may mask a problem around T3-L3.

2.3.2 Radiography

Lang (1988) stated that the anomalous segment can often be identified with plain radiography in dogs, however an extension-flexion myelography, diskography, or epidurography is needed to further clarify the presence of the vertebral canal stenosis.

Carberry *et al.* (1989) performed radiographic evaluation of patients with thoracolumbar fractures or fracture/dislocations under sedation or general anaesthesia. Radiographical analysis consisted of determination of location of fracture or luxation, approximating reduction in size of the vertebral canal, estimating degree of angulation and estimating amount of vertebral displacement. The authors studied the healing of vertebral fractures following non-surgical treatment in cats and dogs radiographically.

McKee (1990) reported radiographical examination of the vertebral column in 51 dogs and cats with spinal trauma, to identify the type and location of the spinal injury and the degree of vertebral displacement.

McKee (1992) took lateral radiograph of the thoracolumbar and mid-lumbar spine in dogs with thoracolumbar disc protrusion. The radiographs were examined for the evidence of narrowing of the intervertebral disc space and/or extruded disc material into the vertebral canal. Fifty two out of 60 dogs had a narrowed intervertebral disc space or calcified disc material within the vertebral canal where as 8 dogs had no evidence of disc protrusion.

Ronald (1992) described the procedure of survey radiograph of the spine. He mentioned that the axial skeleton should be extended and the central x-ray beam centered directly over the area of interest. The ventrodorsal projection should be made when the ventral midline and dorsal midline were superimposed. It was also explained that in both projections it was necessary to use foam pads and wedges to prevent "sagging" of the spine and ensure that spine was parallel to cassette and film.

Yovich *et al.* (1994) reported the radiographic findings of a narrowed or wedged intervertebral space, disc material within the vertebral canal or both in 50(89%) dogs in his study.

Wise (1999) performed radiography in a dog 16 months after vertebral fixation with Steinmann pins and orthopaedic wires which showed that all the implants were still in place and the alignment was the same as it was post-surgically.

Bagley *et al*. (2000) discussed that serial radiographs and cautious palpation of the spine might confirm instability following exogenous trauma. However, instability of the vertebral segment could be difficult to predict from a single radiograph.

Lanz *et al.* (2000) reported that survey radiographs should always be obtained in patients with spinal cord injury and sedation could decrease patient struggling and discomfort and allow one to obtain lateral and ventro-dorsal projection radiographs of the suspected area of injury.

Moore *et al.* (2000) described the radiographic appearance of osteosarcoma of the L_4 and L_5 vertebrae in a dog as mottling of the body of L_4 and misshapen intervertebral foramen at the L_4-L_5 junction. Ventral spondylosis at the L_1-L_2 and L_4-L_5 were also visible. The authors could not identify any soft tissue tumour on plain radiography.

Somerville *et al*. (2001) assessed the accuracy of localization of cervical intervertebral disc extrusion or protrusion in 64 dogs using survey radiographs. In 61% of the survey radiographs, evaluators identified sites of disc extrusion or protrusion based on radiographic findings. Of those radiographs where a site was identified, ability to accurately identify the correct site of disc extrusion ranged from 53 % to 67%, with an average of 58%.

Cook *et al.* (2004) stated that the reliability and sensitivity of both conventional radiography and computed tomography (CT) for identifying fusion healing is unknown and evaluating fusion in an animal model found a congruency between the extent of bony fusion in CT and histologic assessment of only 14%.

Loughin *et al.* (2005) subjected 48 dogs with type-l thoracolumbar intervertebral disc extrusion for lateral and ventrodorsal survey radiographs followed by myelogram to diagnose spinal cord compression. The myelography was performed with Iohexol injected at L_5-L_6 at the rate of 0.5 ml/Kg.

Chandy and Vasanth (2006[e]) subjected 18 dogs with posterior paralysis to survey radiography for radiologic evaluation on o, 1^{st}, 15^{th}, 30^{th}, 45^{th} and 60^{th} day and observed varying levels of callus formation during the healing of spinal fractures in all the dogs.

Steffen *et al*. (2007) opined that survey radiograph cannot be used to predict development of degenerative lumbosacral stenosis in working German shepherd dogs.

Naude *et al.* (2008) performed survey radiograph of thoracolumbar vertebral column in 16 dachshunds with clinical signs of intervertebral disc diseases, diskospondylitis, neoplasia, fracture and luxations.

Suwankang *et al*. (2008) used plain radiography for diagnosis of lumbosacral stenosis in 132 dogs. The lumbosacral step was seen in 78.8% of dogs, telescoping of cranial spinal canal of sacrum relative to the caudal spinal canal of L_7 was seen in 21.1% dogs.

Chai *et al*. (2008) performed spine radiographs in eight dog bite cases in lateral and horizontal beam views and it revealed vertebral fractures in all cases. The vertebral fractures were confined to the cervical spine in all dogs.

Malik *et al*. (2009) reported spinal malformation with a narrowed intervertebral space between L_1 and L_2, and a dorsal fusion at the level of L_2-L_3 with a common dorsal process on thoracolumbar radiograph in a 10 year old spayed female cat.

Worth *et al*. (2009) opined that changes seen using conventional radiograph is unreliable in dogs with degenerative lumbosacral stenosis. However contrast radiography represents an improvement and advanced imaging which is accepted as the diagnostic method of choice.

Sutton *et al*. (2010) reported to have obtained radiographs of the thoracolumbar spine were under general anaesthesia in a four-year-old female neutered dobermann with an acute-onset non-ambulatory pelvic limb paresis. The author states that there was profuse ventral spondylosis involving L2 and L3, an irregularly widened L2-L3 intervertebral disc space and variable radiopacity, including multiple punctate lucencies and sclerosis of the involved vertebral bodies. These findings were suggestive of persistent osteomyelitis of the vertebral bodies L2 and L3 and associated chronic discospondylitis.

Dickomeit *et al.* (2011) reported that lateral and ventrodorsal radiographs were taken for diagnosis preoperatively and to assess the reduction of the atlantoaxial joint and implant positioning post operatively.

Fletcher (2011) reported that Radiography has a sensitivity of 72% for vertebral fractures and 77.5% for subluxations, but has a negative predictive value of 51% in identifying fracture fragments within the vertebral canal. Diagnosis of herniated intervertebral discs by radiography has 64-69% sensitivity while the positive predictive value is 63-71%.

Steffen *et al.* (2011) stated that lateral and ventrodorsal radiographs were taken in each dog during each follow-up examination by positioning the cervical spine in neutral position. Radiographs were interpreted by a board-certified radiologist and assessed for (1) stability of implants, (2) width of the distracted intervertebral space (i.e. presence of subsidence of the cage), and (3) progress of fusion. The criteria for assessment of fusion were adapted from McAfee *et al.* (2001).

Ayyappan (2012) described radiographic findings of intervertebral disc herniation as narrowing or wedging of an intervertebral disc space, change in shape of the intervertebral foramen at the site of the herniation, narrowing of the space between facets and mineralized disc material visible in the spinal canal.

Viganò and Blasi (2013) the authors in their review stated that, after performing a full neurological evaluation, radiographs could be taken: lateral views are generally obtained first, then (with the patient still in lateral recumbency) an oblique beam may be used to identify any fracture of the facet joints. For ventro-dorsal views a horizontal beam may be considered to reduce the risks involved when positioning the animal in dorsal recumbency. Deep sedation or general anesthesia is not recommended because this can remove spasm of the para-vertebral muscles and cause instability.

2.3.3 Myelography

Wright and Jones (1981) performed myelography in 68 dogs by puncturing cisterna magna or lumbar route using metrizamide (160mg I/ml) at the rate of 0.15 to 0.3 ml/kg bodyweight and recorded post-myelographic complications like seizures, convulsion and death in eight dogs.

Wheeler and Davies (1985) performed myelography in dogs and cats using Iohexol and compared its efficacy to Iopamidol and Metrizamide. The drug was injected into the cisterna magna and the concentrations of iodine used were 300 mg of Iodine/ml for cats and small dogs, and 350 mg of Iodine/ml for medium and large dogs. It was stated that Iohexol is good contrast material for small dogs.

Black (1988) used Iohexol (180 mg I/ml) or Metrizamide for myelography in 25 dogs with intervertebral disc disease by lumbar puncture.

McKee (1992) performed myelography in 60 dogs with thoracolumbar disc protrusion by lumbar puncture using Iohexol or Metrizamide. Lateral views were examined for the evidence of an extradural mass and/or intradural swelling. The ventro-dorsal view was examined in 41 dogs for evidence of lateralization of protruded disc material. Fifty-seven dogs had myelographic evidence of an extradural mass.

Widmer *et al.* (1992) conducted myelography in dogs by injecting Iopamidol or Metrizamide into the cerebellomedullary cistern using a 22 gauge 1.5 inch spinal needle. The concentration of Iodine in the preparation of Iopamidol was 200 mg I/ml and that of

Metrizamide was 170 mg I/ml. Either of the agents were used at the rate of 0.45 ml/kg body weight of the animal.

Halland (1993) described that second generation non ionic water soluble contrast agents, Iohexol and Iopamidol produced a lower rate of post myelographic seizures and other neurotoxic complications than Metrizamide. Lowered osmolality and reduced chemotoxic properties of Iohexol produced less post myelographic leptomeningitis than metrizamide and Iopamidol.

Wheeler and Sharp (1994) performed myelography by cisterna magna puncture and stated that the column of contrast agent administered would reach the lumbosacral joint within 10 minutes in normal dogs when the cranial end of the spine was kept elevated at an angle of 15^0 to 20^0.

Muir *et al.* (1995) carried out Myelography by lumbar puncture in Dachshund dogs suspected for intervertebral disc extrusions. The myelogram was used to identify extradural mass or intradural spinal cord swelling or both, and for any evidence of lateralization of extruded disc material.

Duval *et al.* (1996) observed spinal cord swelling as a sign of myelomalacia when myelography was performed in dogs with intervertebral disc disease.

Scott (1997) performed plain radiography and myelography in dogs with thoracolumbar disc disease under general anesthesia. For myelography, Iohexol (300 mg I/ml) at the rate of 0.3 to 0.5 ml/kg body weight of the animal was injected into the ventral subarachnoid space at the L_5-L_6 junction. Myelography helped the author in localizing the site of disc involvement in all the 40 dogs with thoracolumbar disc disease.

Moore *et al.* (2000) conducted myelography by administration of Iohexol (300 mg I/ml) at the rate of 0.4 ml/kg body weight by cisterna magna punture in a dog with osteosarcoma of L_3, L_4, and L_5. The contrast column terminated within the spinal canal of L_4, and the ventral column of the dye appeared to deviate dorsally at termination.

Pendens (2000) reported lumbar myelography in a five-year-old Basset Hound with acute paraplegia, loss of voluntary urination and depressed deep pain sensation in the hind limbs. The author found a focal T_{13}-L_1 spinal cord compression with an intradural extramedullary lesion at the site, which was later identified as a Hansen type-1 prolapse during surgery.

Lu *et al.* (2002) performed myelography in seven dogs using Iohexol (300 mg I/ml) at the rate of 0.3 to 0.5 ml/kg body weight and recorded myelographic signs with myelomalacia of variable degree due to contrast medium infiltration into the spinal cord in six dogs.

Tidwell *et al.* (2002) carried out myelography by intrathecal injection of 0.4 ml/kg body weight of Iohexol (300 mg I/ml) at the L_5/L_6 junction in a four-year-old female Rottweiler to diagnose spinal cord compression due to intervertebral disc herniation.

Gnirs *et al.* (2003) performed myelography in 13 dogs with spinal subarachnoid cysts by subarachnoid injection of Iohexol (300 mg I/ml) at the rate of 0.3 to 0.4-ml/kg body weight into the cerebellomedullary cistern.

Velavan (2003) compared the diagnostic efficiency of both Myelography and Epidurography in 26 dogs subjected for screening of spinal affections. The author subjected 20 dogs for myelography and six dogs for epidurography.

Kaur and Singh (2004) conducted myelography in 13 dogs suffering from various spinal affections, using Iohexol (300mg I/ml) at the rate of 0.45mg/Kg body weight and opined that this dose of Iohexol was quite sufficient to produce good quality myelograms upto the cauda equina, in cases where there was no damage to the spinal cord. However partial impairment to the flow of the agent indicated partial compression, and the complete obstruction to the flow was attributed to severance of the spinal cord.

Pawan Kumar *et al.* (2004) conducted a study on 12 healthy mongrel dogs of either sex and divided them intotwo groups of 6 each. In group I, iohexol (300 mg of I/mL) and in group II, iopamidol (300 mg of I/mL) was administered @ 0.3 mL/kg by cisternal puncture. The lateral and ventrodorsal myelograms were obtained at 5,15,30,60 and 90 rminutes after contrast medium injection. Myelograms were evaluated and compared by blind scoring method for different radiographic qualities. Myelograms appeared to be uniform and of superior radiographic quality and were of diagnostic value up to 60 minutes in both groups.

Steffen *et al.* (2004) performed myelography in three dogs following cisternal puncture using iotrolane at a dosage of 150 mg/kg.

Kinzel *et al.* (2005) performed myelography in 331 dogs with thoracolumbar disc protrusion by injecting 0.3 ml/kg body weight of Iotrolan (300 mg I/ml) into the subarachnoid space at the level of the cisterna magna. They found complications of seizures in 22 out of 331 cases.

Tartarelli *et al.* (2005) reported that myelography alone could not always distinguish between intramedullary swelling caused by spinal cord edema and wide extradural compression caused by diffused disc material and epidural haemorrhage in dogs. Magnetic resonance imaging seemed to be more accurate for delineating the sites of compression.

Chandy and Vasanth (2006[f]) performed myelography in 20 dogs with posterior paralysis and opined that myelography was efficient in identifying spinal cord compression.

Riaz *et al.* (2006) carried out myelography in twelve dogs with posterior paralysis and without gross lesions such as fracture and dislocations and diagnosed stenosis of spinal canal in three animals at the level of L_1-L_4, L_3-L_5 and L_3-L_5 vertebra and opioned that myelography was highly effective for diagnosis of spinal compression in cases of posterior paralysis.

Nagaraja (2007) performed myelography using Iohexol (Omnipaque, 350 mg I/ml) at the rate of 80mg/kg body weight before opting spinal plating with or without laminectomy for posterior paralysis in dogs.

Packer *et al.* (2007) reported intracranial subarachnoid haemorrhage following lumbar myelography in two dogs.

Chai *et al.* (2008) reported performing myelography in a dog with a fracture at the caudal vertebral body of C6 that failed to improve ten days after the initial trauma. The author did not observe compression of the spinal cord despite clear dorsal deviation of C7 seen on the survey radiographs taken on the same day.

Paithanpagare *et al.* (2008) explained the causes of difficulties in interpretation of myelography as 1) Poor radiographic quality: Incorrect patient positioning, incorrect exposure or artifact. Therefore they opined that myelography should be performed only after satisfactory quality survey radiographs have been obtained and carefully examined. 2) Poor distribution of contrast medium: Inadequate volume injected, Incorrect injection site, Epidural opacification, Contrast not inadequately mixed with CSF, Incorrect radiographic views. 3) Pathoanatomical problems: Normal anatomical variations, Spinal cord swelling.

Shimizu *et al*. (2008) compared Iohexol (180 mgI/ml), Iohexol (240 mgI/ml) and Iotrolan (240 mgI/ml) for contrast effect of myelography in normal dogs and stated that low density contrast medium with wide spread contrast effects was considered suitable for myelography.

Trotter (2009) perfomed myelography by subarachnoid injection of an iodinated, nonionic, water-soluble contrast agent (0.45mL/kg; Iohexol [240mg/mL],) via lumbar puncture, most often at the L5–6 level to determine traction responsiveness, confirming neural decompression

Sutton *et al.* (2010) performed lumbar myelography in a four-year-old female neutered dobermann with an acute onset non-ambulatory pelvic limb paresis by injection of 6 ml iohexol via lumbar puncture at L5-L6. There were multifocal mild deviations in the left and right contrast columns (on a ventrodorsal view) and a major deviation of the right contrast column towards the midline at the level of L2-L3

Da costa *et al.* (2011) following a study on myelography in 503 cases of dogs reported that 15 (3%) dogs had postmyelographic seizures. Risk factors significantly associated with seizures were size of dogs (large dogs were 35.35 times as likely to have seizures as were small dogs), location of contrast medium injection (dogs in which iohexol was injected into the cerebellomedullary cistern were 7.4 times as likely to have seizures as were dogs in which iohexol was injected into the lumbar cistern), location of lesion (dogs with lesions at the level of the cervical portion of the vertebral column were 4.65 times as likely to develop seizures as were dogs with lesions in other regions), and total volume of iohexol. The authors concluded that large-breed dogs with cervical lesions and large volumes of iohexol injected into the cerebellomedullary cistern had the highest risk of seizures. The use of contrast medium volumes > 8 mL in large dogs should be avoided, with preference given to injections into the lumbar cistern.

Steffen *et al.* (2011) used lateral and ventrodorsal projections for myelographic diagnosis. To diagnose traction responsiveness of the lesion, an additional lateral projection was performed by application of manual traction by two persons, one the head and other on rear end of the dog. They concluded that myelography and MRI confirmed extradural compression that resolved with traction. An increased, focal intramedullary signal on T2-weighted images was detected in two dogs that had MRI examination.

Ayyappan (2012) stated that cisternal puncture for myelography should not be used in patients suspected (on the basis of plain radiographic techniques) to have cervical vertebral fractures or luxations. Myelography permits the delineation of the following types of lesions affecting the spinal cord: Extradural compression, Intradural-Extramedullary compression (IDEM), Intramedullary compression.

Viganò and Blasi (2013) opined that disadvantages and risks of myelography must be balanced against the potential benefits, namely that compressive pathologies may be identified by deviation, attenuation or obstruction of the contrast medium and more expensive imaging may not be required. Myelography is especially useful in cases where there has been a temporary dislocation of the vertebra but no bony displacement is evident on radiography.

2.3.4 Grading of patients

Griffiths (1982) graded the severity of spinal cord damage as:

Grade 1 - Paretic

Grade 2 - Paraplegic, intact bladder control and pain sensation

Grade 3 - Paraplegic and loss of bladder control, some pain sensation present

Grade 4 – Paraplegic with loss of bladder control and pain sensation

Levine and Caywood (1984) reported the grading of dogs with spinal cord injury in intervertebral disc disease into four groups:

Grade I - Mild paresis, ataxia and pain

Grade II - Severe paresis

Grade III - Paralysis, loss of motor function

Grade IV – Sensory motor paralysis, loss of motor and sensory function.

Wheeler (1988) classified thoracolumbar disc disease on the basis of severity of the neurological deficit in dogs as:

Grade I - hyperesthesia only

Grade II - ataxia, proprioceptive loss, paresis

Grade III - paraplegia

Grade IV - paraplegia, urinary retention and overflow

Grade V - paraplegia, urinary retention and overflow and absence of deep pain Sensation.

McKee (1990) graded dogs and cats with spinal trauma into five grades based on the severity of the neurological dysfunction.

Grade 1 - pain only with no neurological deficits

Grade 2 - paresis or ataxia

Grade 3 - paraplegia or quadriplegia

Grade 4 - paraplegia and quadriplegia with urinary retention and overflow.

Grade 5 - paraplegia or quadriplegia with urinary retention and overflow and absence of conscious pain sensation.

Yovich *et al.* (1994) graded dogs with thoracolumbar disc protrusion into five neurological grades based on clinical findings.

Grade 1 - back pain only

Grade 2 - ambulatory with varying degrees of hind limb paresis/ataxia

Grade 3 – non-ambulatory but voluntary movement, deep pain sensation present

Grade 4 - non-ambulatory, no voluntary movement, deep pain sensation present

Grade 5 - Paraplegia, incontinence, no deep pain sensation.

Muir *et al.* (1995) graded Dachshunds with thoracolumbar intervertebral disc extrusions into

Grade 0 - normal

Grade 1 - spinal pain

Grade 2 - paresis such that the dog could still walk

Grade 3 - non-walking paresis

Grade 4 - paralysis (absence of voluntary motor function)

Grade 5 - paralysis and absent conscious pain sensation.

Scott (1997) graded dogs with thoracolumbar disc disease into five groups

Grade 1 - thoracolumbar pain with no neurological deficits

Grade 2 - ambulatory paraparesis

Grade 3 - non ambulatory paraparesis

Grade 4 - paraplegia with or without bladder control

Grade 5 - paraplegia with loss of both bladder control and deep pain sensation

Ferreira *et al.* (2002) classified paraplegic dogs based on their response to treatment as Excellent outcome (animals regained the ability to walk without proprioceptive deficits), Fair outcome (ongoing paraparesis and/or postsurgical pain) and Poor outcome (paraplegia persisted). Cases belonging to the excellent and fair categories were considered successful. Dogs with poor outcome were euthanized.

Macias *et al.* (2002) graded dogs with thoracolumbar disc disease according to the degree of neurological dysfunction as follows:

Grade 0 - no neurological dysfunction or pain

Grade I - Spinal pain, no paresis

Grade II - Ambulatory paraparesis

Grade III - Non-ambulatory paraparesis

Grade IV - Paraplegia

Grade V - Paraplegia and urinary incontinence

Grade VI - Paraplegia, urinary incontinence and absent conscious pain perception

Voss and Montavon (2004) graded dogs and cats with spinal injury based on their neurological status as:

Grade 1 - signs of localized pain only

Grade 2 - conscious proprioceptive deficit and ambulatory paraparesis

Grade 3 - non-ambulatory paraparesis

Grade 4 - paraplegia, bladder dysfunction or both

Grade 5 - paraplegia with bladder dysfunction and loss of deep pain sensation

Kinzel *et al.* (2005) classified dogs with spinal injuries as either ambulatory or non-ambulatory with deep pain sensation present (Grade III to IV) or absent (Grade V).

Tartarelli *et al.* (2005) graded dogs with thoracolumbar disc extrusion as:

Grade I - spinal hyperesthesia only

Grade II - ambulatory paraparesis

Grade III - non-ambulatory paraparesis

Grade IV – paraplegia

Grade V - paraplegia with urinary incontinence

Grade VI - paraplegia, urinary incontinence and absent deep pain sensation

Levine *et al.* (2006) used modified Frankel spinal cord injury scale to grade severity of neurologic dysfunction as:

Grade 0 - Paraplegia with no deep pain sensation

Grade 1 - Paraplegia with superficial nociception

Grade 2 - Paraplegia with nociception

Grade 3a - Non-ambulatory paraparesis with weight bearing

Grade 3b - Non-ambulatory paraparesis with non-weight bearing

Grade 4 - Ambulatory paraparesis and ataxia

Grade 5 - Spinal hyperesthesia

Stiffler *et al.* (2006) graded the ambulatory and urine status of the dogs affected with type-1 thoracolumbar intervertebral disc extrusion as follows.

Non-ambulatory - unable to bear own body weight

Weakly ambulatory - able to bear own body weight with minimal assistance

Strongly ambulatory - able to walk without assistance.

Urine status was categorized as

a) Voluntary- able to empty the urinary bladder without assistance

b) Non Voluntary- required complete or partial evacuation of the urinary bladder.

Bergman *et al.* (2008) used modified Frankel score for detection of preoperative neurologic dysfunction with

Grade 0 - tetraplegia with no deep nociception,

Grade 1 - tetraplegia with no superficial nociception,

Grade 2 - tetraplegia with intact superficial nociception,

Grade 3 - non-ambulatory tetraparesis,

Grade 4 - ambulatory tetraparesis, and

Grade 5 - cervical spinal hyperesthesia only.

Dickomeit *et al.* (2011) used a modified grading scale for presenting of the pre-surgical neurological status

Grade 1 - normal gait, no deficits

Grade 2 - paresis, ataxia and spasticity

Grade 3 - ambulatory paresis

Grade 4 - non-ambulatory paresis

Grade 5- tetraplegia

Steffen *et al.* (2011) graded the pre and post- surgical neurological status was assessed into

Grade 0 - Normal

Grade 1 - Cervical pain during activity and manipulation

Grade 2 - Cervical pain plus mild pelvic limb ataxia and/or paresis with normal thoracic limb function

Grade 3 - Mild ataxia involving all 4 limbs and/or tetraparesis with a spastic/hypometric gait in the thoracic limbs

Grade 4 - Severe ambulatory tetraparesis with dog being able to walk over a short distance before collapsing

Grade 5 - Nonambulatory tetraparesis.

Ayyappan (2012) graded the neurological statutes of patients as

Increasing severity with higher number:

Grade 1 - spinal pain

Grade 2 - mild ataxia (proprioception deficits)

Grade 3 - severe ataxia, no weight bearing.

2.3.5 Laboratory examination

2.3.5.1 Haematology

Griffiths (1982) failed to record any haematological alterations in dogs with fractures and subluxations of the vertebral column.

Moore and Withrow (1982) have reported haemorrhage in Gatrointestinal tract of dogs with spinal problem and they opined it to be the reason for anaemia in such patients.

Wheeler and Sharp (1994) reported that stress leukogram was a common finding in majority of dogs with spinal disease. The indicators of stress leukogram were lymphopenia, eosinopenia and leukocytosis.

Neel and Dean (2000) assessed blood count and urine analysis in a nine-month-old dog with intradural extramedullary nephroblastoma in the L_2-L_3 region and found parameters within the normal range.

Velavan (2003) reported a decrease in Total leukocyte count on 3rd, 7th and 10th day post myelographic examination and opined that the decrease is because of the steroidal nature of Iohexol.

Riaz (2004) recorded no variation in the haemoglobin, packed cell volume, total erythrocyte count, total leukocyte count or differential leukocyte count in paraplegic dogs treated by surgical or non-surgical means.

Gonzalez and Olby (2006) reported mild thrombocytopenia in a dog suffering with upper motor neuron lesion due to secondary epidural spinal haematoma and intervertebral disc extrusion in thoracolumbar region.

Chai *et al.* (2008) reported abnormal complete blood count in two patients out of eight cases of his study ; one was a dog with marked leukocytosis of $42x10^9$/L and thrombocytopenia of $60x10^9/L$, and the other was a cat (1/5) with mild leukocytosis of $20x10^9/L$.

Rathod *et al.* (2010[a]) reported no significant variation in Haemogram during his study on C-arm assisted modified spinal arch external skeletal fixation for the stabilization lumbar vertebral fracture in dogs.

Dicokmeit *et al.* (2011) reported that the haematological values were detected in the three dogs which underwent the atlanto- axial stabilization.

Md Ansari *et al.* (2012) conducted haemato-biological studies in 24 dogs with hind quarter weakness treated with conventional drug therapy and along with therapeutic ultra sound and short wave diathermy and reported that Total leukocyte count, neutrophil and haemoglobin count showed an increasing and lymphocytes a decreasing trend in all the three groups throughout the period of study of 28 days, where as in Monocytes and eosinophils the authors have not observed any significant change in all groups at different intervals.

2.3.5.2 Serum biochemistry

Simesen (1980) found no changes in serum calcium or phosphorus in dogs with paraplegia.

Lemarie *et al.* (2000) reported range of complete blood count, serum biochemistry profile and coagulation profile in a dog with subluxations of the cervical vertebrae following ventral slot decompression for intervertebral disc prolapsed, in a paraparetic dog.

Moore *et al.* (2000) reported a case of osteosarcoma of the lumbar vertebrae (L_3, L_4& L_5) found the results of complete blood count, serum biochemistry profile and urine analysis within reference ranges though the dog was suffering from progressive paraparesis for two to three weeks duration.

Benjamin (2001) reported no change in serum alanine aminotransferase or aspartate aminotransferase in animals with paraplegia and also found serum calcium, phosphorus and potassium levels within normal range in dogs with paraplegia.

Tidwell *et al.* (2002) reported a case of intervertebral disc disease having bilateral pelvic limb paresis with only minimal voluntary motor function and severe postural action deficits in a four-year-old neutered female Rottweiler and found normal blood count and serum chemistry profile.

Chandy and Vasanth (2006[h]) recorded normal physiological range of serum calcium, phosphorous potassium, aspartate aminotransferase and alanine aminotransferase, in 18 clinical cases of posterior paralysis on the day of presentation as well as on the specific post-operative days of study period in dogs with modified spinal stapling and tension band wiring.

Cabassu and Moissonnier (2007) reported that serum biochemical analysis and urinalysis were within normal range in a seven month old Rottweiler pup which had discospondylitis associated with a pathologic fracture of T_{11} and a haematogenous femoral epiphysitis.

Kokila (2008) reported total serum protein levels to be normal in all dogs selected for the study of Hemilaminectomy combined with medical therapy in lumbar spinal disorders.

Rathod *et al.* (2010[a]) reported AST, ALT, ALP to be in normal range during 0,7th,15th P.O.days in dogs subjected to modified spinal arch external spinal fixation for lumbar vertebral fractures.

Dicokmeit *et al.* (2011) reported that no change in serum biochemistry values were detected in the three dogs which underwent the atlanto- axial stabilization.

Md Ansari *et al.* (2012) Carried out a study of 24 canine patients with hind quarter weakness and its clinical management with haematobiochemical correlation. The dogs were randomly divided into three groups with 8 dogs each. Dogs in group I were treated with Conventional drug therapy (CDT) alone. In addition to the CDT, animals of group II and group III were also treated with ultrasound (US) and Shortwave diathermy (SWD), respectively. The authors have reported that the glucose showed a significant increase from day 3 in groups I and III and day 7 in group II, except on day 14 in group I and continuous decrease in cortisol level in all the groups till day 28 of the study period. The authors have also reported a continuous progressive decrease in serum alkaline phosphate, sodium, potassium and creatine kinase levels in all the groups till day 28.

2.4 Treatment

2.4.1 Non surgical treatment

Levine and Caywood (1984) reported the medical management in dogs with intervertebral disc disease which consisted of a combination of cage rest, physiotherapy, corticosteroids and bladder evacuation and found 40 per cent recurrence in such treatment modality.

Trotter *et al.* (1988) used dexamethasone systemically for its protective effects in spinal cord trauma which resulted in delay rather than beneficial limitation of laminectomy membrane formation. The authors also reported that the use of dexamethasone intra-and postoperatively in dogs subjected for modified dorsal laminectomy caused a decrease in the proliferation of granulation tissue and new bone formation.

Carberry *et al.* (1989) used corticosteroids with or without external support to treat vertebral fractures and luxations in 12 dogs and 5 cats. The dexamethasone was administered for three days (0.55 mg/kg body weight subcutaneously divided thrice a day for one day). Strict cage rest was implemented for a minimum of one week in all cases, and exercise restriction was advised for a minimum of four weeks. External support in the form of body splint was applied in seven animals. Fourteen animals regained the ability to walk, one was euthanized four weeks after injury and two remained paralyzed upto three years following surgery.

Yovich *et al.* (1994) reported that out of 61 dogs with thoracolumbar disc protrusion treated by lateral spinal decompression supplemented either with 2 mg/kg of dexamethasone or 10 mg/kg Methyl Prednisolone sodium succinate intravenously immediately pre-operatively, except in three dogs that had haemorrhagic diarrhoea.

Muir *et al.* (1995) used peri-operative corticosteroids in 46 out of 47 Dachshunds in which hemilaminectomies and 49 out of 51 Dachshunds in which dorsal laminectomies were performed for the treatment of intervertebral disc extrusion.

Schulz *et al.* (1997) reported that signs of severe pain and neurological deficits are considered to be indications for primary surgical reduction for atlantoaxial instabiity. The authors stated that nonsurgical techniques include stabilization with a cervical splint, corticosteroid administration and exercise restriction.

De Risio *et al.* (2001) stated that Conservative treatment of DLSS is recommended when pain is the main clinical sign and consists of weight loss, physiotherapy, administration of anti-inflammatory drugs, and medication for neuropathic pain, such as gabapentin.

Macias *et al.* (2002) reported that the condition of nearly half of the dogs with thoracolumbar disc disease that were treated non-surgically deteriorated within a year and had to be euthanized.

Riaz (2004) subjected paraplegic dogs to nonsurgical treatment involving ultrasound therapy of the back for 15 minutes duration on alternate days, and epidural administration of methyl prednisolone acetate at the rate of 1 mg/kg body weight and B complex injection at weekly intervals by IM route. The dogs were also administered B complex vitamin tablets orally daily for a period of six weeks and concluded that non surgical treatment was better than surgical stabilization.

Chandy (2006) used methyl prednisolone acetate epidurally at the dose rate of 2mg/kg body weight in 14 dogs with paraplegia and opined that methyl prednisolone acetate was found to be effective for the treatment of traumatic paraplegia in dogs without fractures or dislocation of the vertebral column when given epidurally. The authors conclude that the prognosis for neurological recovery was poor for patients which did not show any signs of improvement even after three weeks of treatment.

Chandy and Vasanth (2006[c]) evaluated the efficacy of medical and surgical treatment for traumatic posterior paralysis in 18 dogs and observed that 9 out of 12 dogs (75%) treated surgically by modified spinal stapling with tension band wiring with or without laminectomy, became ambulatory. While two out of six (33.33 %) dogs treated medically (epidural methylprednisolone acetate, B-complex vitamins, cage rest and ultrasound therapy) became ambulatory by 60th post-operative day, they concluded that surgical treatment improved the chances of recovery in dogs with traumatic posterior paralysis compared to those treated medically.

Chandy and Vasanth (2006) rehabilitated a seven year old male Dacshound dog with indigenously prepared wheel cart along with medical treatment.

Hayashi *et al*. (2007) reported that electro acupuncture combined with standard western medical treatment was effective in restoration of ambulation and deep pain perception within short time than the use of western treatment alone in dogs with signs of thoracolumbar intervertebral disc disease.

Mann *et al.* (2007) opined that the dogs treated with non steroidal anti-inflamatory drugs (NSAIDs) or methylprednisolone sodium succinate (MPSS) was likely to experience recurrence than dogs treated with corticosteroids other than MPSS for intervertebral disc diseases.

Nagaraja *et al*. (2007[d]) reported medical management of traumatic posterior paralysis in six dogs using methylprednisolone acetate epidurally,supplemented vitamin B complex and ultra sound theraupy @ 1.5watts/sq.cm for 10 minutes on alternate days for sixty daysand found that three dogs without fracture or the vertebrae showed good improvement and were ambulatory by 60th PO day, where as other three dogs with fractured vertebrae had to be euthanized for deterioration of the condition. The authors concluded that in case of fracture of vertebrae, spinal plating is a better approach than medical management.

Raut *et al.* (2008) reported complete recovery of a 5 year old paraplegic dog by the use of two homeopathic drugs Arnica and Lathyrus at specific dosage.

Janssens *et al.* (2009) reported that 38 dogs with Hansen type II lumbosacral disc protrusion were treated with epidural infiltration of methylprednisolone acetate between seventh lumbar vertebra and the sacrum under C-arm fluroscopic guidance and found 53% dogs were totally cured.

Worth *et al.* (2009) stated that corticosteroids are more effective than NSAIDs for treatment of degenerative lumbosacral stenosis in working dogs.

Babette and Gladstein (2010) have reported to have cured two dogs - Bella, a 3½-year-old female, spayed shih tzu and Mattie, an 11-year-old male, neutered maltese which were diagnosed as having possible cervical spine intervertebral disc disease C4–C5 > C5–C6 > C6–C7 and narrow C5–C6 and C6–C7 intervertebral spaces and chronic instability at C7–T1 intervertebral space respectively using prolotherapy in combination of physiotherapeutic modalities at weekly interval for four weeks. The authors have also reported that they started each treatment with laser therapy, then Prolotherapy was administered. Small amounts (1/8cc) of Prolotherapy solution (¼ dextrose, ¼ lidocaine, ¼ traumel, ¼ Vit B12), was injected in the intervertebral spaces from C3–T3 on either side of the spine. The fourth session they also administered Prolotherapy into maltese dog's right knee because of patellar luxation (common in the breed). All sessions were followed by acupuncture and electric stimulation. This procedure was followed up by supplementation of weekly Adequan® injections alone.

Md Ansari *et al.* (2012) reported that short wave diathermy (SWD) along with conventional drug therapy (CDT) was more effective in bringing the animals back to normal physiological status in dogs with hind quarter weakness followed by ultra sound (US) along with CDT and CDT alone. Conventional drug therapy was given for 14 days using methyl prednisolone acetate @ 30 mg/kg body weight i.m. on first day and later on 15 mg/kg body weight i.m. on alternate days, Meloxicam @ 0.2 mg/kg body weight i.m.

daily, Gabapentine 300mg and Mecobalamine 500mcg combination orally once daily and injection of Vitamin B1,B6, B12 and D-Panthenol 2ml, i.m. on alternate day.

Md Ansari and Zama (2012) were of the opinion that various physiotherapeutic modalities like ultrasound, magnetic field, interferential current and diathermy have been found beneficial in the management of spinal trauma, pain and posterior paresis, but their effects on body systems have not been documented.

Ayyappan (2012) briefly explained Non-Surgical Management of spinal fractures and luxations as Strict cage rest for 4-6 weeks, Back braces or body casts, Cessation of steroids, use of analgesics, and serial neurologic examinations (determination warrants reevaluation, with or without surgery).

2.6 Surgical treatment

Swaim (1971) applied small bone plates to the dorsolateral aspect of the vertebral bodies in 20 dogs to immobilize unstable spinal column. The technique was found to be physiologically and mechanically sound as a means of spinal immobilization in spinal fractures and luxations.

Braund *et al.* (1976) reported minihemilaminectomy to decompress spinal cord and stated that the technique resulted in less instability as it preserved the articular processes in dogs with posterior paralysis

Dulisch and Withrow (1979) reported that plastic plates were a rapid and easy method to realign and stabilize the spinal column of dogs. Authors also stated that these plates gave greater bone to plate contact than metal plates.

McAnulty *et al.* (1986) reported the use of modified segmental spinal fixation for stabilization of spinal fractures and dislocations in dogs.

Slocum and Devine (1986) described a distraction-fusion technique, which consisted of enlarging the collapsed lumbosacral IVD space and foramina, relieving the pressure on the nerve roots, and stabilizing the LSJ by inserting pins from the base of the L7 spinous process, through the facet joints and into the sacrum and the iliac wings.

Walter *et al.* (1986) stated that in canine lumbar vertebra, plate stabilization with bicortical screws provided superior strength and rigidity when compared in vitro with other forms of vertebral stabilization, including pin–PMMA.

Kupper *et al.* (1989) described, for the first time the minimally invasive technique of partial percutaneous discectomy in dogs.

Shores *et al.* (1989) reported use of combined Kirschner-Ehmer device and dorsal spinal plate fixation for treatment/stabilization of caudal lumbar vertebral fractures in dogs.

Touliatos *et al.* (1992) observed the advantages of minimally invasive methods of spinal surgery like faster recovery, lower infection rate and less perineural fibrosis in dogs.

Ullman and Boudrieau (1993) described a modified transilial pin technique to repair and fix fracture/luxation of the LSJ in 6 dogs.

Muir *et al.* (1995) reported the removal of disc material from the spinal canal during decompressive surgery in dogs. If the disc material remained in the spinal canal, resulted in residual spinal cord compression, which led to poorer results after surgery.

Dixon *et al.* (1996) performed discectomy followed by manual or mechanical distraction of the affected segment. Various implants can be used to maintain distraction including Steinmann pins and polymethylmethacrylate (PMMA), cancellous bone screws and a bone graft, a PMMA-interbody plug, or a locking spinal plate.

Rusbridge *et al.* (1998) used vertebral distraction techniques to widen spinal canal diameter and/ or intervertebral foramina and thus relieve compression on neural tissue and realign collapsed facet joints. The two vertebra are subsequently stabilized with an orthopedic implant to maintain distraction.

Spivak *et al.* (1999) worked on the effect of locking fixation screws on the stability of anterior cervical plating and reported that goals of cervical internal fixation are to control the unstable segment, improve bony union, correct spinal deformity and decrease the need for a cervical brace.

Moore *et al.* (2000) performed hemilaminectomy to relieve spinal cord compression due to an osteosarcoma in a dog.

Kanamori *et al.* (2001) stated that free fat graft seem to work better than other materials for spinal surgery of dogs and humans.

De Risio *et al.* (2002) stated that surgical treatments can be classified into decompression of spinal cord and nerve roots with and without stabilization. Decompression without stabilization can be performed by ventral slot or dorsal laminectomy or cervical hemilaminectomy and subsequent removal of structures that compress spinal cord and/or nerve roots.

Macias *et al.* (2002) treated 72 dogs with thoracolumbar disc disease by hemilaminectomy or vertebral body plating and stated that vertebral stabilization was more likely to be useful in larger, younger dogs with a single affected disc.

Walker *et al.* (2002) reported the advantages of external skeletal fixation of the canine spine over internal fixation like, minimal dissection for pin placement, the ability to span affected vertebrae with placement of implants distant from the site of injury, post-operative adjustability and complete removal of implants after healing.

Bagley (2003) reported distraction of the LSJ, followed by removal of the articular cartilage of the facet joints and insertion of cortical bone screws ventrolaterally across the facets through the sacrum.

Gnirs *et al.* (2003) reported dorsolateral hemileminectomy in the thoracolumbar and cervical areas as ventrally as possible (close to the vertebral canal floor) for treatment of spinal sub arachnoid cysts in 12 dogs.

Voss and Montavon (2004) reported the use of tension band stabilization of fractures and luxations of the thoracolumbar vertebrae in 38 dogs and cats and stated that method is good for small breeds of dogs and cats.

Bruecker (2006) reported locking plate/screw implants application to the vertebral bodies, which would improve overall stability of the construct and permit unicortical vertebral body application minimizing potential trauma to the spinal cord in dogs with spinal fractures and luxations.

Chandy and Vasanth (2006[d]) performed modified spinal stapling with tension band wiring for treatment of traumatic posterior paralysis in six dogs and opined that the technique provided adequate stabilization of the vertebral column.

Da Costa *et al.* (2006) reported the effectiveness of cellulose membrane or free fat graft on laminectomy membrane formation in 16 dogs, which underwent a modified dorsal laminectomy on T_{13}-L_1 and advised to avoid these when performing modified dorsal laminectomy in thoracolumbar area in the dogs.

Gonzalez and Olby (2006) reported that right sided hemilaminectomy for decompression of the spinal cord in a dog suffering with upper motor neuron fecal incontinence as a result of secondary epidural spinal haematoma and intervertebral disc extrusion in thoracolumbar region (T_{13}-L_1).

Cabassu and Moissonnier (2007) reported stabilization of vertebral fracture using screws and PMMA with Gentamicin by lateral intercostal approach for vertebral fracture associated with a haematogenous osteomyelitis in dogs.

Fransson *et al*. (2007) reported that in dogs various distraction stabilization techniques have been described including stand-alone intervertebral implants such as polymethylmethacrylate (PMMA) plugs and intervertebral washers which have not resulted in convincing long-term results, and that the combination of intervertebral implants and vertebral stabilization with spinal locking plates or screws and PMMA tend to be more effective.

Godde and Steffen (2007) reported that surgical treatment for degenerative lumbosacral stenosis consists of dorsal laminectomy, if necessary combined with partial discectomy, and is aimed at alleviating the compression of the cauda equina.Additional unilateral or bilateral facetectomy and foraminotomy (possible via lateral approach) may be indicated if stenosis of the intervertebral foramina is present. Distraction fusion of the LSJ with pins through the L7 spinous process, facet joints, sacrum, and iliac wings, has also been described.

Jeffery *et al*. (2007) reported implantation of positive threaded external fixator pins into the vertebral bodies of T_8, T_9, and T_{10} in three dogs which were suffering from severe dorsoventral stenosis of the vertebral canal resulting in spinal cord compression. The vertebrae were than fixed in position by application of PMMA bone cement for surgical treatment of hemivertebrae in dogs.

Nagaraja *et al*. (2007[a]) performed spinal plating with and without laminectomy for posterior paralysis in 6 dogs each and stated spinal plating without laminectomy was found to be effective surgical technique for the treatment of traumatic posterior paralysis in dogs especially with vertebral body fractures and luxations.

Weh and Kraus (2007) conducted that stabilization of lumbosacral fracture using 4 pin and bone cement fixation in the lumbar vertebrae and ilial body, using 29 and 20^0 as guidelines for the craniocaudal and lateromedial pin insertion angles in the ileum for dogs with lumbosacral fracture/luxations.

Wheeler *et al.* (2007) conducted closed fluoroscopic assisted application of external fixator for the stabilzation of vertebral column injuries in five dogs and reported that it provided satisfactory reduction and effective stabilzation in five dogs.

Bruce *et al*. (2008) reported that spinal fracture and luxation in dogs and cats and stated that the patients that were treated with pins and/or screws were significantly more improved than conservatively managed patients at the time of discharge, although the surgically treated patients were hospitalized significantly longer than the conservatively managed patients.

Bergman *et al.* (2008) reported that for dogs with CSM at a single level, the use of a spinal locking plate in combination with a cortical ring allograft can be an effective surgical treatment. Costs of the implants as well as anatomic differences in dogs make this type of surgery less appealing.

Kokila (2008) performed hemilaminectomy combined with medical therapy for management of lumbar spinal disorders in 12 paraplegic dogs divided into two groups of six each. The author concluded that combination of methyl prednisalone sodium succinate, hemilaminectomy with local application of polyethylene glycol has shown higher neuralogical recovery grades than hemilaminectomy with local application of polyethylene glycol and is due to the synergetic action of methyl prednisalone sodium succinate and polyethylene glycol.

Mckee and Downes (2008) reported bilateral quadruple vertebral body stabilisation using novel canine locking fixation plates in two dogs for triple thoracolumbar disc protrusions. They found screw breakage in one dog following five month of surgery. Spinal pain resolved and neurological function improved in both dogs.

Downes *et al*. (2009) reported that hemilaminectomy and vertebral stabilisation are an effective treatment for chronic spinal cord compression due to thoracolumbar annular protrusion in dogs.

Trotter (2009) reported the use of the use of locking plates and cortical ring or block allografts for distraction/fusion in spinal fractures with satisfactory outcome in most cases.

Rathod *et al.* (2010[b]) reported Modified spinal arch external skeletal fixation for stabilization of lumbar vertebral fractures in dogs and stated that the method had poor success rate. Out of six cases, none of the dogs recovered due to post operative complications like animal immobilization, pin looseing, wodden plate breakage, seroma formation, decubital ulcer formation.

Renwick *et al.* (2010) reported surgical stabilization of lumbosacral discospondylitis in a two-year-old boxer dog using screws and polymethylmethacrylate, and implantation of a gentamicin-impregnated collagen sponge into the L7-S1 disc space.

Sutton *et al*. (2010) performed a right-sided hemilaminectomy centered over the L2-L3 intervertebral disc in a four year old neutered Doberman and retrieved a large sprig of plant material, approximately 25 mm in length which had migrated to the spinal canal.

Vani (2010) studied Modified segmental spinal fixation for lumbar spinal injuries in young companion animals and suggested that the technique was found to be simple, provided rigid fixation and was much suitable for young companion animals.

Dickomeit *et al.* (2011) reported that the stabilization of atlantoaxial surgical conditions in toy breeds with the 1.5 mm titanium 5-hole butterfly locking plate appears to be an effective means of surgical treatment.

Guiot and Allman (2011) reported a csae of Median sternotomy and ventral stabilization for a comminuted T5 vertebral fracture using pins and polymethylmethacrylate in a 2.6 kg Miniature Schnauzer. The authors also stated that recovery was uncomplicated and fracture healing was evaluated at 8 weeks post surgery.

Steffen *et al.* (2011) stated that distraction–fusion of single level CCSM in dogs with a combination of intervertebral cage and ventral locking plates is clinically effective and results in successful bony fusion.

Ayyappan (2012) reported the comparison of surgical and nonsurgical management of spinal trauma and states that Success rate in surgical management is 95% whereas in non surgical method it is 70%, recurrence rate in surgical management is less than 50% whereas in non surgical method it is 50%, predictability of recovery in surgical management is high whereas in non surgical method it is low, requirement for confinement in surgical management is minimal whereas Strict confinement for 6 weeks or more is required in non surgical method, it is safe to perform techniques of physiotherapy in surgical management whereas some techniques may be hazardous in non surgical method.

O'Riordan *et al.* (2013) reported a Cadaveric descriptive study in which a ventral surgical approach to the LS junction was made and local anatomic structures documented. Accessible ventral L7 and S1 vertebral bodies and LS disc were marked with India ink. Total and marked surface areas were calculated. The potential for bicortical and unicortical implant placement was determined in transverse slices of L7 and S1. Exposed ventral disc annuluses relative to vertebral canal diameters were measured. The authors concluded that ventral approach to the LS junction is possible, with LS discectomy, and implant placement in L7 and S1 vertebral bodies possible from this approach.

2.4.3 Post operative care

Blass *et al.* (1988) used cephadrine and dexamethasone intravenously immediately after induction of anaesthesia for spinal surgery in dogs.

McKee (1990) used of broad-spectrum antibiotics and corticosteriods until return of voluntary control of urination in dogs and cats with spinal injuries followed by catheterization of bladder when necessary.

Rayward (2002) used oral cephalexin at the rate on 250 mg every 12 hours for 14 days, enrofloxacin at the rate of 100 mg every 24 hours for 14 days and carprofen at the rate of 30 mg every 24 hours for five days for a 17 kg dog in which hemilaminectomy of

C_5-C_6 vertebra was performed. Morphine was administered periodically as intramuscular injection over the first four post-operative days.

Da Costa *et al.* (2006) used morphine epidurally at lumbosacral junction to maintain post-operative analgesia in dogs, which underwent modified dorsal laminectomy on T_{13}-L_1 to evaluate the effectiveness of cellular free fat graft on laminectomy membrane formation.

Gonzalez and Olby (2006) post-operatively used fentanyl patch, hydromorphone and carprofen for right sided hemilaminectomy in seven year-old dog affected with intervertebral disc extrusion at thoracolumbar region.

Laim *et al*. (2009) reported that adjunct electroacupuncture might provide some mild benefit with regard to severity of postoperative pain in dogs undergoing hemilaminectomy because of acute thoracolumbar intervertebral disk disease.

Sutton *et al*. (2010) stated that postoperative analgesia was provided with 20 mg methadone, administered intramuscularly as required for the first 24 hours, and then with a 100 μg transdermal fentanyl patch thereafter. Carprofen at 2 mg/kg was given orally for 14 days following surgery. Antibiotic therapy with 600 mg cefalexin and 400 mg metronidazole, both administered orally twice daily.

Steffen *et al.* (2011) reported the use of morphine, fentanyl-patches, or a constant rate infusion morphine, lidocaine, and ketamine combined for post operative pain control.

Ayyappan (2012) opined that manual expression of bladder is always preferable to catheterization. The latter has an increased risk of inducing cystitis as a result of the mechanical irritation of catheterization and the difficulty in performing the procedure in a completely sterile way. The author recommends four main aspects to the prevention of decubital ulcer problem: Prevent prolonged recumbency in one position, use well – padded bedding (or local padding in the form of 'doughnut dressings'), be attentive to bladder management and groom the patient at least once daily.

2.5 Post-operative complications

Brown *et al.* (1977) found in a retrospective study that laminectomy membrane formation after surgery which was responsible for recurrences in thoracolumbar disc disease in dogs.

Chambers *et al.* (1982) stated that the ventral decompression was evaluated as a treatment for cervical disk protrusion in large and giant breed dogs. All the dogs improved after ventral decompression. After a follow up period averaging 16 month, half of the dogs were clinically normal and other half were functional pets despite minor residual proprioceptive deficits. Ventral decompression alone appears to be acceptable treatment for dogs not having other radiographic signs of caudal cervical spondylopathy.

Moore and Withrow (1982) did not observe death in any dog related to gastrointestinal complications in spinal patients without dexamethasone administration. It was stated that administration of corticosteroid helps in preventing gastrointestinal haemorrhage and pancreatitis.

Smith (1985) reported that PMMA (polymethylmethacrylate) is also likely to have a higher incidence of complications than metallic implants because of PMMA's inferior mechanical properties to metal alloys (ex, low ductility), heat generation, release of methylmethacrylate monomer into circulation, and hypersensitivity reactions

Baskin (1988) reported that stabilization of a distracted segment does not however equal fusion. Development of bony fusion is a technical goal with spinal stabilization procedures because stability provided by implants alone may not be lifelong, which may result in clinical and technical failure in the long term. Similarly, hardware failure and development of pseudoarthrosis have been described in cases of instrumented mechanical stabilization with absent bony fusion.

Blass *et al*. (1988) stated that even though the use of polymethylmethacrylate to augment the stabilization and prevent pin migration has shown to provide a rigid and reinforced framework, the disadvantages include thermal damage, increased risk of infection, pressure necrosis of adjacent structures and inconvenience when revision surgery is required.

Gundy (1988) stated that ventral decompression may also result in further collapse of the disc space and renewed or even exacerbated spinal cord attenuation with additional infolding of these structures and the dorsally located interarcuate ligament and joint capsules.

Stauffer *et al.* (1988) reported complications following the ventral slot procedure include venous sinus hemorrhage resulting in progressive tetraparesis following surgery, Horner's syndrome, hypotension and bradycardia resulting in death, cardiac arrhythmias, and instability with subsequent subluxation of the surgical site.

McKee (1992) observed constrictive laminectomy membrane formation consequent to extensive dorsal laminectomy technique in dogs with spinal injury. According to the author it might itself compress the spinal cord when laminar bone was removed to a level below that of the spinal cord and therefore autogenous fat grafts had been advocated for the prevention of this invasion of the vertebral canal.

Wheeler and Sharp (1994) reported that abnormal lumbosacral motion leads to compensatory skeletal changes, including sclerosis of the lumbosacral end plate, osteophyte development on the articular facets, hypertrophy of the interarcuate ligament and articular facet joint capsule, and bulging of the dorsal annulus.

Yovich *et al.* (1994) reported one dog out of 61exhibited permanent scoliosis post-operatively, which underwent modified lateral spinal decompression for thoracolumbar disc protrusion. One dog with grade 3 injuries deteriorated to grade 5 post-operatively and was euthanized.

Schultz *et al.* (1997) stated that if surgical success is considered as the resolution of neurological signs and no requirement for further surgery, a failure rate of up to 44% for all ventral atlantoaxial fixation procedures has been reported.

Rusbridge *et al.* (1998) stated that the adjacent segment disease, which is the development of spinal cord compression over sites surrounding a rigidly fixed vertebral articulation, has been reported to develop from 5 to 48 months after stabilization and may be the cause of many cases of recurrence.

De Risio *et al.* (2002) stated that the Dogs undergoing a dorsal laminectomy procedure have had immediate postoperative decline in neurologic grade in 14 of 20 dogs; thus, several had ulcers or wound infections develop during recovery.

Kaiser *et al.* (2002) reported pseudoarthrosis, or non-union of the vertebral segments, which developed in 4% of patients. Pseudoarthrosis has been associated with an increased incidence of postoperative pain and complication may have been related to screw loosening that occurred in the immediate postoperative period

McKee and Sharp (2003) stated that implant ‘‘back out,’’ interspace collapse because of crushing, intrusion, or extrusion of the graft or subsidence of the cement plug, spacer, or graft into the soft cancellous bone of the vertebral body (from crushing through the vertebral end plates, from end-plate resorption, or from end-plate perforation as a result of endplate preparation or ventral decompression), penetration of bicortical pins or screws into the vertebral canal with spinal cord perforation or transverse foramen with vertebral artery compromise, fracture of bone cement bridges, screws and plates, failure at the implant–cement interface, delayed graft incorporation with or without pseudoarthrosis, and various soft tissue complications such as esophageal erosion because of ventral hardware or bone cement prominence have been reported even in cases with satisfactory (neurologic) recoveries.

Kaur and Singh (2004) did not observe any complications while performing myelography except for subdural injection in one case of 13 dogs suffering with various spinal affections.

Miossonnier *et al.* (2004) observed seroma formation in one dog out of 15 that underwent corpectomy as a treatment for thoracolumbar disc herniation.

Loughin *et al.* (2005) noted post-operative complications viz, decubital ulcers, recurrent back pain and loss of voluntary motor function in 8 of 48 dogs (16.7 %), which underwent hemilaminectomy with or without durotomy for the purpose of treating type-1 thoracolumbar intervertebral disc extrusion.

Rossmeisl *et al.* (2005) noted seroma formation after one week as post operative complication in one dog. The authors also noted aspiratory pneumonia, sepsis and fulminant disseminated intravascular coagulation (DIC), 16 dogs which underwent modified lateral approach to the cervical spine for surgical treatment of cervical telepathic or radiculopathy lesions. Adjacent segment disease has been reported to occur up to 4 years after the original surgery, with a mean recurrence around 2 years.

Bergman *et al.* (2008) stated that complications associated with the distraction/fusion procedure included screw loosening, plate shifting, urinary tract infection, graft displacement, pseudoarthrosis and post-surgical wound infection. All complications, with the exception of pseudoarthrosis, were closely approximated to the immediate postoperative period, within 30 days of surgery.

Kokila (2008) reported wound dehiscence,mild seroma formation,decubital ulcers at illiac prominence, urine scalds, quadriceps muscle contracture and post operative scoliosis as the post operative complications during her study.

Trotter (2009) stated that the potential complications of distraction stabilization techniques include iatrogenic injury to neural and vascular structures during surgery, implant-associated complications and loss of distraction because of endplate-fracture, incomplete bony fusion with pseudoarthrosis and adjacent segment disease.

Rathod *et al.* (2010[b]) reported pin loosening from the vertebral metaphysis due to which the implant stability was failed in two dogs, breakage of the wooden plates on fourth and eighth post operative day in another two dogs, decubital ulcers due to urine scalding and superficial wound over the dorsal aspect of the paw region in one dog each which underwent modified spinal arch external skeletal fixation for stabelization of lumbar vertebral fracture.

Steffen *et al.* (2011) stated that the post operative complication arising after surgical procedure were seroma formation, adjacent segment disease lesion, acute onset of severe tetraparesis and cervical pain which prompted further investigations. Radiographic and myelographic examination revealed a collapsed intervertebral disc space with a disc protrusion with severe stenosis of the spinal canal one segment cranial to the stabilized segment.

2.5 Surgical anatomy of lumbar vertebrae

Bruecker and Howard (1992) reported that the understanding of the regional anatomy of thoracolumbar region has a direct significance in the treatment of the traumatic spinal disorders in dogs.

Lumbar region consists of vertebrae, joints, ligaments epaxial and hypaxial muscles with segmental blood supply. Vertebrae consist of body, vertebral arch, pedicles, lamina, intervertebral foramen, and intervertebral disc, various processes like transeverse, dorsal spinous, articular, accessory and mamillary process. These vertebrae with their bodies and long transverse processes form the bony roof of the abdomen.

Lumbar Vertebrae has the following features: Transverse processes are long and in the form of bony plates. They are inclined cranially and ventrally. Articular processes are well developed. Cranial processes are curved inward and the caudal processes are convex and pointed. Spinous process is in the form of a quadrilateral plate. Body of the last lumbar is little compressed dorsoventrally. Its transverse processes are narrow. It articulates with the cranial end of the sacrum. Neural ring is roughly triangle. Small mamillary processes (Fig. 1).

Joints of Vertebral Column.

Adjacent vertebral bodies of vertebral column are joined by fibrocartilagenous joints. Articular processes of the contiguous vertebrae and joints between the ribs and vertebrae are joined by synovial joints.

Ligaments of Vertebral Column.

Long and short ligaments of the vertebral column stabilize the inter-vertebral articulations and maintain the integrity of the spinal cord. The supraspinous, dorsal and ventral longitudinal ligaments are the long ligaments. The short ligaments include, inter-vertebral discs, inter-Spinous, inter-transverse, yellow and conjugal ligaments. The supraspinous ligament runs over the summits of the spinous process of the first thoracic vertebra to the third coccygeal vertebra. Bilaterally the dense collagenous lumbodorsal fascia blends with it throughout the thoracic and lumbar regions. These ligaments provide abnormal separation of the spines during flexion of the vertebral column.

Dorsal longitudinal ligament runs along the floor of the vertebral canal from axis to sacrum. It is narrowest at the middle of the vertebral bodies and widens at the inter-vertebral discs. Between the transverse processes of the lumbar vertebrae are the intertransverse ligaments. They are not distinct in any other regions of the spine. The yellow ligaments join the arches of the adjacent vertebrae. Conjugal ligaments join the heads of the given pair of ribs passing transversely between the annulus fibrosus and the dorsal longitudinal ligament.

Muscles of Vertebral Column.

Muscles above the level of the transverse process of the vertebrae are called epaxial muscles and those below it are called hypaxial muscles.

Epaxial Muscles Of the Lumbar Region:

Serratus dorsalis caudalis, splenius, iliocostalis, longissimus, spinalis, semispinalis, multifida, rotator muscles, interspinalis and rectus capitis dorsalis muscles.

Hypaxial Muscles Of the Lumbar Region:

Psoas minor, Psoas major, Iliacus, quadratus lumborum. These are also called as **sublumbar muscles** and are located ventrolateral to the lumbar vertebral column and are supplied by ventral branches of the lumbar nerves.

The **quadratus lumborum muscle** originates at the last three thoracic vertebrae and the transverse processes of the lumbar vertebrae and courses to its region of insertion, which extends from the alar spine to the auricular surface of the iliac bone. The **psoas major muscle** arises from the vertebral end of the last two ribs and from the lumbar vertebrae and, at the level of the pelvis, joins the iliacus muscle to form the iliopsoas muscle .The iliopsoas traverses the muscular lacuna to insert at the lesser trochanter of the femur (femoral bone). The iliacus muscle takes origin from the sacropelvic surface of the ilium and from the lateral surface of the insertion tendon of the psoas minor muscle. The psoas minor muscle arises from the last three thoracic and first four lumbar vertebrae where it lies ventral to the psoas major muscle. It terminates with a flat tendon at the psoas minor tubercle of the ilium (Fig. 2).

The abdominal aorta releases the segmentally arranged paired lumbar arteries from its dorsal surface. These pass in company with the veins to the lumbar vertebral column and associated soft tissues. From the lateral wall of the aorta originate the common trunk of the caudal phrenic artery and cranial abdominal artery as well as the renal, ovarian or testicular, and deep circumflex iliac arteries. The same-named veins accompany all of these arteries. From the ventral wall of the aorta originate the unpaired celiac, cranial and caudal mesenteric arteries. In the initial portion of their course to the internal organs these arteries are unaccompanied by veins. The celiac artery originates immediately caudal to the aortic hiatus at the level of the 13th thoracic vertebra. A little caudal to that the cranial mesenteric artery follows at the level of the first lumbar vertebra. At the level of the second lumbar vertebra the cranial abdominal artery originates from the aorta jointly with the caudal phrenic artery. The renal artery follows immediately caudal, still at the level of the second lumbar vertebra. The ovarian artery or testicular artery originates at the level of the third lumbar vertebra. The caudal mesenteric artery leaves the aorta at the level of the forth lumbar vertebra, and can be observed easily by putting tension on the mesentery of the large intestine at the level of the colon-rectum junction. The deep circumflex iliac artery arises a short distance caudal to the caudal mesenteric artery at the level of the forth lumbar vertebra, at a right angle to the aorta, cranial to the aorta's dividing into the external iliac arteries and internal iliac arteries, which is at the level of the fifth lumbar vertebra.

The caudal vena cava lies to the right of the aorta and receives veins that are satellite to all the above-mentioned arteries; except that the celiac, cranial and caudal mesenteric arteries are at their origin, unaccompanied by veins.

Blood Supply:

Vertebral column has got segmental arterial blood supply with a spinal branch entering the vertebral canal via the intervertebral foramen. The origin of the branches varies between the regions of the spine. Vertebral venous plexus**,** comprising two valveless veins on the floor of the vertebral canal, drains into the vertebral veins via intervertebral veins, these may be single or paired, at each intervertebral foraminae. The intervertebral veins are very fragile and can bleed profusely if damaged. Spinal cord in the lumbar region is supplied by spinal arteries**.** These enter the vertebral canal through intervertebral foramen and branch in to dorsal and ventral reticular arteries**,** which form anastomotic network on the surface of the spinal cord. The venous drainage of the cord occurs via vertebral venous plexus (Fig. 3).

Nerve supply:

At the level of intervertebral foramen each spinal nerve trifurcates in to dorsal, ventral and communicating (visceral) branches. The dorsal branch courses dorsally and supplies epaxial muscles, vertebrae, ligament and duramator and subsequently devides into medial and lateral parts. The hypaxial muscles receive the nerve supply from ventral branch. The visceral branch carries the motor and sensory fibers to and from visceral structures.

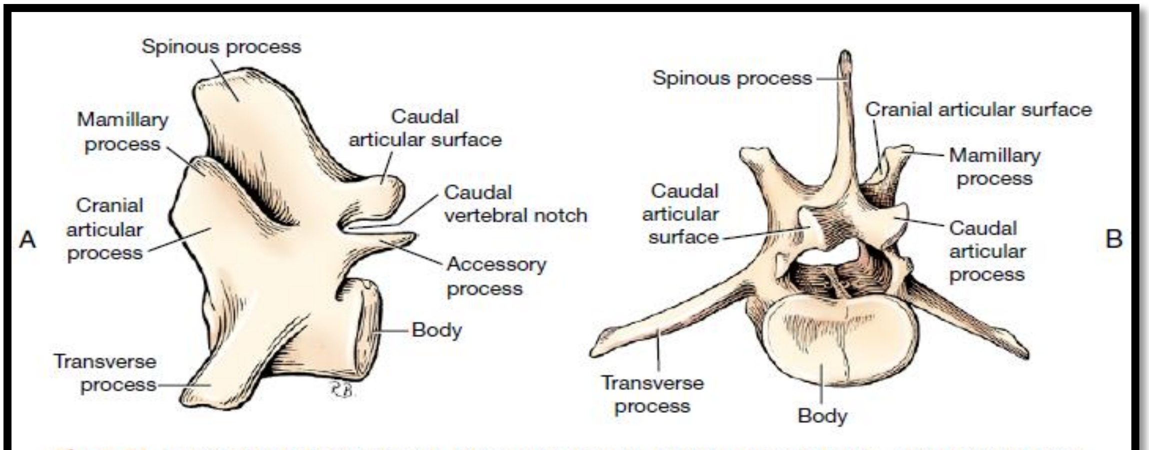


Fig. 2-71 A, Fourth lumbar vertebra, left lateral view. B, Fifth lumbar vertebra, caudolateral view.

Fig. 1: Anatomy of lumbar vertebra

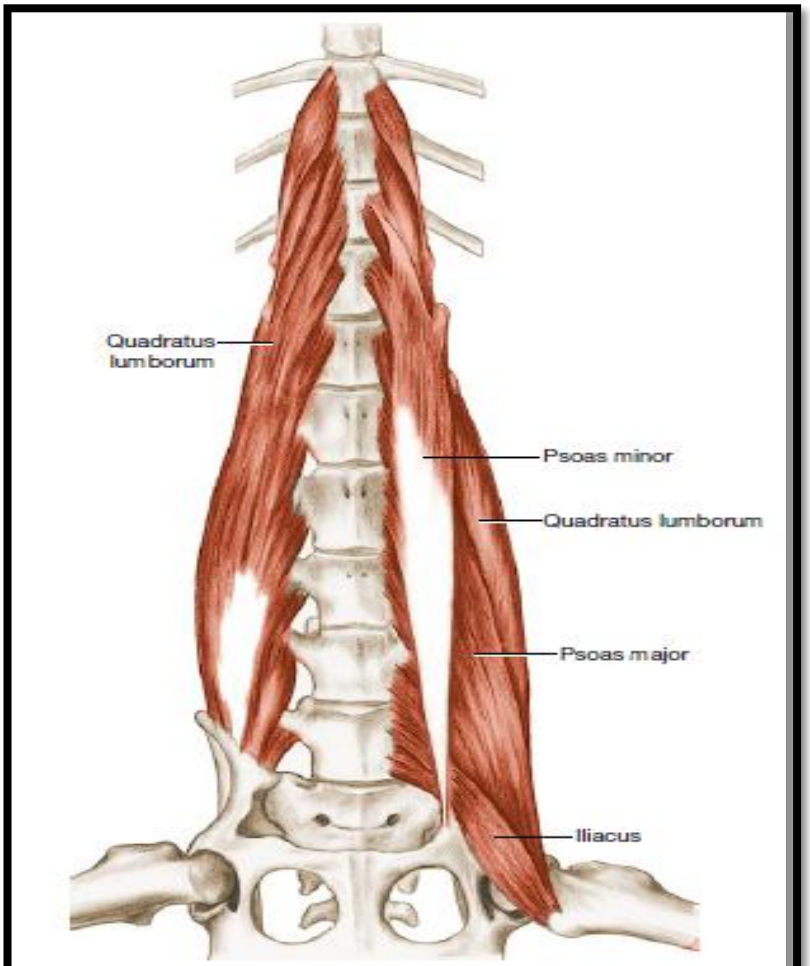


Fig. 2: Hypaxial muscles of the lumbar region

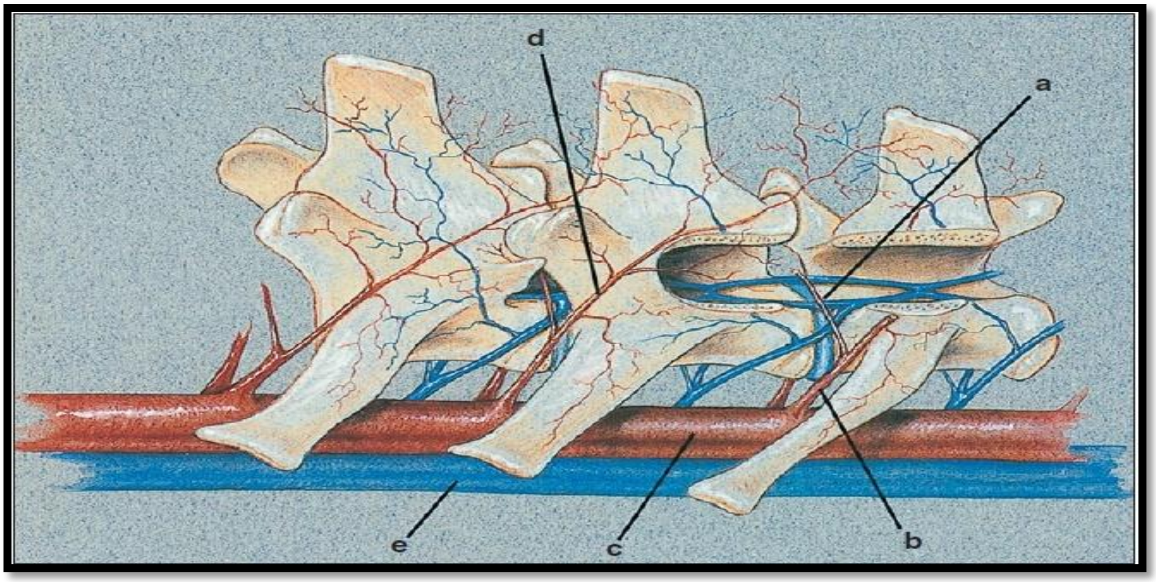


Fig. 3: Blood supply to lumbar vertebrae

The lumbar spine is supplied by spinal branches (**a**) of the lumbar arteries (**b**), which arise from the aorta (**c**). Each lumbar artery also gives rise to a nutrient vessel that enters the vertebral body. A dorsal branch runs caudally behind the articular processes in the musculature (**d**). The lumbar internal vertebral venous plexus drains into major veins of the abdomen (**e**), mainly the azygous vein and the caudal vena cava.

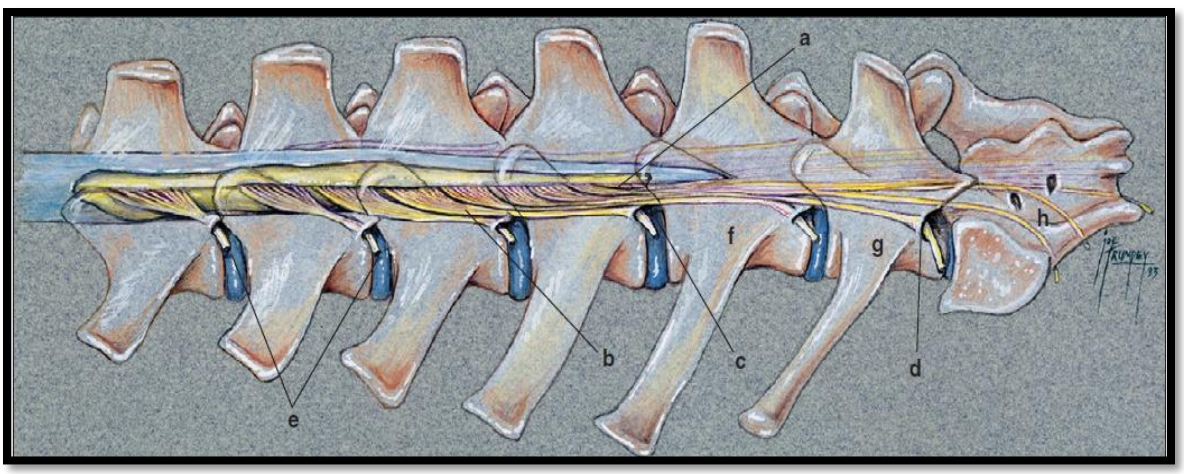


Fig. 4: nerve supply of lumbar vertebrae

Nerve roots of the cauda equina. Conus medullaris (**a**). Nerve roots and rootlets (**b**). Intervertebral foramen (**c**). Spinal ganglion (**d**). Spinal nerve (**e**). L6 vertebra **(f)**. L7 vertebra **(g)**. Sacrum (**h**).

Materials and Methods

III. MATERIALS AND METHODS

The present study was undertaken to standardize the technique of ventral approach for stabilization of lumbar fractures and dislocations in dogs among clinical cases presented to Dept. of Veterinary Surgery and Radiology, Veterinary College Hebbal, Bangalore with the history of posterior paralysis. The study was done for a period of one year between April 2012 to March 2013. The materials used and the methodology were as fallows.

3.1 Occurrence

The occurrence of lumbar vertebral injuries causing posterior paralysis in different breeds, age groups and sex of dogs which were presented to the college hospital over a period of one year from April 2012 to March 2013 were recorded.

3.2 Source of animals

The study was conducted on six clinical cases of dogs belonging to different age, sex, breed and body weights which were presented to Veterinary College Hospital with traumatic posterior paresis or paralysis, with inability to bear weight on hind quarters.

3.3 Patient evaluation

3.3.1 Case history

Detailed history of each case from the owner for cause of traumatic posterior paralysis was recorded.

3.3.2 Physical examination

The axial and apendicular skeleton was thoroughly examined and palpated to identify possible site of vertebral column and apendicular skeleton damage. Urinary bladder function was evaluated by abdominal palpation to ascertain the upper and lower motor neuron dysfunction. In upper motor neuron deficit urine stasis was confirmed by pressing the bladder from abdominal wall and observing urine flow through the urinary tract. The lower motor neuron deficit was confirmed by noticing dribbling of urine

3.3.3 Clinical examination

Heart rate (beats/min), Temperature (^{0}F) and Respiratory rate (breaths/min) were recorded in all dogs before performing surgery and after operation on 3, 5, 7, 15, 30, 45 and 60 days.

3.3.4 Neurological examination

3.3.4.1 Attitude, posture and gait:

Dogs attitude was recorded as alert, depressed or stuporous. Posture was also recorded as lying down, recumbent, sitting or standing, with or without support (Fig. 5). Gait of dogs were recorded as normal, dragging or ataxic.

3.3.4.2 Locomotor status:

The locomotor status of the dogs was evaluated based on the observations of the owner and after attempting to make them to move on the floor. However, care was taken to avoid excessive movements of the vertebral column to prevent further damage to the spinal cord. When a gross abnormality of the vertebral column could be detected on presentation, no attempt was made to make the animal move about to prevent aggravation of the spinal cord injury. Based on the observations, the dogs were classified as paraparetic, tetraparetic, paraplegic, tetraplegic or hemiplegic. Only paraplegic dogs were selected for the present study.

3.3.4.3 Conscious proprioception:

The dogs hind limbs were lifted and their paws turned backwards to make the dorsal surface of the paws to touch the ground (Fig. 6). The ability of the animal to return the paws to the normal position was recorded as present or absent.

Paw position response where an animal’s body-weight was supported fully and then each paw is turned over individually to bring the dorsal surface into contact with the ground. Animals with conscious proprioception return the paw to an upright position almost immediately; those with neurological disease cranial to the limb may leave the paw flexed.

3.3.4.4 Deep pain perception:

Deep pain sensation was assessed by pinching the toes with an allis forceps (Fig. 7). Based on the behavioral response of the animal, deep pain sensation was recorded to be present or absent. The reflex withdrawal of the limb must not be mistaken for a behavioral response. Similarly, some animals will react to the change in body position induced by the withdrawal reflex. Ideally, the withdrawal reflex should be initiated first, and then further pressure applied to evaluate pain perception.

Fig. 5: Photograph showing sitting posture of the dog with stiff forelimbs and paresis of hind limbs (Schiff – Scherrington posture)

Fig. 6: Photograph showing proprioceptive deficit

3.3.4.5 Panniculus reflex:

Skin on either side of dorsal midline over the lumbar spine was pinched with an allis forceps in a caudal to cranial direction, and the twitch of the cutaneous trunci muscle was recorded (Fig. 8). The response was recorded as normal, reduced or absent.

3.3.4.6 Patellar reflex:

The patellar reflex was tested by placing the dog on lateral recumbency and the limb to be tested held with the left hand in a relaxed position. A knee hammer was used to tap the straight patellar ligament of the knee joint and the jerking of the knee was observed (Fig. 9). This procedure was repeated on the other side also. The reflex was recorded as normal, reduced or absent. The patellar reflex is evoked by tapping the straight patellar ligament. It can be done on either the upper or the lower limb when the patient is placed in lateral recumbency in contrast to the withdrawal reflex that is unreliable in the lower limb.

3.3.4.7 Flexor reflex:

The flexor is stimulated by pinching the plantar surface of the hindlimb, which results in flexion of the limb. It is important to persist with the stimulus until it is clear that all the limb joints are flexing. While the flexor reflex was being evoked, the contralateral limb was observed for reflex extension—the crossed extensor reflex. The dogs were restrained in right lateral recumbency and the left hind limb was held in a relaxed position and the toes pinched with fingers (Fig. 10). The ability of the animal to withdraw the paws was recorded as normal, reduced or absent. The procedure was repeated with contralateral limb.

Fig. 7: Photograph showing testing for deep pain sensation

Fig. 8: Photograph showing testing for panniculus reflex

Fig. 9: Photograph showing testing for patellar reflex

Fig. 10: Photograph showing testing for flexor reflex

3.3.4.8 Anal sphincter reflex:

The perineal and the perianal skin was pinched using allis forceps and the ability of the external anal sphincter to contract was recorded as normal, reduced or absent (Fig. 11).

After complete neurological examination and localization of the lesion, the neurological grading is done as described by Griffith – 1982 and dogs with neurological grading from two to four are selected for the study.

3.4 Plain radiography

Survey radiographs were taken under sedation with Diazepam (Calmpose®, Ranbaxy Laboratories, H.P) at the dose of 0.5 mg/kg intravenously.

Lateral and Ventro-Dorsal view radiographs of the suspected region in the vertebral column were taken. Lateral view radiographs of the vertebral column were obtained by placing dogs on lateral recumbency, with the fore and hind limbs stretched in cranial and caudal direction respectively (Fig. 12). Ventro-Dorsal view radiographs were obtained with the dogs on dorsal recumbency by stretching fore and hind limbs cranial and caudal direction respectively. However, care was taken to prevent overstretching of the vertebral column to avoid further damage to the spinal cord.

3.5 Myelography

After plain radiography, dogs were subjected to myelography to localize lesions and to determine the extent of compression of the spinal cord. The contrast agent used for

Fig. 11: Photograph showing testing for anal sphincter reflex

Fig. 12: Photograph showing positioning for lateral radiograph

myelography was Iohexol (Omnipaque®, 350 mg/ml, Amersham health, Ireland) (Fig. 13) used at the rate of 80 mg /kg.

An area of skin extending from the caudal aspect of the skull anterior to the occipital protuberance to the level of the axis and extending on either side of the dorsal midline beyond the level of the edges of the wings of the atlas was shaved and prepared aseptically. The dogs were premedicated with Diazepam (Calmpose®, Ranbaxy Laboratories, H.P) at the dose rate of 0.5 mg/ kg intravenously and atropine sulphate (Atropine sulphate Injection IP- Superb Drugs Private Ltd., Kolkata) at the dose rate of 0.04 mg/kg subcutaneously. Anaesthesia was induced and maintained with a 2.5 % solution of thiopentone sodium (Thiosol®, Neon Laboratories Private Ltd., Mumbai) intravenously given “to effect”.

The dogs were placed on lateral recumbency with the dorsal midline of the neck in line with the table edge. The shaved area of the skin was prepared aseptically by applying surgical spirit followed by tincture of iodine. The head was flexed so that the skull was at 90 degrees to the cervical vertebrae. Wings of atlas were palpated with the thumb and middle finger of the left hand. The occipital protuberance was palpated with the index finger (Fig. 14). The point of insertion of needle was determined from intersection of two imaginary lines. One line was drawn on the midline from the external occipital protrubarence to dorsal spinous process of axis and the other line at right angles to it joining the cranial borders of wing of atlas. A 1.5 inch long 22-gauge hypodermic needle was introduced at an angle of 90 degrees to the skin. The needle was pushed gently through the musculature and subarachnoid space was punctured.

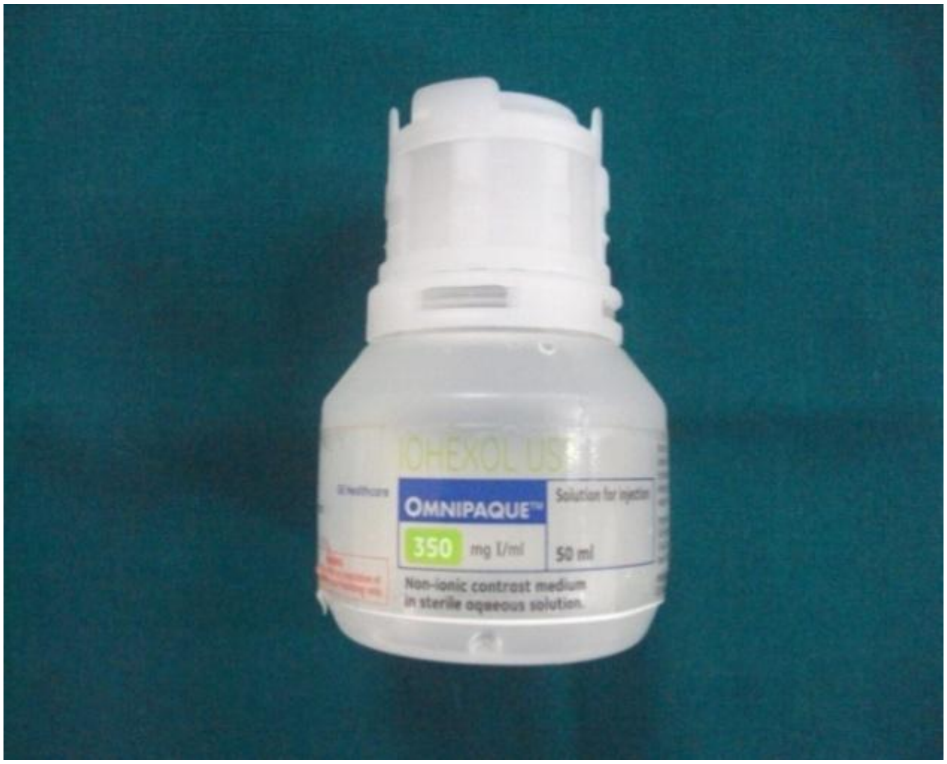


Fig. 13: Photograph showing Omnipaque® vial (Iohexol-350mg/ml)

Fig. 14: Photograph showing palpation of wing of atlas and occipital protuberance for locating the site of cisterna magna puncture

As the needle advanced a “popping” sensation was felt when the needle entered cistern magna. The flow of cerebro spinal fluid confirmed the placement of needle in the subarachnoid space.

The cerebrospinal fluid was allowed to flow out drop by drop and the quantity of drawn cerebrospinal fluid was measured (Fig. 15). The volume of cerebrospinal fluid drained is equal to the quantity of Iohexol to be administered. The contrast agent was injected slowly into the cisterna magna (Fig. 16). The dogs were then placed at about 15^0 inclined position with head being in an elevated position. While taking serial radiographs the animal was placed in normal position as that in plain radiograph. Serial radiographs were taken to locate the lesion in the spinal cord at time intervals of 0, 15, 30, 45 and 60 mins. After locating the lesion or completing the myelography procedure, the dogs were placed on lateral recumbency and allowed to recover from anaesthesia.

3.6 Surgical treatment

3.6.1 Pre-operative preparations

3.6.1.1 Preparation of surgical instruments

In addition to the general surgical pack and orthopaedic set, bone plates, screws, jacob’s chuck with key, K-wire and screw driver were included in the pack. (Fig. 17, 18 and 19). All the surgical instruments were sterilized by autoclave for 30 minutes before surgery.

Fig. 15: Photograph showing draining of cerebrospinal fluid

Fig. 16: Photograph showing injection of Iohexol

Fig. 17: Photograph showing general Surgical pack

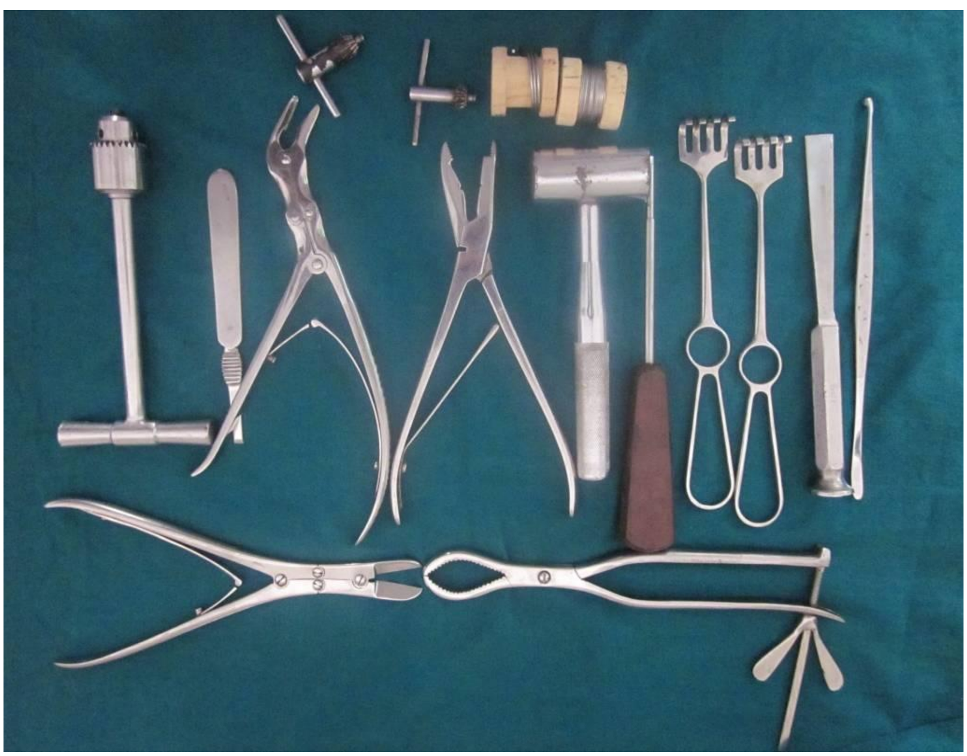


Fig. 18: Photograph showing orthopaedic set

3.6.1.2 Patient preparation

All the dogs were fasted for twelve hours and water was withheld for six hours prior to surgery. Enema was given the previous night and urinary bladder catheterization was done before preparing the animal for surgery. Injection amoxicillin clavulanate potassium at the rate of 20mg/kg intravenously was given prior to surgery.

The surgical site was prepared aseptically. Shaving was done on ventral abdomen from xhiphoid region to perenium region. Skin was washed with soap, cleaned with chlorhexidine solution, swabbed with surgical spirit and painted with tincture of iodine.

Dogs were placed on dorsal recumbency on the operation table with their fore and hind legs secured to the table. Sand bags covered with sterile plastic sheets were placed on either side of the dogs' chest to retain in position. Dogs were draped with a sterile drape extending from sternum to pubic region (Fig. 20).

3.6.1.3 Premedication and Anaesthesia

The surgery was performed under general anesthesia. The dogs were pre-medicated with atropine sulphate (Atropine sulphate Injection IP-. Superb Drugs Private Ltd., Kolkata) at the dose rate of 0.04 mg/kg IM , diazepam (Calmpose®, Ranbaxy Laboratories, Panota Sahib, H.P) at the rate of 1 mg/kg IV and pentazocine (Fortwin®, Ranbaxy Laboratories, Ahmedabad) at the rate of 1mg/kg IM. After 15 minutes of pre-medication, the general anaesthesia was induced with a 2.5 % solution of thiopentone sodium (Thiosol®, Neon Laboratories, Mumbai) and maintained with isoflurane (Sosrane®, Metrix Pharmaceutical, Mumbai) inhalant anesthesia. Intravenous infusion of

Fig. 19: Photograph showing plates and screws of various sizes

Fig. 20: Photograph showing draping of the dogs

Ringers Lactate (RL,Claris Life science) at the rate of 20ml/kg was done during the surgical procedure.

3.6.2 Surgical Procedure

Ventral midline incision was made from xiphoid to pubis depending on the site of fracture and in males parapenile incision on the skin was made (Fig. 21).

Skin and the subcutaneous tissue were separated to expose the linea-alba (Fig. 22) and the abdominal cavity was entered through linea-alba incision.

The incision was extended to the desired length to have sufficient working space. The abdominal viscera was exteriorized and placed on the sterile drapes to prevent contamination (Fig. 23).

The drying of the exteriorized viscera was prevented by frequently pouring normal saline on the viscera and by completely covering the viscera with sterile moistened mops. Upon exteriorization of the viscera, hemorrhage in the sublumbar muscles with formation of hematoma around the fracture site was observed (Fig. 24).

The sublumbar fascia and fat was bluntly dissected to expose psoas minor muscles. The psoas minor muscles are bluntly separated carefully avoiding the blood vessels and heamatoma was mopped off to identify the fracture site (Fig. 25).

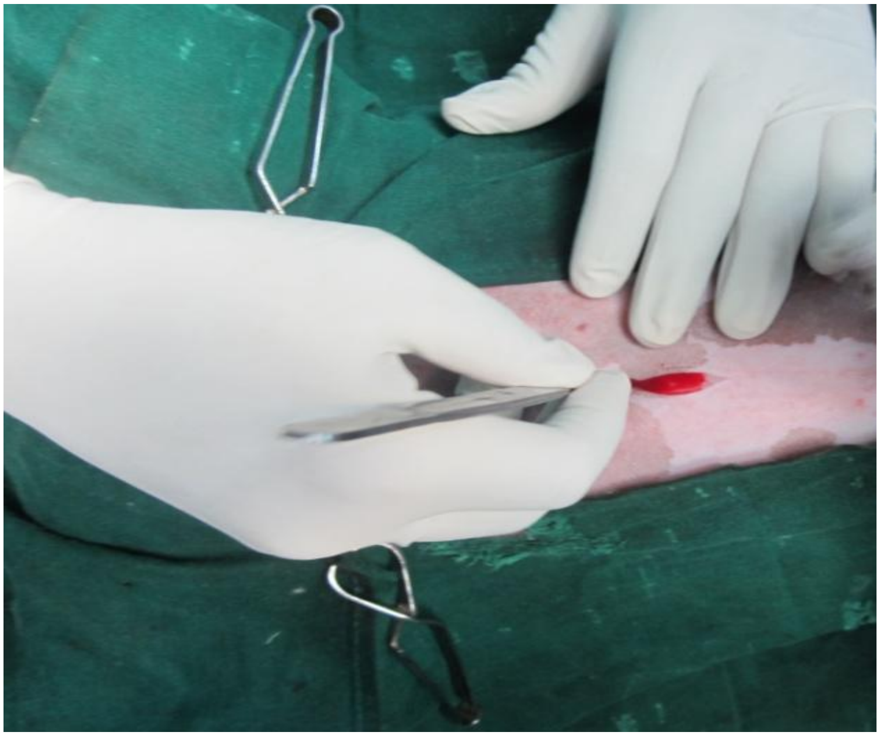


Fig. 21: Photograph showing ventral midline incision

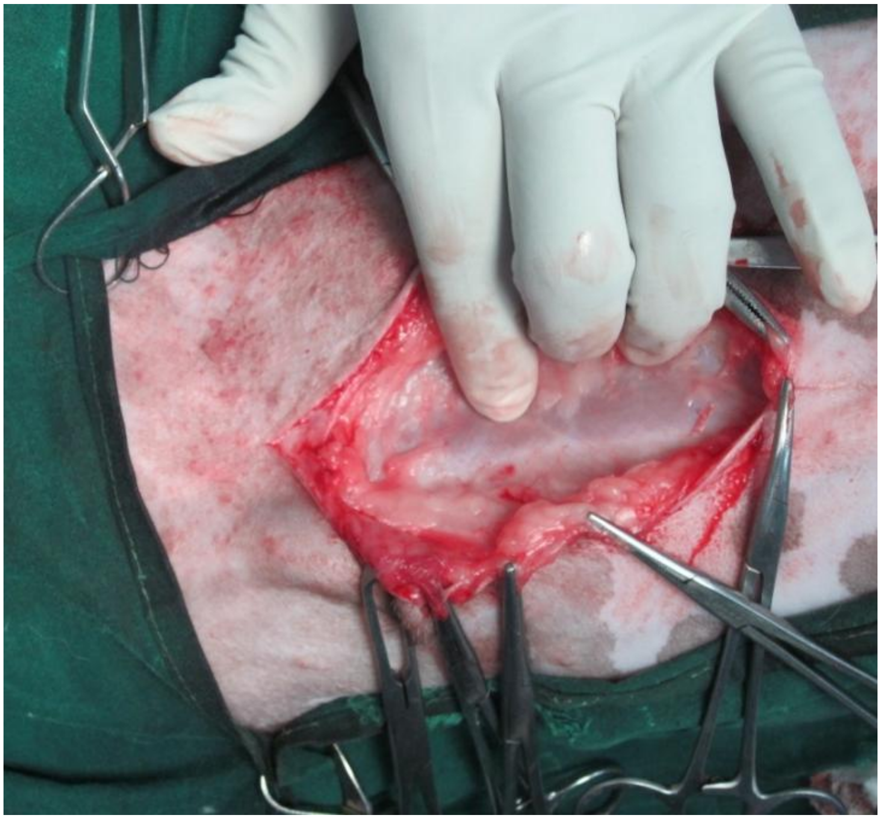


Fig. 22: Photograph showing exposing the Linea-alba

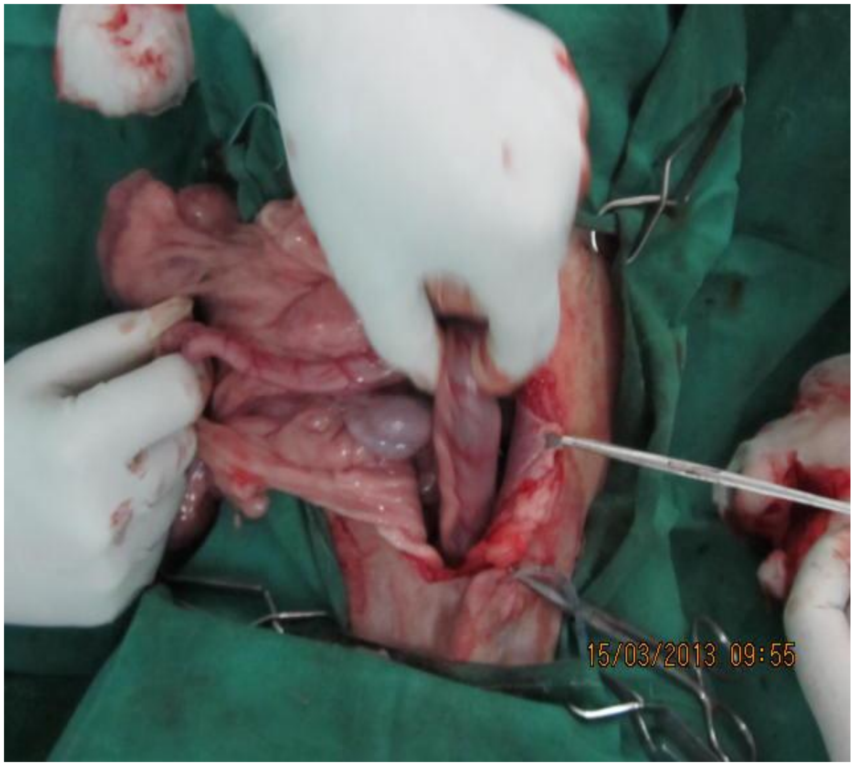


Fig. 23: Photograph showing exteriorization of abdominal viscera

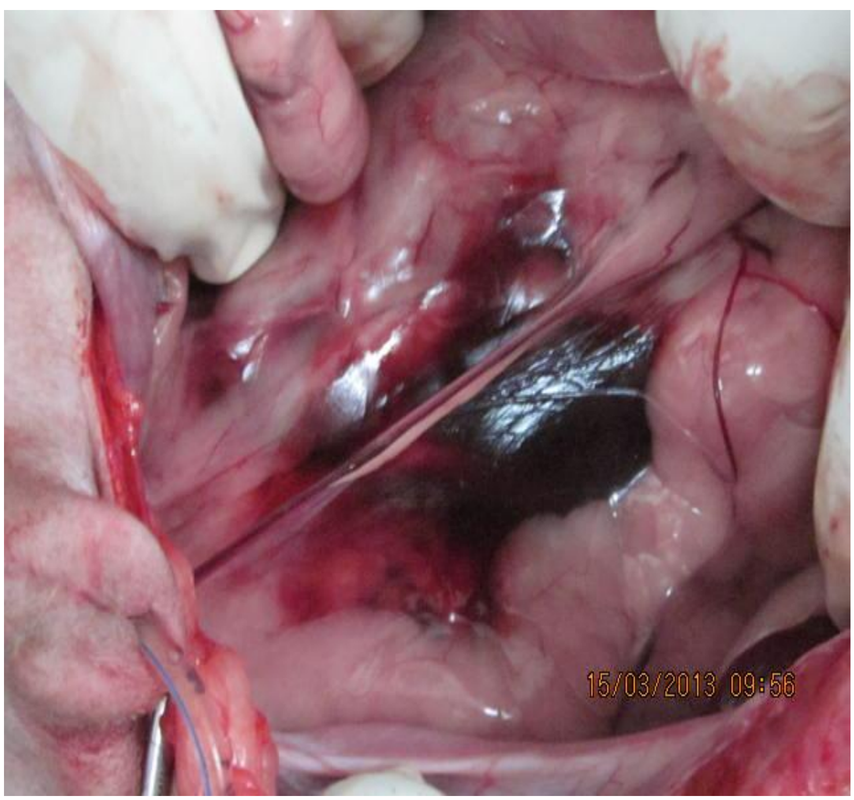


Fig. 24: Photograph showing haematoma at the site of injury

The displaced vertebrae were reduced manually .When the displacement was too much, the reduction was assisted by an assistant raising the site of injury by lifting the vertebral column of the animal from underneath and simultaneous manipulation of the affected vertebrae.

After complete reduction of the fracture a 2.7mm or 3.5mm bone plate of 6 holes, 8 holes, or 10 holes depending on the age and size of the animal was placed on the vertebrae making the fractured vertebrae as the center. The plate was held in position by the assistant surgeon with the use of digital pressure. A hole was drilled with 1.5mm K-wire fixed to Jacob's chuck at sites where screws were to be placed in such a way so as to avoid inter-vertebral space (Fig. 26).

Fully threaded cancellous screws of prefixed length were selected and placed in the caudal most hole of the bone plate. Securing of the plate was done by placing the cranial and caudal most screws first thereafter the remaining screws were placed. After the last screw was placed, all the screws were tightened to ensure a stable fitting of the plate against the vertebrae (Fig. 27).

The exteriorized viscera was replaced back in the peritoneal cavity into their respective positions, taking extra care not to rotate the spleen. Finally, the omentum was covered over the intestines and peritoneal cavity was thoroughly flushed with normal saline. The linea-alba along with peritoneum was sutured with No-1 Polyglactin 910 (Vicryl™, Johnson & Johnson, Aurangabad) in simple interrupted pattern (Fig. 28).

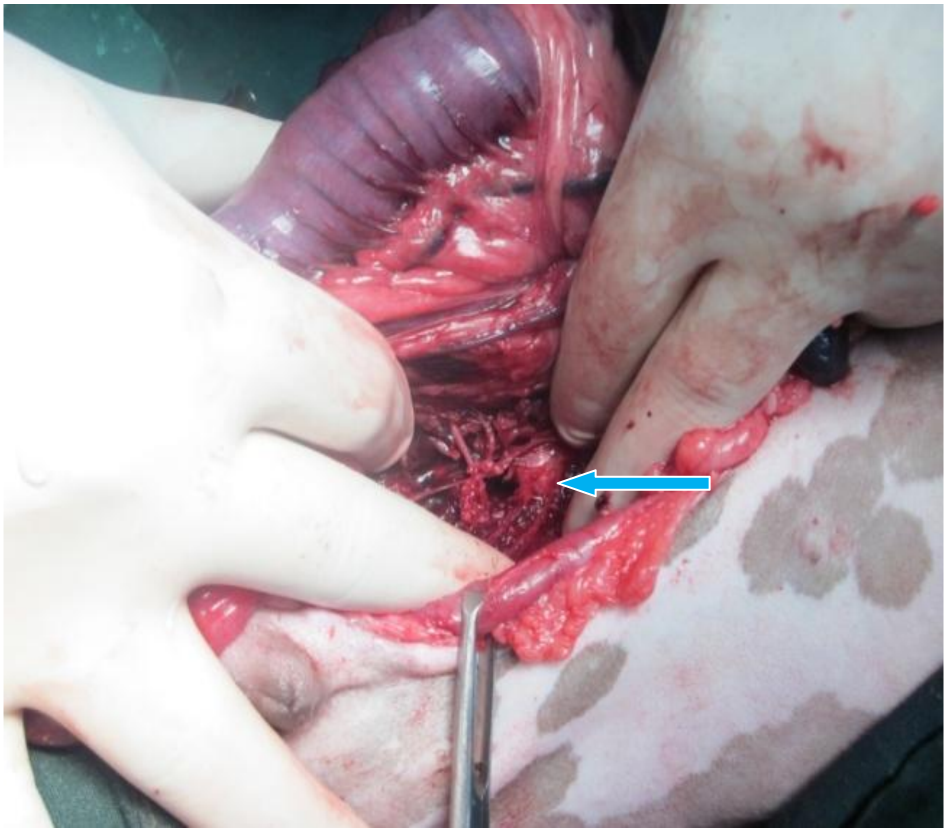


Fig. 25: Photograph showing identification of fracture site

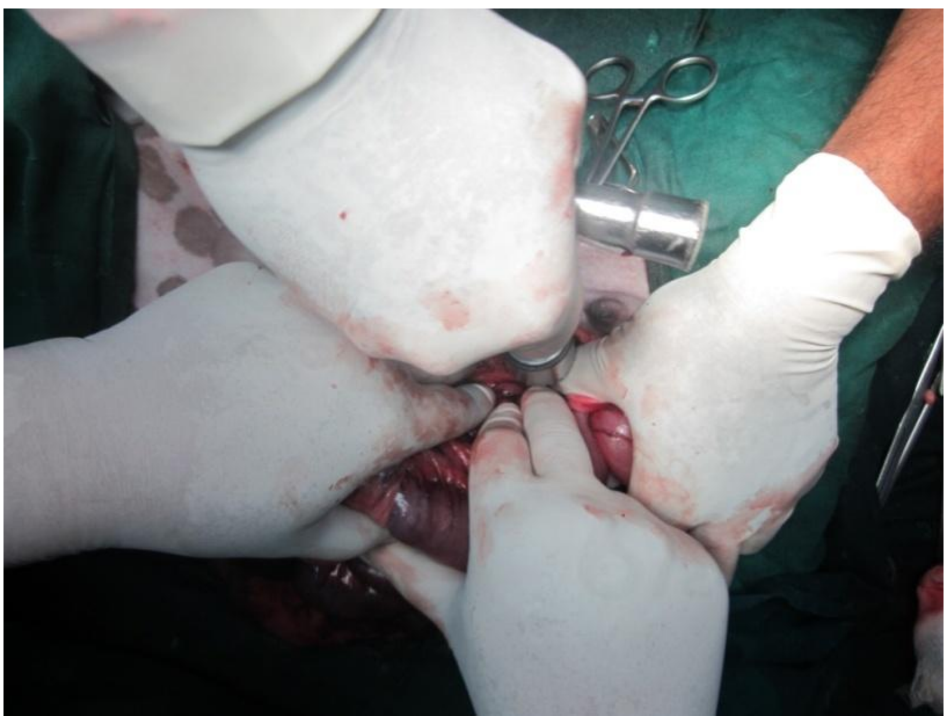


Fig. 26: Photograph showing drilling of hole with a K-Wire and Jacob's Chuck

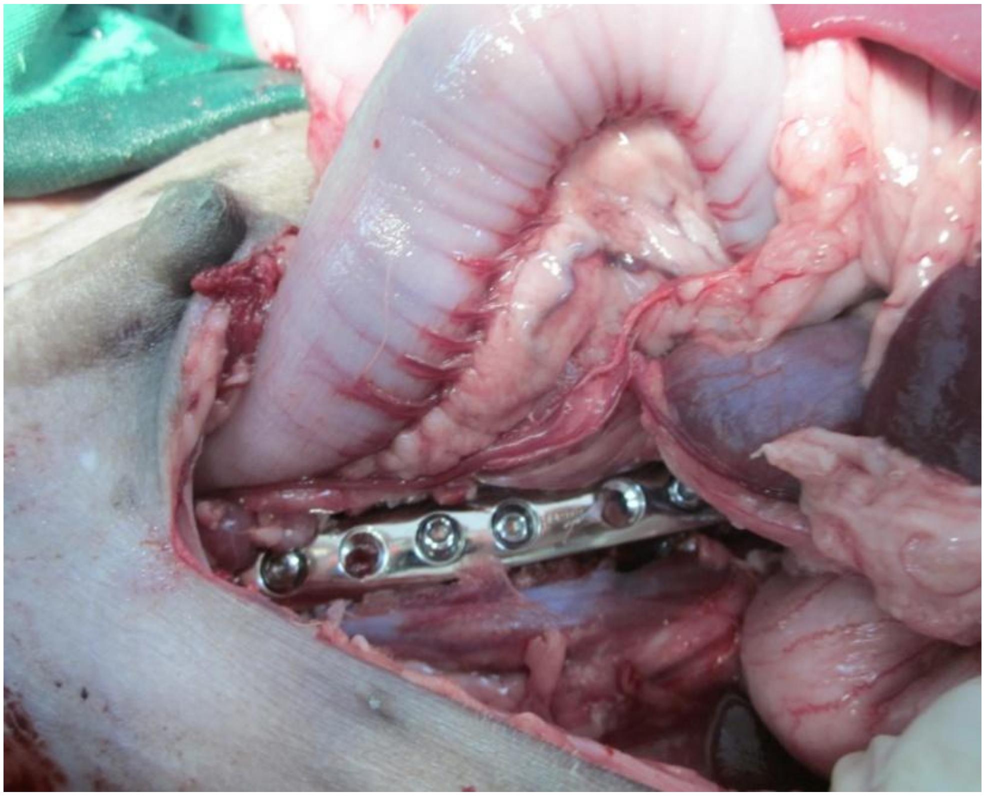


Fig. 27: Photograph showing complete fixation of the bone plate

Fig. 28: Photograph showing closure of linae-alba using polyglactin 910 suture material

Sub cutaneous tissue was opposed using chromic catgut No-0 (Trugut™, Sutures India Private Limited, Bangalore) in a simple continuous fashion. Skin was closed using polyamide No 1-0 (Trulon™, Sutures India, Bangalore) sutures in a horizontal mattress pattern (Fig. 29).

3.6.3 Post operative care.

Injection Amoxycillin – clavulanate potassium (Augmentin®, GlaxoSmithKline pharmaceuticals Limited, Mumbai) at the rate of 20mg/kg twice a day I/V for seven post-operative days, injection Meloxicam (Melonex®, Intas Pharmaceuticals private Limited, Ahmedabad) at the rate of 0.2 mg/kg I/M once a day for three days and injection of vitamin B1, B6, B12 (Tribivet®, Intas Pharmaceuticals private Limited, Ahmedabad) 2ml per day I/M for seven days were given. Wound was dressed on alternate days by swabbing the suture line with surgical spirit followed by tincture iodine solution and application of povidone iodine ointment, and sterile gauze pads were applied with adhesive tapes.

The urinary bladder was cathetrized and the catheter was left in-situ by anchoring it to the tip of the penis for a period of five to seven days or till the dogs got control over the bladder function. The dogs were secured on a grilled cot with soft bedding at pressure points with help of plastic belts (Fig. 30) in order to restrict the movement of the spine for seven to ten days.

The dogs were turned over or sides were changed three to four times daily till they were able to turn on their own, which prevented formation of decubital ulcers and hypostatic congestion of lungs.

Fig. 29: Photograph showing closure of skin incision

Fig. 30: Photograph showing restricting the movement of the spine

Passive physiotherapy was started from the third postoperative day in the form of massaging of the hind limb muscles and flexion and extension of the joints for ten minutes twice daily. Physiotherapy was also done using Infrared rays for 15 min twice daily. All the dogs were put on wheel cart from day 15 onwards to improve the muscle tone and stimulate footpad for improvement of proprioception (Fig. 31a, 31b).

3.7 Postoperative parameters studied

3.7.1 Clinical evaluation

Rectal temperature, respiratory rate, and heart rate were recorded on 0, 3, 5, 7, 15, 30, 45 and 60 Post-operative day in all dogs.

3.7.2 Neurological evaluation

All the dogs were evaluated for improvement in locomotor status, conscious proprioception and other reflexes on 0, 3, 5, 7, 15, 30, 45 and 60 days post operatively.

3.7.3 Radiographic evaluation

All the dogs were evaluated for radiographic improvement by survey radiography in fracture healing and to assess the status of implants on 0, 7, 15, 30, 45, 60 days post operatively.

3.7.4 Collection of blood

Five ml of blood was collected from saphenous vein in each animal, of which 2.5 ml blood was collected in EDTA vials at 0, 3, 5, 7, 15, 30, 45 and 60 days after surgery for haematological studies and remaining 2.5 ml blood was used for biochemical studies.

Fig. 31a: Photograph showing rehabilitation of the dog by using wheel cart

Fig. 31b: Photograph showing rehabilitation of the dog by using wheel cart

3.7.5 Laboratory examination

3.7.5.1 Haematological studies.

Haemoglobin (g/dl), total erythrocyte count (millions/cmm), total leukocyte count (thousands/cmm), packed cell volume (%) were estimated on 0, 3, 5, 7, 15, 30, 45 and 60 days post operatively and blood smear for differential leukocyte count was stained with Giemsa stain and 100 cells were counted using battlement method.

3.7.5.2 Biochemical studies

Biochemical parameters namely serum inorganic calcium, phosphorus, potassium and serum enzymes like serum alkaline phosphatase, Serum alanine amino transferase (ALT) and Serum aspartate amino transferase (AST) were estimated on 0, 3, 5, 7, 15, 30, 45 and 60 days.

3.8 Statistical analysis

All the results of clinical, hematological and biochemical parameters were statistically analyzed using one way Analysis of variance with more than observation per cell and means for the respective periods were tested by Dunnets post hoc test as described by Snedecor and Cochran (1996).

Results

IV. RESULTS

The efficacy of ventral plate fixation for lumbar spinal injuries was evaluated in six clinical cases of dogs presented to the Department of Veterinary Surgery and Radiology, Veterinary College Hospital, Hebbal, Bangalore from April 2012 to March 2013 and results of the study are as follows.

4.1 Occurrence

Totally 10,043 cases were presented to veterinary college hospital during April 2012 to March 2013. Of these 432 (4.30 %) cases had posterior paralysis. Among 432 cases, 208 were dogs (48.1%). Among 208 dogs, 35 cases had spinal fractures with an overall occurrence of 0.34 % (Fig.32).

4.1.1 Gender-wise occurrence

Among 35 cases 27 were males (77.14 %) and 08 were females (22.85 %) (Fig. 33).

4.1.1.2 Breed-wise occurrence

Breed wise occurrence was highest in non descriptive dogs i.e 12 (34.28%) followed by Labrador Retriever 7 (20%), Pomeranian 6 (17.14%), German Shepherd Dog 4 (11.42%), Doberman pinscher 3 (8.57%) and Dachshund 3 (8.57%) (Fig. 34).

Fig. 32: Graph showing occurrence of spinal fractures in dogs.

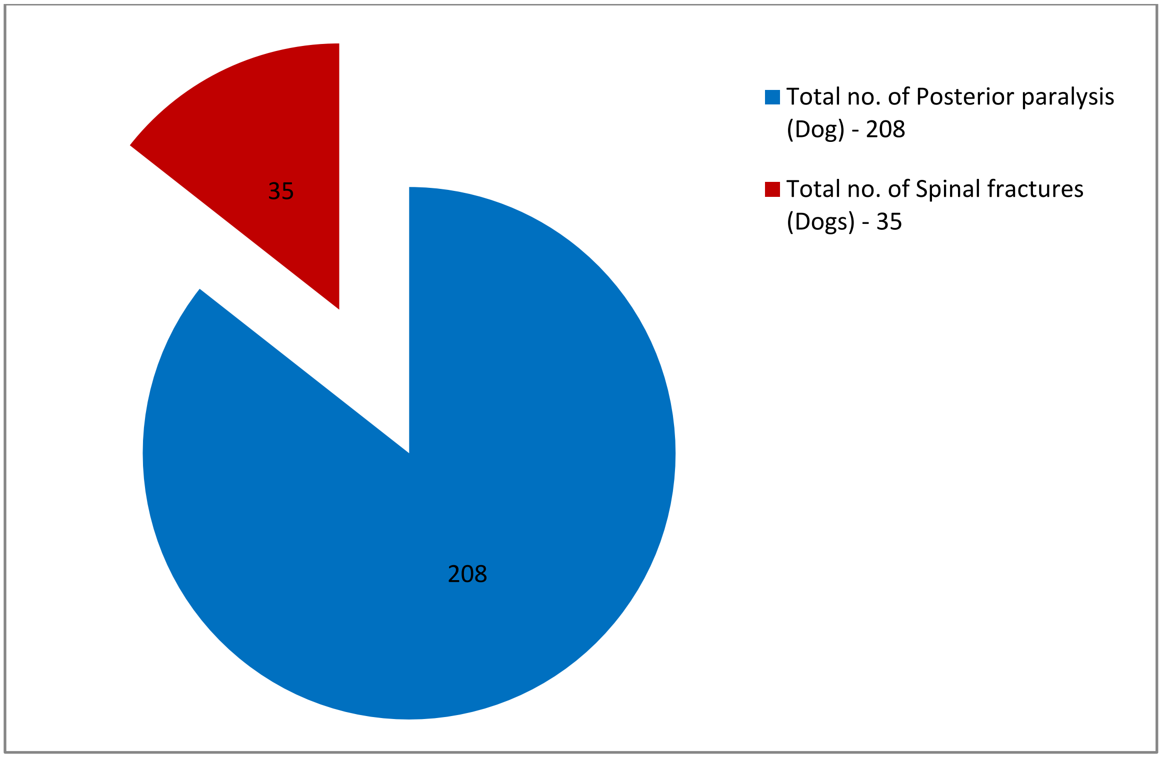


Fig. 33: Graph sex-wise distribution of spinal fractures in dogs.

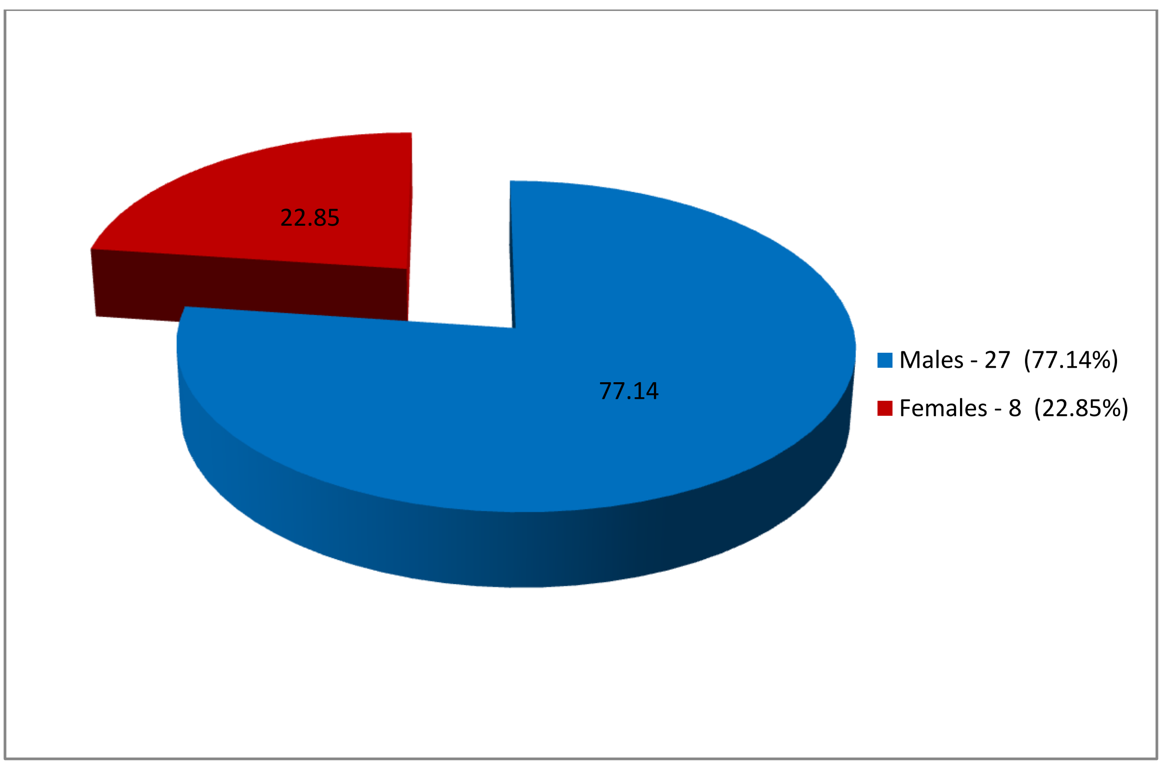


Fig. 34: Graph showing breed-wise distribution of spinal fractures in dogs

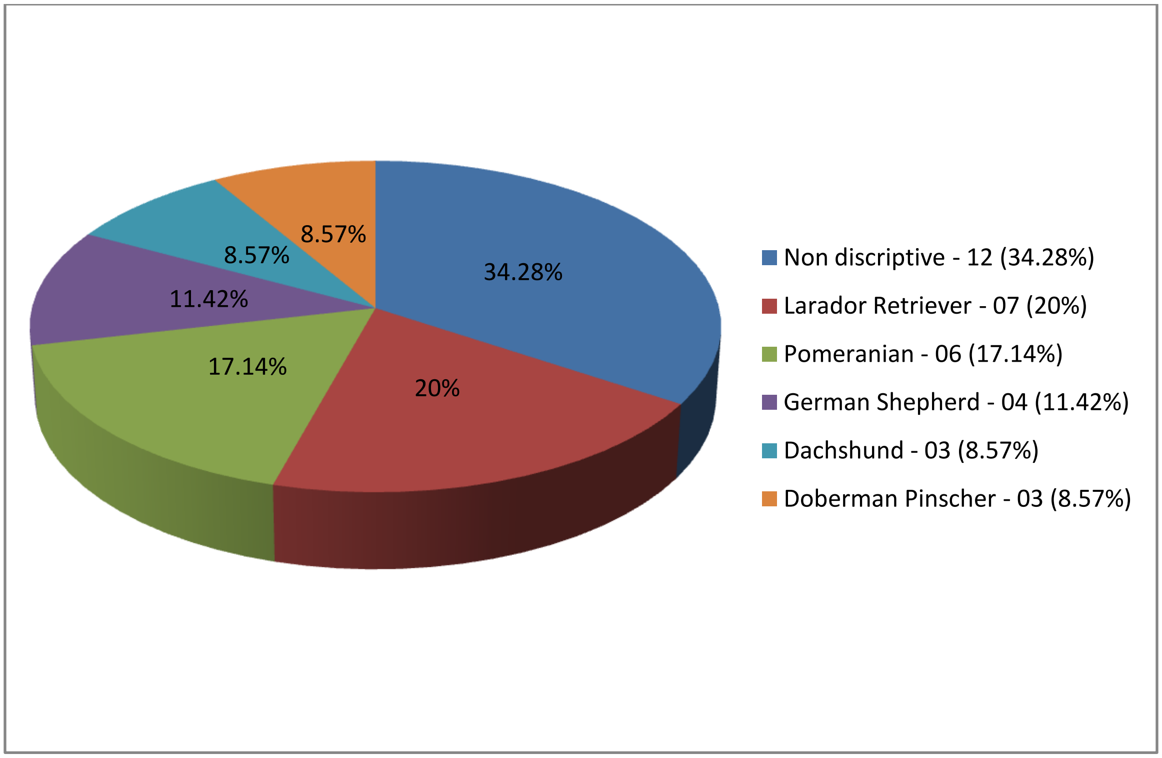
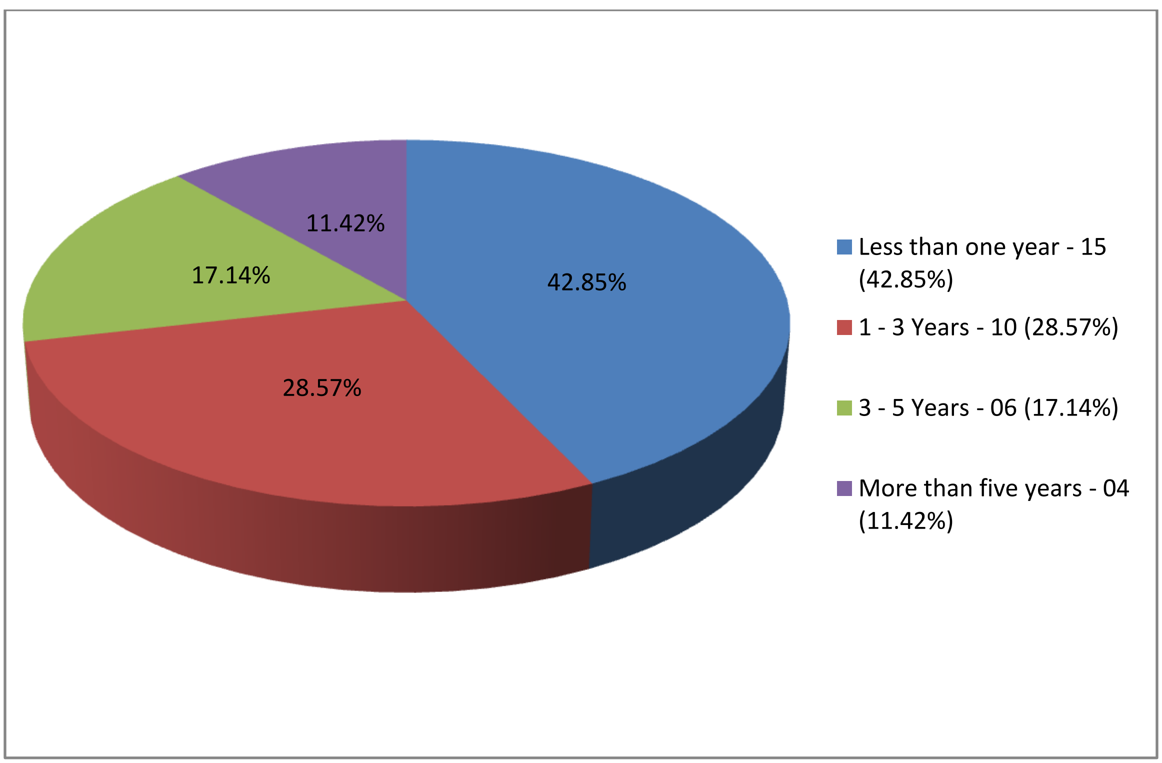


Fig. 35: Graph showing Age-wise distribution of spinal fractures in dogs



4.1.1.3 Age wise occurrence

The age-wise occurrence indicated that 15 dogs (42.85%) were within one year of age, 10 (28.57 %) were between one to three years, 6 (17.14%) were between three to five years, and 4 (11.42%) were more than five years of age (Fig.35).

4.1.2 Prospective study

Breeds selected for the six cases of spinal injuries exhibiting posterior paralysis included non-descript (4), Labrador (1) and German shepherd (1). The age of the animals ranged from 4 months to 3 years. The dogs selected for the study weighed between 4 kg to 32 kgs. Among those animals affected 5 (83.33%) were males and 1 (16.66%) was female (Table 1).

4.2 Grading of animals

In the present study, Griffith's scale of grading system is adopted and all the dogs are graded on the day of presentation of the case.

Griffith in 1982 graded the severity of spinal cord damage in 5 grades as:

Grade 1 - Pain only.

Grade 2 - Ataxia, conscious proprioceptive deficit and paraparesis.

Grade 3 - Paraplegia.

Grade 4 - Paraplegia with urine retention and overflow.

Grade 5 - Paraplegia, urine retention and overflow and loss of deep pain sensation

All the six dogs selected for the study were with grade 3 - 4 dysfunction only.

Table 1: Details of paraplegic dogs selected for the study

CASE NO.	BREED	AGE	SEX	BODY WEIGHT (Kg)	CAUSE OF FRACTURE	FRACTURE SITE
1	Non descript	11m	Male	12	Automobile accident	L_5
2	Non descript	4m	Male	7	Dog bite	L_3
3	Non descript	1yr 6 m	Male	15	Human attack	L_5
4	Non descript	2 yrs	Male	18	Automobile accident	L_3
5	Labrador	3 yrs	Female	32	Automobile accident	L_4
6	German Shepherd Dog	7m	Male	14	Fall from height	L_4

One dog was graded three while the remaining had complete recovery by 60th post-operative day.

4.3 Physical examination

4.3.1 Palpation of spine:

Palpation of affected part of spine elicited pain in five dogs (83.33 %) whereas the other one dog (16.66%) did not elicit pain on palpation of the spine. One dog with dog bite had clear bite marks on the affected site.

4.3.2 Palpation of bladder

Two dogs had UMN bladders at the time of presentation while four had LMN bladder. One female dog had cloudy urine with flakes of pus on the day of presentation indicating cystitis. However, the urine cleared in three days after antibiotic therapy was initiated. All the dogs showed normal bladder function by 15^{th} post operative day (Table 2).

4.4 Neurological examination

4.4.1 Attitude, posture, and gait

On the day of presentation, among six dogs, five dogs were alert and one dog showed depressed attitude. Five dogs presented were in sitting posture and one dog was recumbent, all dogs had ability to drag their hind quarter. At the end of the study period five dogs had clinical recovery and one did not recover till the end of the study period (Table 3).

Table 2: Bladder functioning in the dogs selected for the study.

Sl. No.	Days							
	0 day	**3 day**	**5 day**	**7^{th} day**	**15^{th} day**	**30^{th} day**	**45^{th} day**	**60^{th} day**
1	LMNB	LMNB	LMNB	NB	NB	NB	NB	NB
2	UNMB	UNMB	UNMB	NB	NB	NB	NB	NB
3	LMNB	LMNB	LMNB	NB	NB	NB	NB	NB
4	UMNB	UMNB	UMNB	NB	NB	NB	NB	NB
5	LMNB	LMNB	LMNB	LMNB	NB	NB	NB	NB
6	LMNB	LMNB	LMNB	NB	NB	NB	NB	NB

LMNB- Lower Motor Neuron Bladder,

UMNB- Upper Motor Neuron Bladder

NB- Normal Bladder

Table 3: Attitude, posture and gait in dogs subjected to Ventral Plate Technique for Lumbar spinal stabilization

Dog No.	Attitude								Posture								Gait							
	Days								Days								Days							
	0	3	5	7	15	30	45	60	0	3	5	7	15	30	45	60	0	3	5	7	15	30	45	60
1	A	A	A	A	A	A	A	A	++	++	++	++	++	++++	++++	++++	+	+	+	++	+++	+++	+++	+++
2	A	A	A	A	A	A	A	A	++	++	++	++	+++	++++	++++	++++	+	+	+	+	+++	+++	+++	+++
3	A	A	A	A	A	A	A	A	++	++	++	++	++	++++	++++	++++	+	+	+	+	++	+++	+++	+++
4	A	D	A	A	A	A	A	A	++	++	++	++	+++	+++	++++	++++	+	+	+	+	++	++	+++	+++
5	D	A	A	A	A	A	A	A	+	+	+	++	++	++	++	+++	+	+	+	+	+	+	++	++
6	A	A	A	A	A	A	A	A	++	++	++	++	+++	++++	++++	++++	+	+	+	++	++	+++	+++	+++

ATTITUDE

A- Alert
D-Depressed

POSTURE

+ Recumbent
++ Sitting
+++ Stand with help
++++ Stand on its own

GAIT

+ Dragging of hindquarters
++ Ataxia
+++ Normal

4.4.2 Locomotor status.

All dogs were paraplegic on the day of presentation. Four dogs became ambulatory during 15th post-operative day onwards and one dog became ambulatory after 30th postoperative day. One dog did not recover till the end of study period (Table 4) (Fig 36-43).

4.4.3 Conscious proprioception

On the day of presentation, all the dogs had conscious proprioception deficit. Later five dogs regained proprioception and one dog did not recover till the end of study period (Table 4).

4.4.4 Deep pain sensation

All six dogs had deep pain sensation on the day of presentation. At the end of the study period five dogs had clinical recovery and one dog did not recover till the end of study period.

4.4.5 Panniculus reflex

On the day of presentation two dogs had panniculus reflex caudal to the site of injury on either side of the vertebral column. Two dogs had reduced or sluggish panniculus reflex caudal to the site of injury on either side of the vertebral column. Two dogs did not have panniculus reflex caudal to the site of injury on either side of the vertebral column. Five dogs had regained normal panniculus reflex during different post operative days (Table 5).

Table 4: Locomotor status, Conscious proprioception in dogs subjected to ventral Plate technique for lumbar spinal stabilization

Dog no	Locomotor status								Conscious proprioception															
	Days								Days															
	0	3	5	7	15	30	45	60	0		3		5		7		15		30		45		60	
									L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
1	+	+	++	++	+++	+++	+++		-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+
2	+	+	++	++	+++	+++	+++		-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+
3	+	+	++	++	+++	+++	+++		-	-	-	-	-	-	-	-	+	-	+	+	+	+	+	+
4	+	+	++	++	++	+++	+++		-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+
5	+	+	+	+	++	++	++		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	+	+	++	++	+++	+++	+++		-	-	-	-	-	-	-	-		+	-	+	+	+	+	+

Locomotor status

\+ Paraplegia

++ Paraparesis

+++Ambulatory

Conscious proprioception

\+ Present

\- Absent

L: Left hind limb

R: Right hind limb

Table 5: Panniculus reflex in dogs subjected to Ventral Plate Technique for Lumbar spinal stabilization

Panniculus reflex																
Dog No.	Days															
	0		3		5		7		15		30		45		60	
	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
1	+	+	+	+	+	+	+	+	+	+	++	++	++	++	++	++
2	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
3	+	+	+	+	+	+	+	+	+	+	++	++	++	++	++	++
4	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	+	+	+	+	+	+	+	++	++	++	++	++

Panniculus reflex

- Absent　　**L**: Left hindlimb

+ Reduced　　**R**: Right hindlimb

++ Normal

Fig. 36: Pre operative photograph showing the sitting posture of the dog

Fig. 37: Photograph showing the dog secured to the grilled cot on PO day - 3

Fig. 38: Photograph showing the dog secured to the grilled cot with catheter insitu PO day - 5

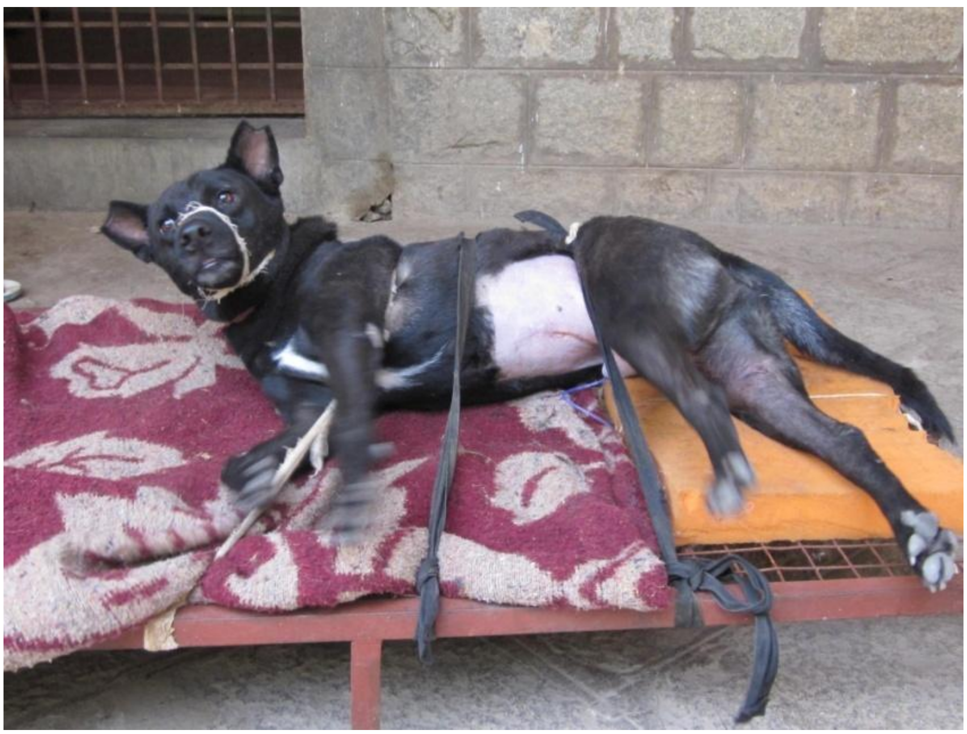


Fig. 39: Photograph showing the dog secured to the grilled cot showing movement of hind limb PO day- 7

Fig. 40: Photograph showing the dog is able to bear weight but still has proprioceptive deficit PO day - 15

Fig. 41: Photograph showing the dog is able to bear weight with abducted limbs PO day - 30

Fig. 42: Photograph showing the dog with normal stance PO day - 45

Fig. 43: Photograph showing good weight bearing on hind limbs PO day - 60

4.4.6 Patellar reflex

On the day of presentation, patellar reflex was sluggish or reduced in three dogs and abssent in one dog and it was increased in two dogs. Of these, five dogs had normal patellar reflex after the end of the study period and one dog did not recover till the end of study period (Table 6).

4.4.7 Flexor reflex

On the day of presentation, three dogs had reduced or sluggish flexor reflex in both hind limbs, while it was absent in other three dogs. Of these three dogs two dogs regained normal flexor reflex in both hind limbs during post-operative days and at the end of the study period, a total of five dogs had normal flexor reflex in both hind limbs and one dog did not gain the reflex till the end of study period (Table 7).

4.4.8 Anal sphincter reflex

On the day of presentation, four dogs had reduced anal sphincter reflex while it was absent in two dogs. Among four two dogs gained normal reflex from fourth post operative day itself. All dogs regained normal anal sphincter reflex at the end of the study period (Table 7).

Table 6: Patellar reflex in dogs subjected to Ventral Plate Technique for Lumbar spinal stabilization

Patellar reflex																
Dog No	**Days**															
	0		**3**		**5**		**7**		**15**		**30**		**45**		**60**	
	L	**R**	**L**	**R**	**L**	**R**	**L**	**R**	**L**	**R**	**L**	**R**	**L**	**R**	**L**	**R**
1	+++	+++	+++	+++	+++	+++	+++	+++	++	++	++	++	++	++	++	++
2	+	+	+	+	+	+	+	+	++	++	++	++	++	++	++	++
3	+++	+++	+++	+++	+++	+++	+++	++	++	++	++	++	++	++	++	++
4	++	++	++	++	++	++	++	++	++	+	++	++	++	++	++	++
5	+++	+++	+++	+++	+++	+++	+++	+++	+	+	+	+	+	+	+	+
6	+++	+++	+++	+++	+++	+++	+++	+++	++	+	++	++	++	++	++	++

Patellar reflex

- Absent
\+ Reduced
++ Normal
+++ Increased

L: Left hindlimb
R: Right hindlimb

Table 7: Flexor reflex, anal sphincter reflex in dogs subjected to Locking Plate Technique for spinal stabilization

Dog No.	Flexor reflex																Anal sphincter reflex							
	Days																Days							
	0		3		5		7		15		30		45		60		0	3	5	7	15	30	45	60
	L	**R**	**L**	**R**	**L**	**R**	**L**	**R**	**L**	**R**	**L**	**R**	**L**	**R**	**L**	**R**								
1	+	+	+	+	+	+	+	+	+	+	++	++	++	++	++	++	+	+	++	++	++	++	++	++
2	-	-	-	-	-	-	+	+	+	+	++	++	++	++	++	++	+	+	+	+	++	++	++	++
3	+	+	+	+	+	+	+	+	++	++	++	++	++	++	++	++	+	+	++	++	++	++	++	++
4	-	-	-	-	-	-	+	-	+	+	++	+	++	++	++	++	-	-	+	+	++	++	++	++
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	++	++	++
6	+	+	+	+	+	+	+	+	++	+	++	++	++	++	++	++	+	+	+	+	++	++	++	++

Flexor reflex

- Absent

\+ Reduced

++ Normal

Anal sphincter reflex

- Absent

\+ Reduced

++ Normal

4.5 Radiographic examination

4.5.1 Pre and Post operative radiography

On preoperative survey radiography two dogs had L_3 fracture and luxation, two dogs had fracture at L_4, two dogs had fracture at L_5 (Fig. 44 and 45).

Post operative survey radiography revealed normal anatomical alignment of vertebral segments and proper positioning of the plate and screws in all six cases after the bone plate fixation. In one dog screw loosening was evident in radiograph taken on 7^{th} post operative day.

4.5.2 Myelography

Myelography by cisterna magna puncture was performed successfully in all the six animals. The anesthetic protocol used provided adequate restraining during Myelography. Usage of Iohexol at the dose rate 80mg/Kg body weight in the study provided excellent contrast for demarcation of spinal cord on myelogram. In all the six dogs contrast material had stopped anterior to the fracture site. Keeping the dogs in slant position of 15^0 with the elevation of head promoted the caudal flow of Iohexol and prevented its flow anteriorly. None of the dogs in the study showed post-myelographic complications like seizures. All of the dogs made uneventful recovery from anaesthesia (Fig. 46 - 49).

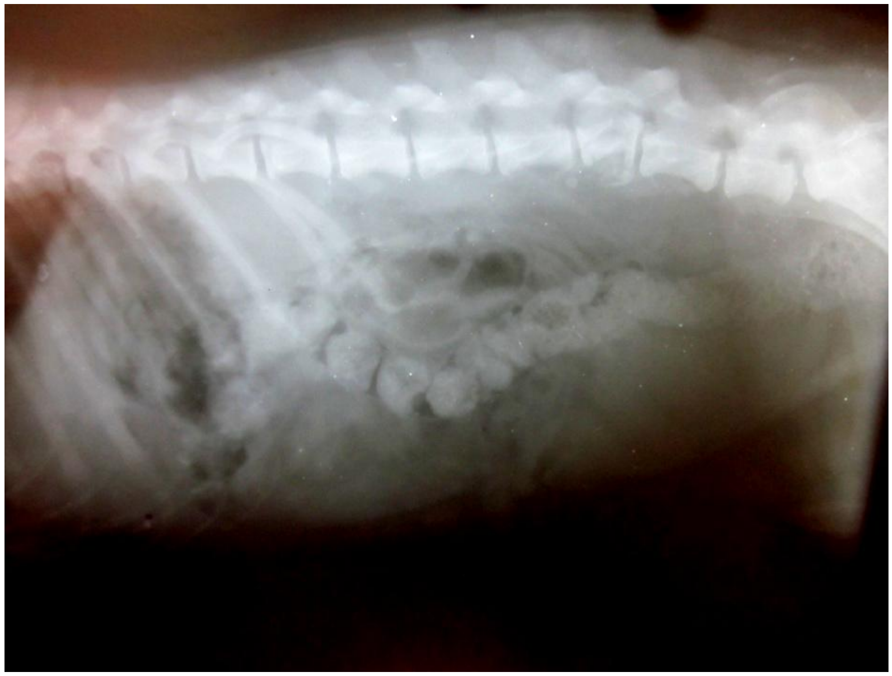


Fig. 44: Radiograph of lumbar spine (lateral view) showing fracture and dislocation of L_5 preoperatively

Fig. 45: Radiograph of lumbar spine (Ventrodorsal view) showing fracture and dislocation of L_5 preoperatively

Fig. 46: Myelography of Cervical region (15min) showing passage of the contrast material in the cervical region

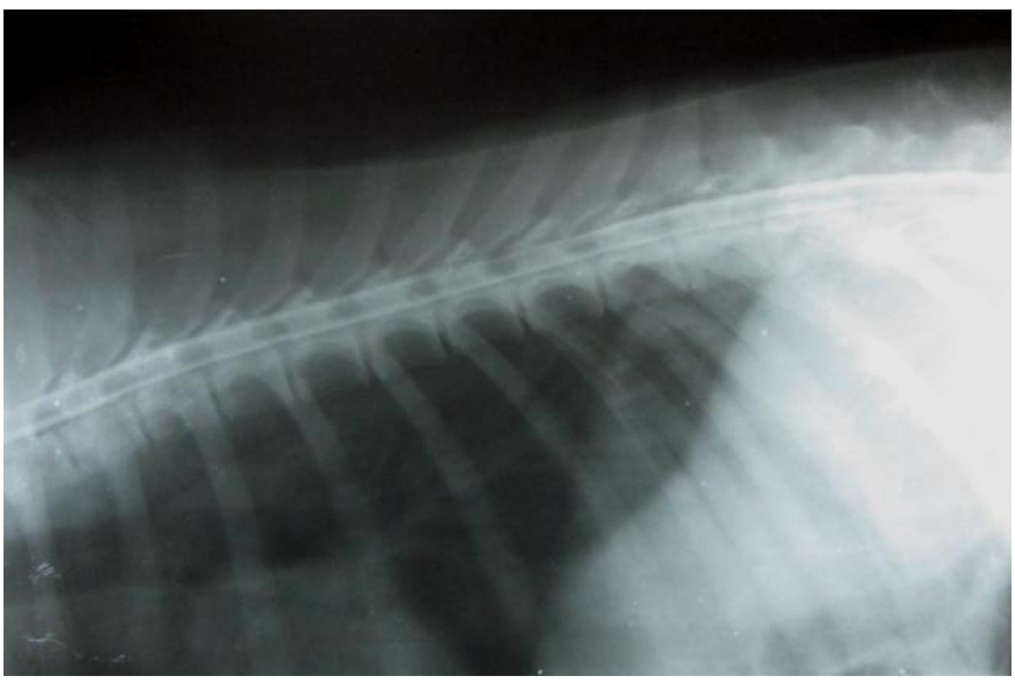


Fig. 47: Myelography of Thoracic region (30min) showing passage of the contrast material in the thoracic region

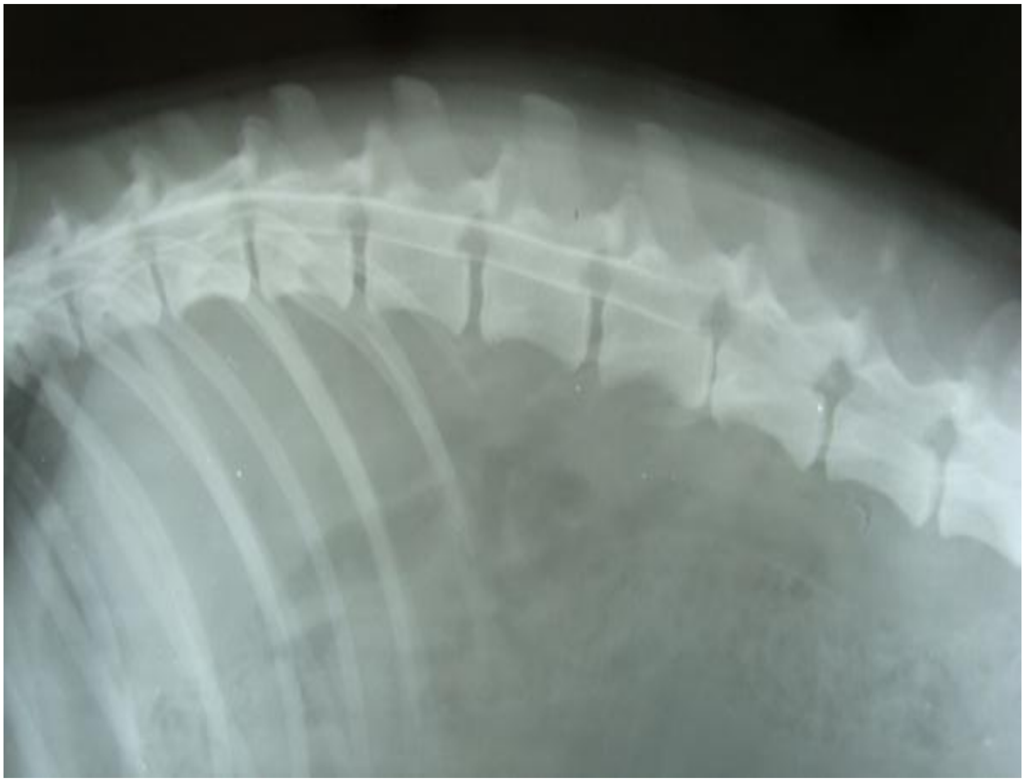


Fig. 48: Myelography of Thoraco-lumbar region (45 min) showing passage of the contrast material in to the lumbar region.

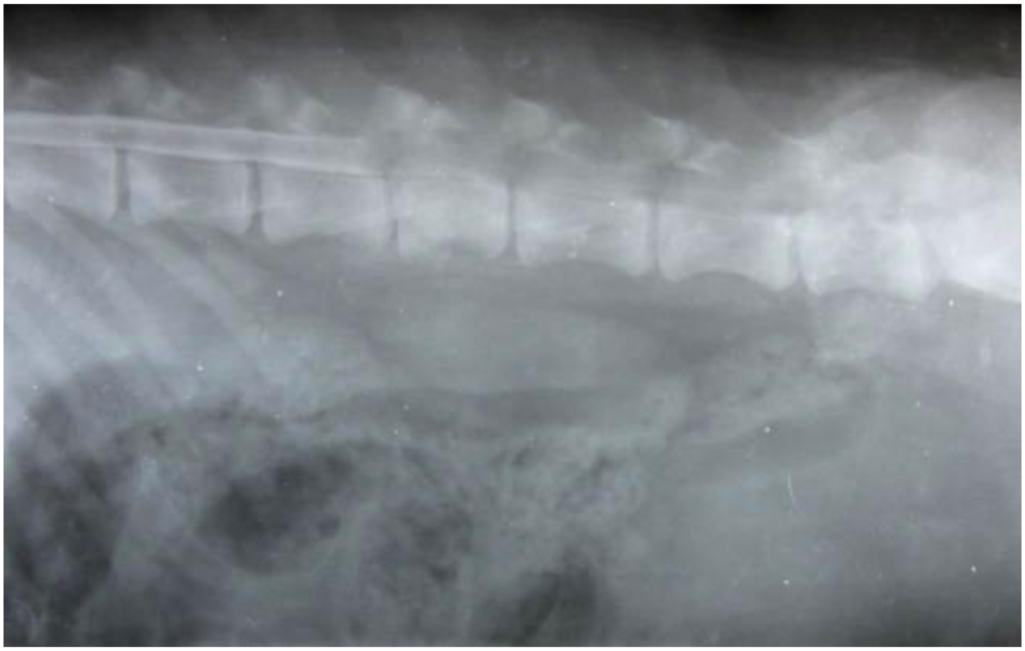


Fig. 49: Myelography of Lumbar region (60 min) showing stoppage of the contrast material at L_4 vertebra

4.6 Surgical treatment

4.6.1 Pre-operative preparations

Withholding of food for 12 hours and water for six hours pre-operatively in dogs prevented complications like vomition and aspiration during the surgery. The extensive shaving of hair and aseptic preparations prevented contamination of the surgical site during surgery. Pre-operative administration of the antibiotic was helpful in reducing chances of intra-operative infection of the surgical site. Giving Enema previous night helped in complete evacuation of fecal material and thereby easy exteriorization of viscera and easy visualization of injured area. Premedication with atropine was adequate for prevention of excessive salivation and facilitated easy tracheal intubation. Diazepam provided satisfactory muscle relaxation for surgery in all cases. Induction with thiopentone and maintenance with isoflurane 2% provided adequate anesthesia for successful completion of surgery without any complication in all cases.

4.6.2 Surgical procedure

Placing the dogs in dorsal recumbency and securing the limbs to the table enabled proper skin incision and easy identification of linea-alba. Proper positioning played an important role in reduction of the fracture and fixing the bone plate. Frequent pouring of normal saline over the exteriorized viscera was effective in preventing the dryness of the viscera. Reduction of fracture was achieved manually in five dogs whereas one dog required the assistant to raise the vertebral column from underneath. Sublumbar fat interfered too much in locating and reducing the fracture in one dog. Bone plates selected with appropriate screws provided optimum stabilization for the lumbar spine.

Identification of the intervertebral space was easy as it appeared like shiny white raised area and therefore in none of the dogs screws were put into the intervertebral space. Dorsal laminectomy was performed in two dogs to decompress the spinal cord (Fig. 50, 51)

4.6.3 Postoperative care

Amoxicillin with clavulanate potassium was found to be highly effective in the prevention of infection in all of the dogs. However, two dogs had mild purulent discharge evident at the dorsal laminectomy site during the first post-operative week. Addition of gentamicin to the normal saline solution used for flushing helped in the resolution of the condition within three days. The method of dressing adopted was also found to be efficient in keeping the surgical site clean and preventing infection. Indwelling catheterization of bladder helped continuous evacuation of bladder and helped in early restoration of bladder function control. Restricting the movement of the spine by securing the dogs to the grilled cot with soft bedding was helpful in preventing implant loosening, urine scalding, and decubital ulcers. Turning of the dogs every two to three hours as long as they were paraplegic and providing soft bedding were effective in preventing formation of decubital ulcers.

The treatment undertaken like providing extra bedding, regular cleaning of wound with pavodine iodine liquid, application of fly repellent spray for the already formed decubital ulcers was effective in preventing infection from setting in and assisting the healing of the ulcers when the dogs became ambulatory. Passive physiotherapy that

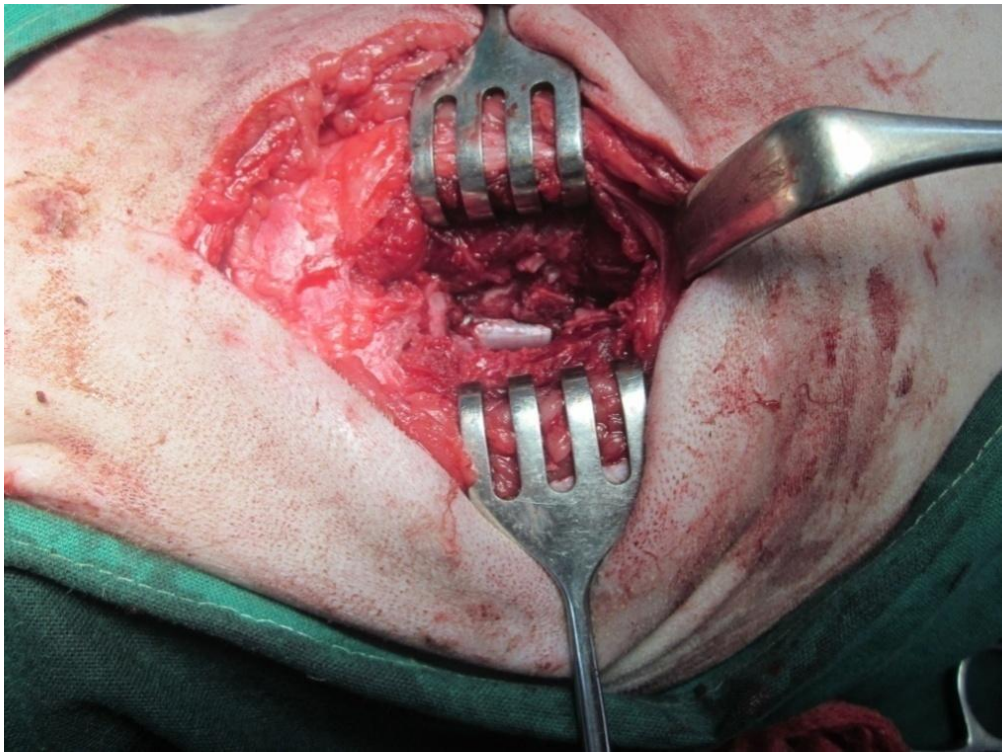


Fig. 50: Photograph showing spinal cord exposed after dorsal laminectomy of Lumbar spine

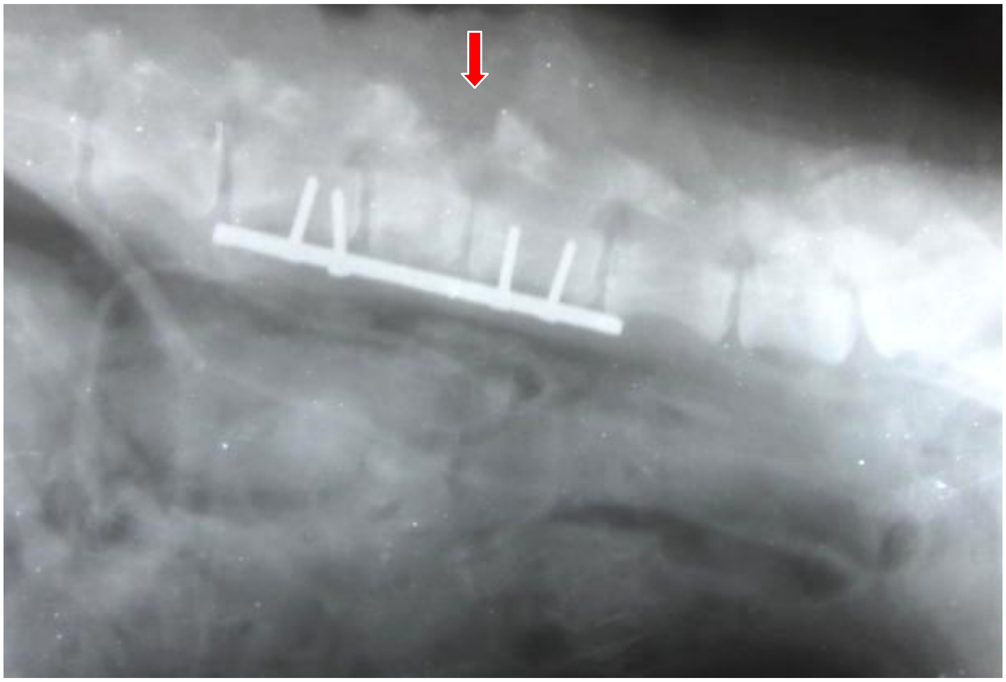


Fig. 51: Radiograph showing ventral plating of lumbar spine with dorsal laminectomy

started from the third post-operative day in the form of massaging of the hind limb muscles and flexion and extension of the joints was highly effective in preventing further atrophy of muscles and keeping the joints mobile. Rehabilitation of all the dogs by putting them on wheel cart from 15th postoperative day helped in early ambulation and improved proprioception.

4.7 Post-operative complications

Screw loosening was observed in one dog on 7th post operative day and a second surgery was done to rectify it. Adhesion at the surgical site was observed. Dog made uneventful recovery thereafter.

4.8 Radiographic evaluation

The assessment of healing of spinal fracture was done by pre and post operative survey radiography.

Day 0

The radiographs obtained preoperatively revealed mid diaphyseal fracture of L_5 vertebra (Fig. 52).

Day 7

Radiographs on 7th post operative day revealed evident fracture gap with no callus formation. There was no change in alignment of fracture segment. Screws and plate were in place (Fig. 53).

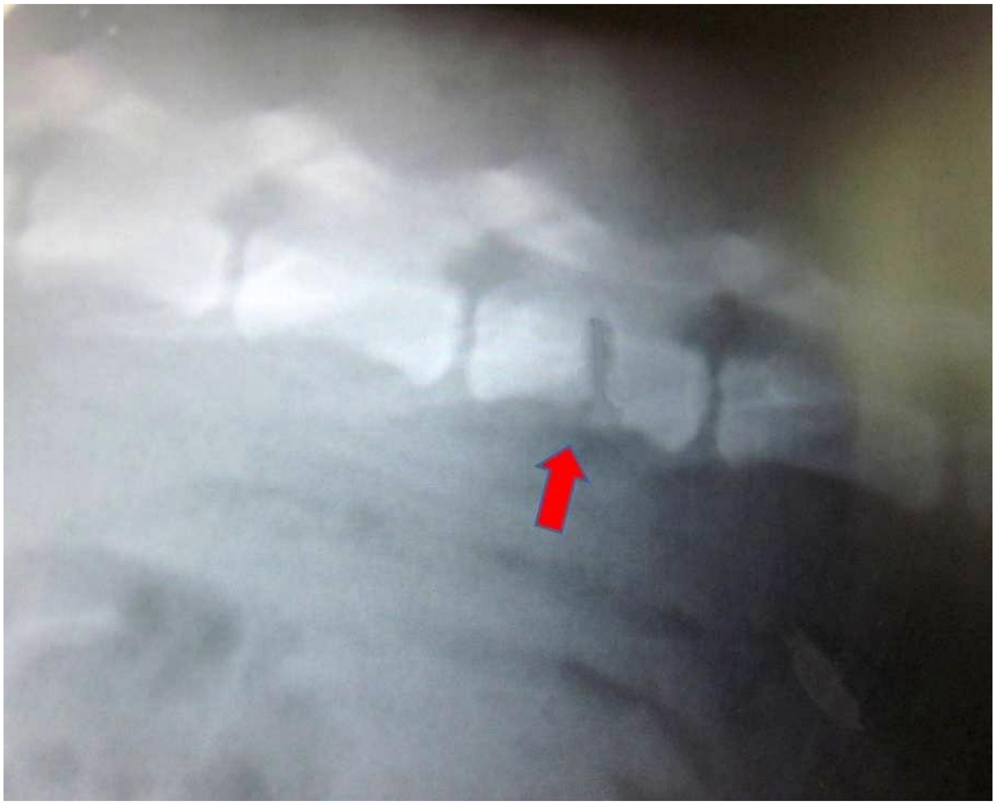


Fig. 52 : Pre operative radiograph showing the fracture site(Red arrow)

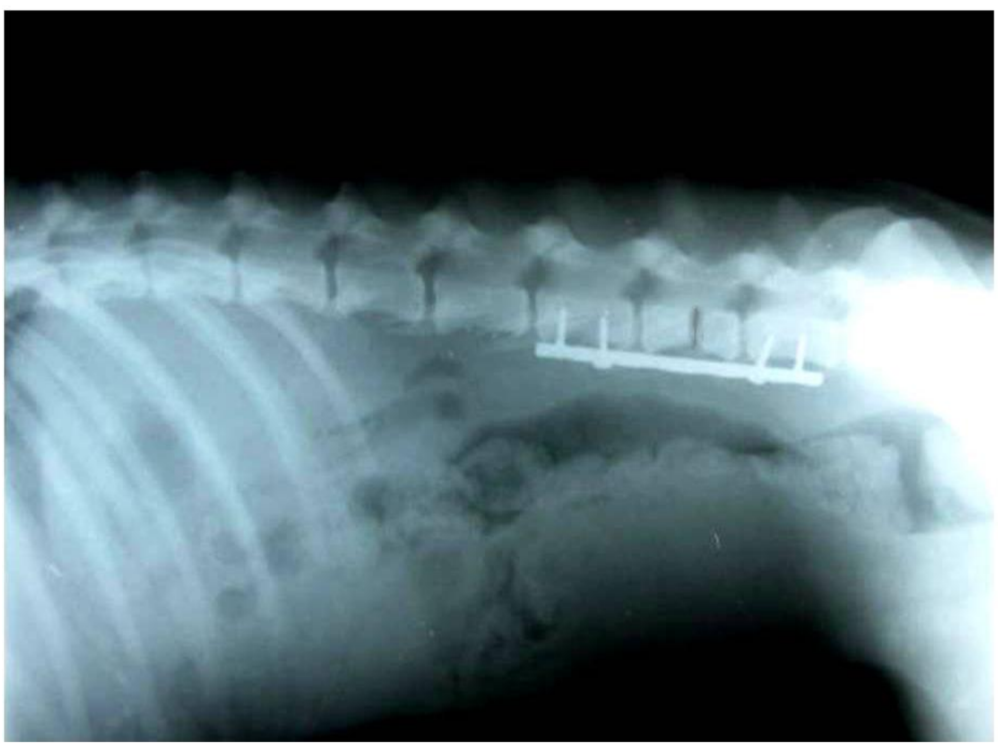


Fig. 53 : post operative radiograph: 7th day

Day 15

Fracture line was visible, plate was in position. No change in alignment of fracture segment was noticed without much mineralized callus (Fig. 54).

Day 30

Mild periosteal reaction at the fracture fragments ends with distinct fracture line (Fig. 55).

Day 45

Periosteal reaction was evident at the fracture fragments with indistinct fracture line (Fig. 56).

Day 60

The observations include completely healed fracture with no evidence of fracture line with complete resorption of the primary callus with complete bony union (Fig. 57).

4.9 Post-operative observation

4.9.1 Clinical evaluation

4.9.1.1 Rectal temperature

The mean rectal temperature (^{0}F) in dogs pre and post surgical value are depicted in Table 8 and Fig. 58. The mean rectal temperature (^{0}F) before and on 3rd, 5th, 7th, 15th, 30th ,45th and 60th post operative days were 100.70 ± 0.34, 101.60 ± 0.19, 101.90 ± 0.23, 101.60 ± 0.09, 101.40 ± 0.04, 101.50 ± 0.07, 101.40 ±0.03 and 101.50 ± 0.04

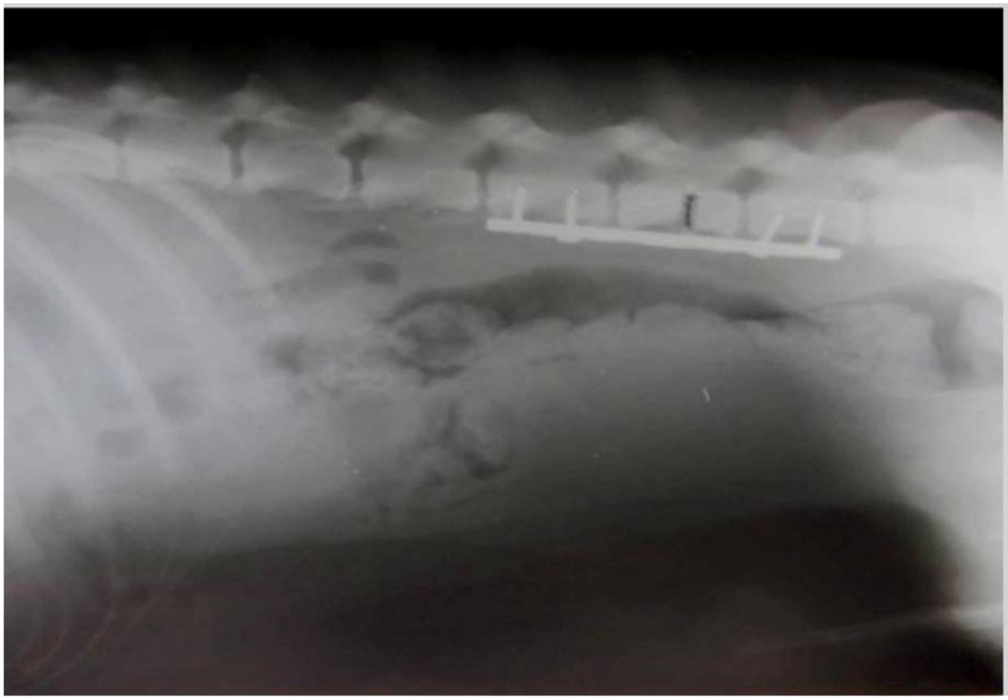


Fig. 54: post operative radiograph: 15th day

Fig. 55: post operative radiograph: 30th day

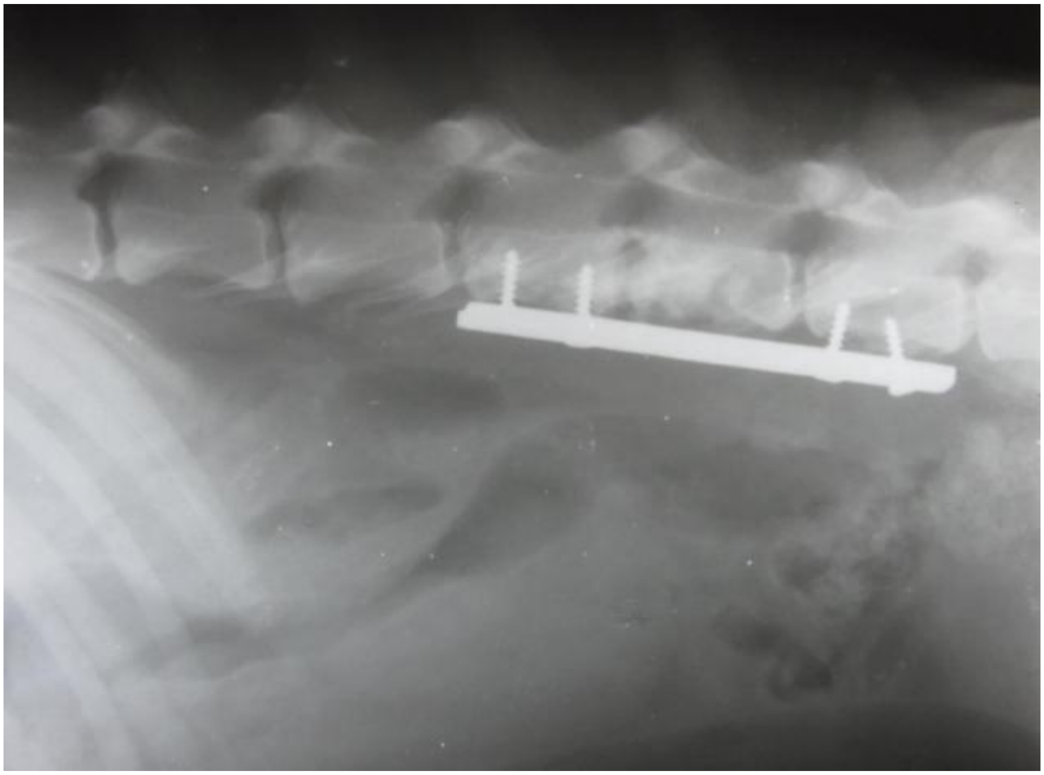


Fig. 56: post operative radiography: 45th day

Fig. 57: post operative radiograph: 60th day

respectively. The mean temperature was elevated on 5th postoperative day. The rectal temperatures were within normal range.

4.9.1.2 Heart rate

The mean Heart Rate (beats/min) before and on 3rd, 5th, 7th, 15th, 30th ,45th and 60th post operative days were 76.83 ± 2.86, 78.83± 1.79, 78.17 ± 1.04, 78.17 ± 1.35, 79.83 ± 1.47, 80.33 ± 1.97, 76.17±0.83 and 76.17±0.83 respectively.Slight increase was observed on 30th postoperative day. The Mean Value of heart rate did not vary significantly throughout the study period and were within normal physiological range. (Table 8 and Fig 59).

4.9.1.3 Respiratory rate

The mean respiration/min before and on 3rd, 5th, 7th, 15th, 30th ,45th and 60th post operative days were 30.17 ± 2.72, 30.50 ± 1.74, 32.17 ± 1.19, 31.50 ± 0.71, 31.83 ± 1.37, 31.67 ± 0.98, 31.17 ± 0.65 and 30.17 ± 0.47 respectively. The mean value of respiratory rate did not vary significantly throughout the study period (Table 8 and Fig 60).

4.10 Haematological studies

4.10.1 Haemoglobin

The mean haemoglobin (g/dl) in dogs before and after surgical procedure is depicted in Table 9 and Fig 61. The mean haemoglobin before and on 3rd, 5th, 7th, 15th, 30th ,45th and 60th post operative days were 12.50 ± 0.21, 12.07 ± 0.12, 12.47 ± 0.17, 12.35 ± 0.19, 12.44 ± 0.26, 12.86 ± 0.14, 12.66 ± 0.16 and 12.70 ± 0.16 respectively. The ariations in mean value of haemoglobin (g/dl) level were statistically not significant ($P \leq 0.05$).

Table 8: Rectal temperature, Heart rate and Respiratory rate in dogs subjected to ventral plate fixation technique for lumbar spine stabilization

Days	Rectal temperature (^{0}F) Mean±SE	Heart rate (beats/min) Mean±SE	Respiratory rate (/min) Mean±SE
0 day	100.70 ± 0.34	76.83 ± 2.86	30.17 ± 2.72
3rd day	101.60 ± 0.19	78.83± 1.79	30.50 ± 1.74
5th day	101.90 ± 0.23	78.17 ± 1.04	32.17 ± 1.19
7th day	101.60 ± 0.09	78.17 ± 1.35	31.50 ± 0.71
15th day	101.40 ± 0.04	79.83 ± 1.47	31.83 ± 1.37
30th day	101.50 ± 0.07	80.33 ± 1.97	31.67 ± 0.98
45th day	101.40 ±0.03	76.17±0.83	31.17 ± 0.65
60th day	101.50 ± 0.04	76.17±0.83	30.17 ± 0.47

Fig. 58 : Graph showing Rectal temperature in dogs subjected to ventral plate fixation technique for lumbar spine stabilization.

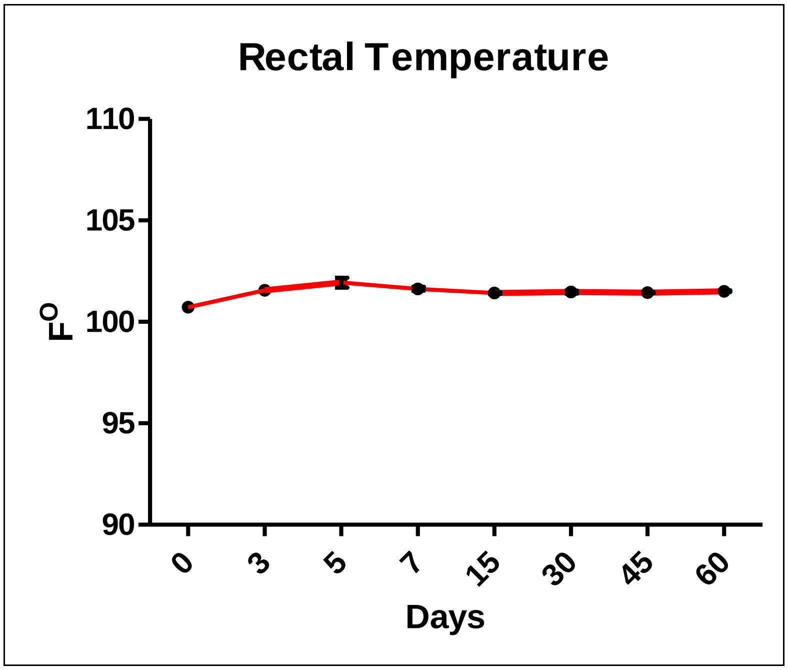


Fig. 59 : Graph showing Heart rate in dogs subjected to ventral plate fixation technique for lumbar spine stabilization.

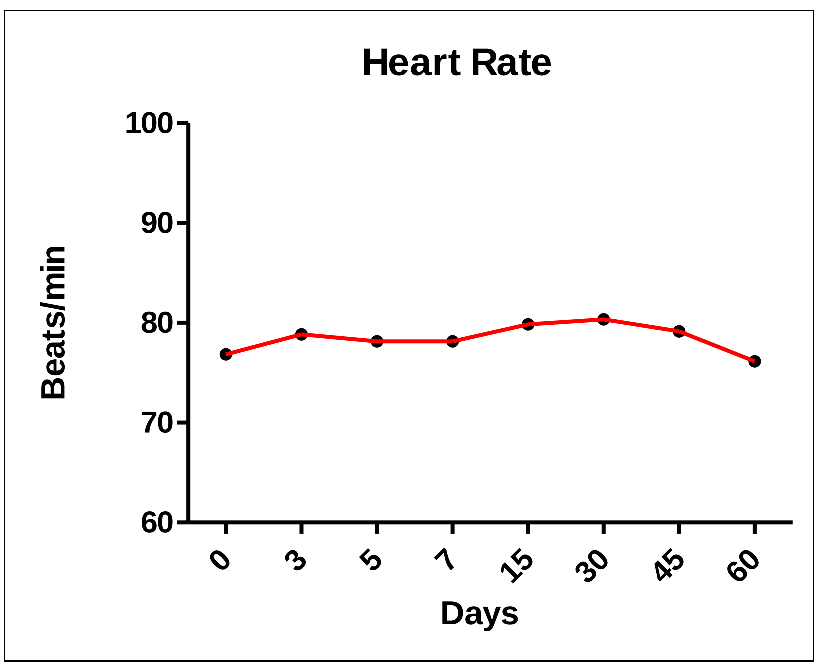
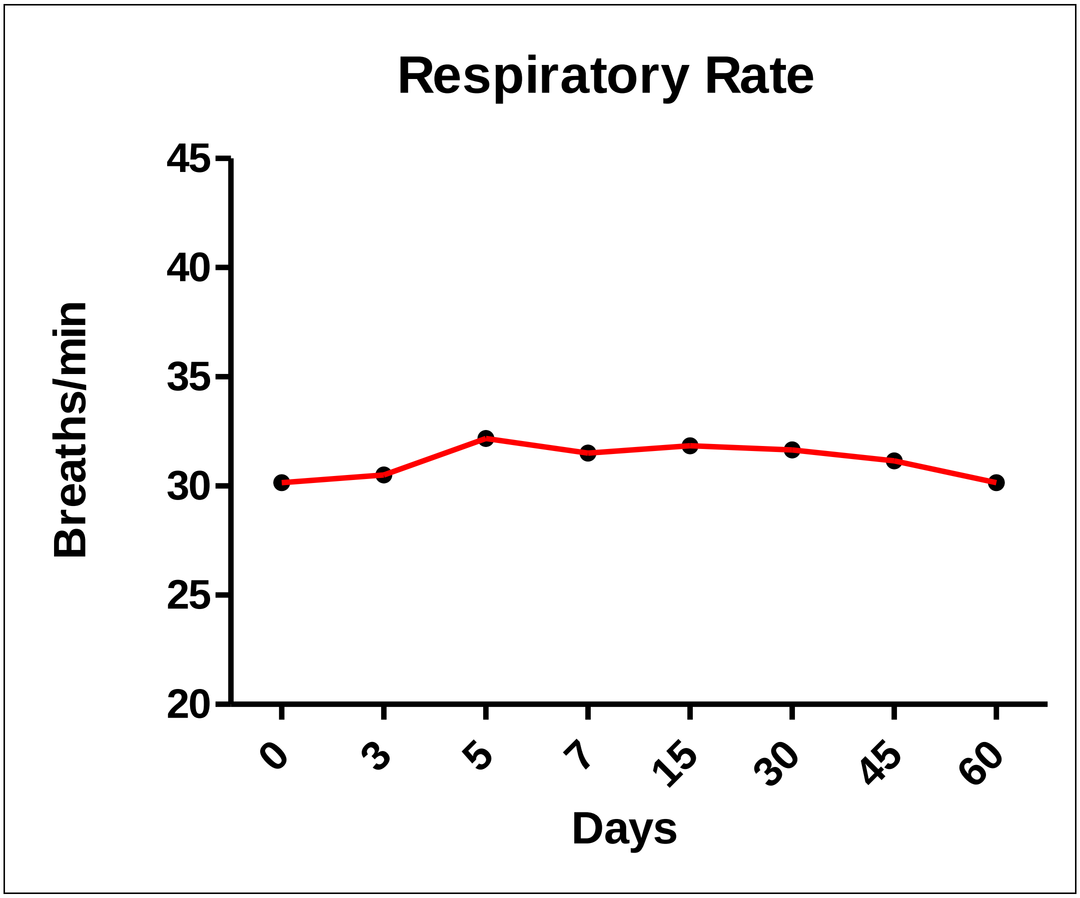


Fig. 60 : Graph showing Respiratory rate in dogs subjected to ventral plate fixation technique for lumbar spine stabilization



4.10.2 Packed Cell Volume

The mean PCV (%) in dogs before and after surgical procedure is depicted in Table 9 and Fig. 62. The mean PCV before and on 3rd, 5th, 7th, 15th, 30th ,45th and 60th post operative days were 38.83±0.70, 38.43± 0.90, 39.83 ± 0.60, 41.00 ± 0.51, 39.13 ± 0.58, 40.33 ± 0.42, 40.67 ± 0.42 and 41.17 ± 0.30 respectively. The variations in mean value of PCV was within the normal range throughout study period and were statistically not significant (P≤0.05).

4.10.3 Total erythrocyte count

The mean TEC (10^6 cells/cmm) in dogs before and after surgical procedure is depicted in Table 9 and Fig. 63. The mean TEC before and on 3rd, 5th, 7th, 15th, 30th ,45th and 60th post operative days were 6.64 ± 0.08, 6.44 ± 0.08, 6.46 ± 0.08, 6.50 ± 0.08, 6.54 ± 0.07, 6.58 ± 0.07, 6.60 ± 0.07, and 7.01 ±0.38 respectively. The variations in mean value of mean TEC value were statistically not significant (P≤0.05).

4.10.4 Total leukocyte count

The mean TLC (thousands/cmm) in dogs before and after surgical procedure is depicted in Table 9 and Fig. 64. The mean TLC (thousands/cmm) before and on 3rd, 5th, 7th, 15th, 30th ,45th and 60th post operative days were 15.73 ±0.59,15.35 ±0.68, 14.20 ±0.22, 12.98±0.83, 12.69 ± 0.66, 12.18 ± 0.59, 11.90 ± .60 and 11.72 ± .50 respectively. Increase in TLC was observed on 0, 3, 5 post operative days and thereafter it gradually returned to normal values. The variations in mean value of TLC level were statistically significant.

Table 9: Haemotological values in dogs subjected to ventral plate fixation technique for lumbar spine stabilization

Days	Haemoglobin (gm/dl) Mean ± SE	Packed Cell Volume (%) Mean ± SE	TEC (10^6 cells/cmm) Mean ± SE	TLC (thousands/cmm) Mean ± SE
0 day	12.50 ± 0.21	38.83±0.70	6.64 ± 0.08	15.73± 0.59
3rd day	12.07 ± 0.12	38.43± 0.90	6.44 ± 0.08	15.35 ± 0.68*
5th day	12.47 ± 0.17	39.83 ± 0.60	6.46 ± 0.08	14.2 ± 0.22*
7th day	12.35 ± 0.19	41.00 ± 0.51	6.50 ± 0.08	12.98 ± 0.83*
15th day	12.44 ± 0.26	39.13 ± 0.58	6.54 ± 0.07	12.69 ± 0.66*
30th day	12.86 ± 0.14	40.33 ± 0.42	6.58 ± 0.07	12.18 ± 0.59**
45th day	12.66 ± 0.16	40.67 ± 0.42	6.60 ± 0.07	11.90 ± 0.60**
60th day	12.70 ± 0.16	41.17 ± 0.30	7.01 ±0.38	11.72 ± 0.50**

***** Indicates moderately significant

** Indicates highly significant

Fig. 61: Graph showing Haemoglobin levels in dogs subjected to ventral plate fixation technique for lumbar spine stabilization.

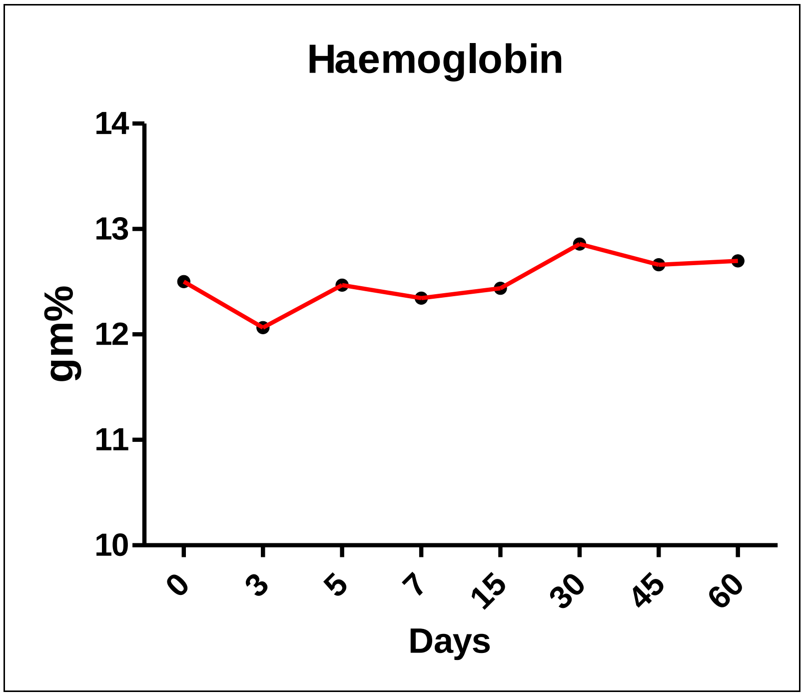


Fig. 62: Graph showing Packed cell volume in dogs subjected to ventral plate fixation technique for lumbar spine stabilization.

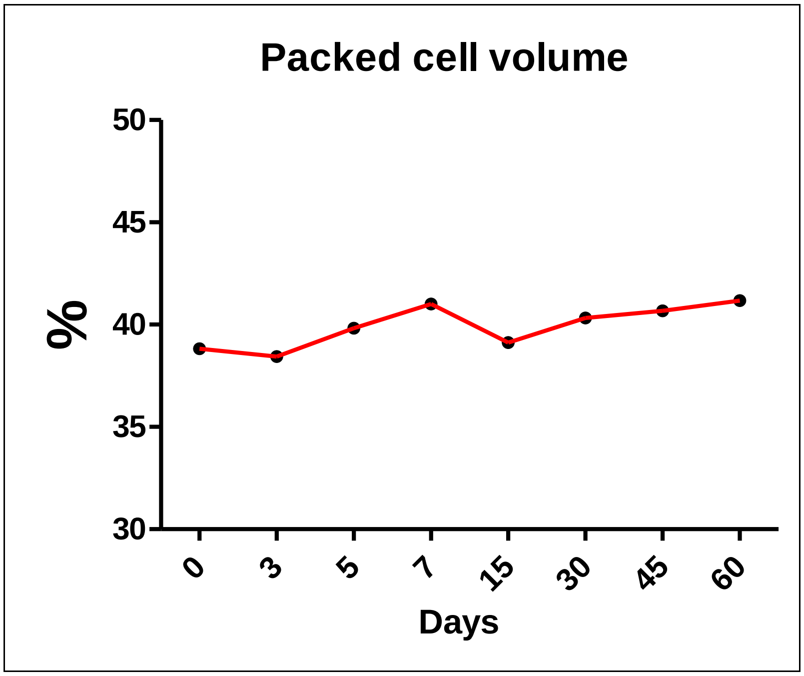


Fig. 63: Graph showing Total erythrocyte count in dogs subjected to ventral plate fixation technique for lumbar spine stabilization.

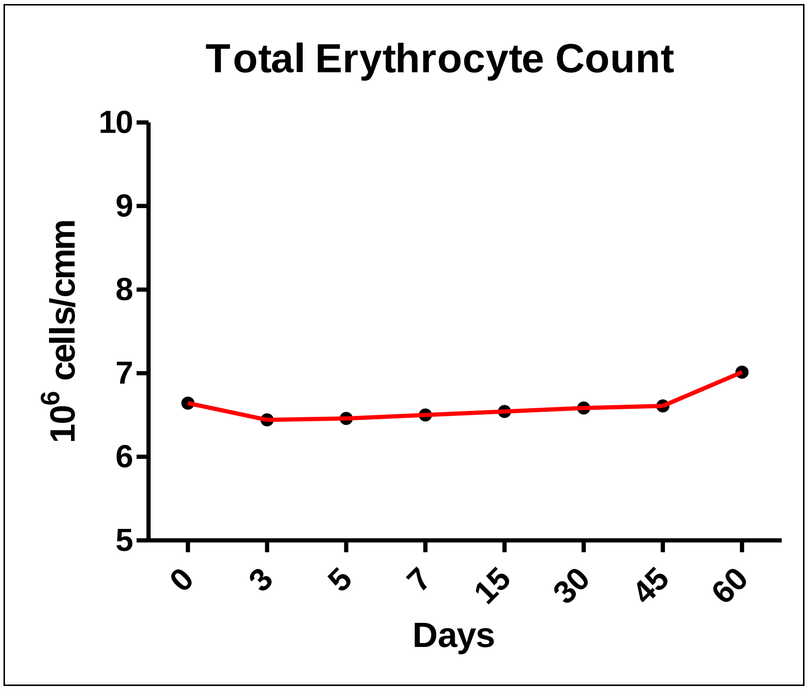
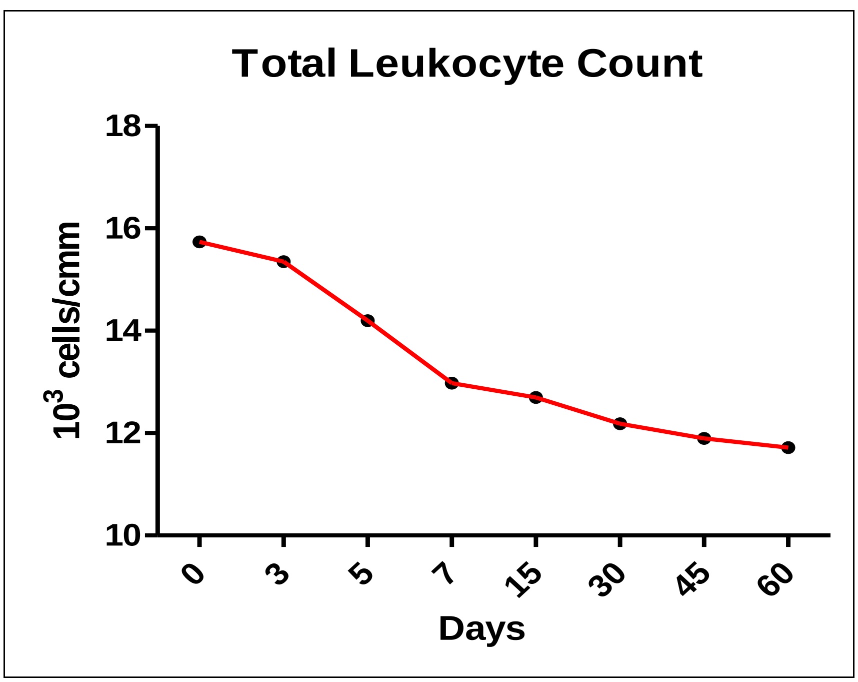


Fig. 64: Graph showing Total Leukocyte count in dogs subjected to ventral plate fixation technique for lumbar spine stabilization.



4.10.5 Differential leukocyte count

4.10.5.1 Neutrophil

The mean neutrophil count (%) before and on 3rd, 5th, 7th, 15th, 30th ,45th and 60th post operative days were 81.33 ±1.21, 82.50 ±1.04, 80.00 ±1.67, 77.17 ±1.39, 76.83 ±.98, 74.33 ±0.81, 73.83 ± 1.16 and 73.83 ±1.16 respectively. Increase in neutrophil count was observed on 0, 3, 5 post operative days and thereafter it returned to normal values. The variation in mean value of neutrophil was statistically significant (Table 10 and Fig. 65).

4.10.5.2 Lymphocyte

The mean lymphocyte count (%) before and on 3rd, 5th, 7th, 15th, 30th ,45th and 60th post operative days were 17.50 ±1.51, 14.33 ±1.03, 16.50 ±1.87, 20.00 ±1.89, 20.17 ±1.60, 23.50 ±1.04, 23.33 ±0.51 and 23.33 ± 0.81 respectively. Decrease in lymphocyte count was observed on 0, 3, 5 post operative days and thereafter it returned to normal values. The variation in mean value of lymphocyte was statistically significant (Table 10 and Fig. 66).

4.10.5.3 Monocyte

The mean monocyte count (%) before and on 3rd, 5th, 7th, 15th, 30th ,45th and 60th post operative days were 0.66 ± 0.21, 2.16 ± 0.30, 2.33 ± 0.21, 1.66 ± 0.33, 1.83 ± 0.30, 1.50 ± 0.42, 2.16 ± 0.30 and 2.33 ± 0.21 respectively .The variations in the mean value of monocyte count was statistically non significant ($p \leq 0.05$) (Table 10 and Fig 67).

Table 10: Differential Leukocyte Count in dogs subjected to ventral plate fixation technique for lumbar spine stabilization

Days	Neutrophils (%) Mean±SE	Lymphocyte (%) Mean±SE	Monocytes (%) Mean±SE	Eosinophils (%) Mean±SE	Basophils (%) Mean±SE
0 day	81.33 ± 1.21	17.50± 1.51	0.66 ± 0.21	0.50 ± 0.22	0.00±0.00
3rd day	82.50 ± 1.04*	14.33 ± 1.03*	2.16 ± 0.30	1.00 ± 0.36	0.00±0.00
5th day	80.00 ± 1.67*	16.50 ± 1.87*	2.33 ± 0.21	1.16 ± 0.16	0.00±0.00
7th day	77.17 ± 1.32*	20.00 ± 1.89*	1.66 ± 0.33	1.16 ± 0.16	0.00±0.00
15th day	76.83 ± 0.98**	20.17 ± 1.60*	1.83 ± 0.30	1.16 ± 0.30	0.00±0.00
30th day	74.33 ± 0.81**	23.50 ± 1.04**	1.50 ± 0.42	0.66 ± 0.21	0.00±0.00
45th day	73.83 ± 1.16**	23.33 ± 0.51**	2.16 ± 0.30	0.66 ± 0.33	0.00±0.00
60th day	73.83 ± 1.16**	23.33 ± 0.81**	2.33 ± 0.21	0.5 ± 0.22	0.00±0.00

***** Indicates moderately significant

** Indicates highly significant

Fig. 65: Graph showing Neutrophils in dogs subjected to ventral plate fixation technique for lumbar spine stabilization.

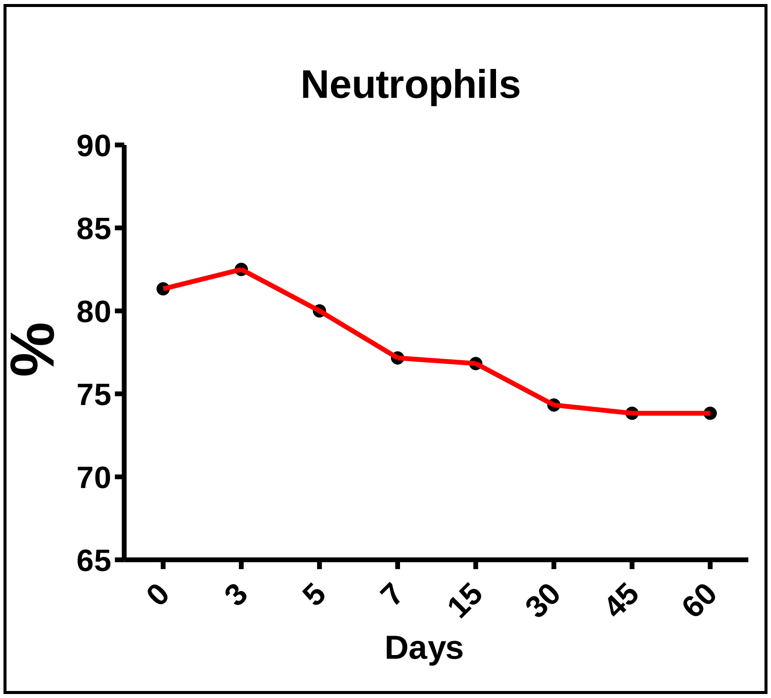
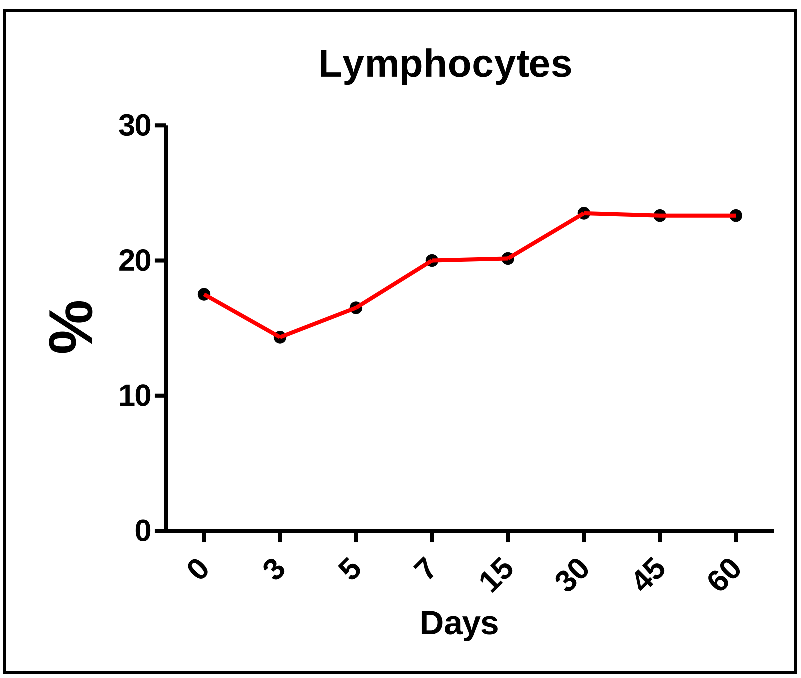


Fig. 66: Graph showing Lymphocyte in dogs subjected to Ventral Plate Technique for lumbar spine stabilization.



4.10.5.4 Eosinophil

The mean eosinophil count (%) before and on 3rd, 5th, 7th, 15th, 30th ,45th and 60th post operative days were 0.50 ± 0.22, 1.00 ± 0.36, 1.16 ± 0.16, 1.16 ± 0.16, 1.16 ± 0.30, 0.66 ± 0.21, 0.66 ± 0.33 and 0.5 ± 0.22 respectively. The Mean Value of eosinophil count was statistically non significant ($P \leq 0.05$) (Table 10 and Fig. 68).

4.10.5.5 Basophils

The basophil count was nil in both the pre and postoperative periods (Table 10).

4.11 Biochemical Studies

4.11.1 Serum Calcium

The mean serum calcium levels (mg/dl) recorded in dogs before and after surgical procedure are depicted in Table 11 and Fig. 69. The mean calcium (mg/dl) before and on 3rd, 5th, 7th, 15th, 30th ,45th and 60th post operative days were 10.51 ± 0.04, 10.66 ± 0.05, 10.74 ± 0.05, 10.88 ± 0.04, 11.03 ± 0.04, 11.15 ± 0.04, 11.00 ± 0.02 and 10.86 ± 0.03 respectively. An increase in calcium was observed on 7, 15, 30 and 45 post operative days when compared to pre surgical value of 10.51 ± 0.04. However, these changes were within the normal range and statistically non-significant.

4.11.2 Serum Phosphorus

The mean phosphorus (mg/dl) in dogs before and after surgical procedure is depicted in Table 11 and Fig.70. The mean phosphorus (mg/dl) before and on 3rd, 5th, 7th, 15th, 30th ,45th and 60th post operative days were 4.72 ± 0.06, 4.65 ± 0.08, 4.56 ± 0.04, 4.50 ± 0.04, 4.39 ± 0.05, 4.31±0.04, 4.42 ± 0.04 and 4.62 ± 0.05 respectively. The variation in mean value of phosphorus level was statistically non significant.

Fig. 67: Graph showing Monocytes in dogs subjected to ventral plate fixation technique for lumbar spine stabilization.

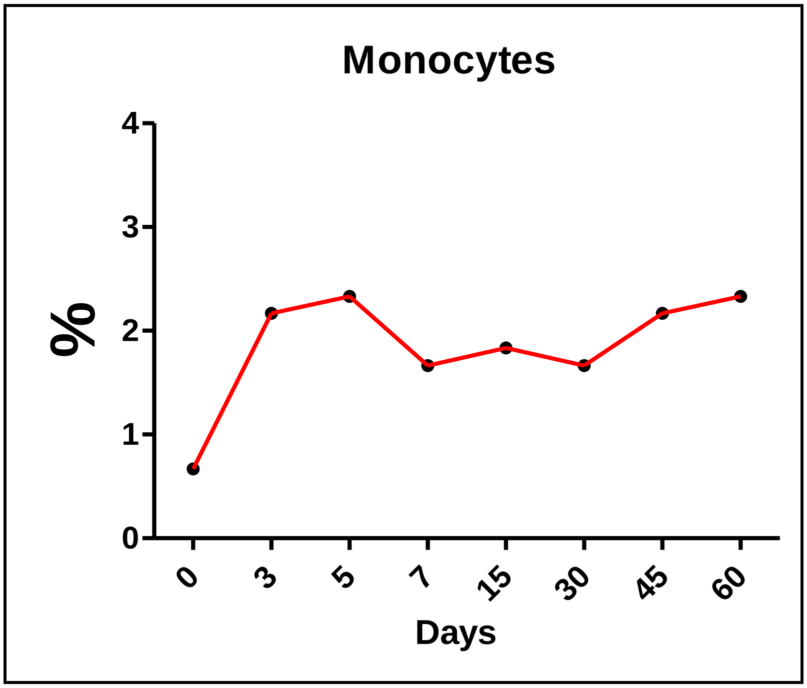


Fig. 68: Graph showing Eosinophils in dogs subjected to ventral plate fixation technique for lumbar spine stabilization.

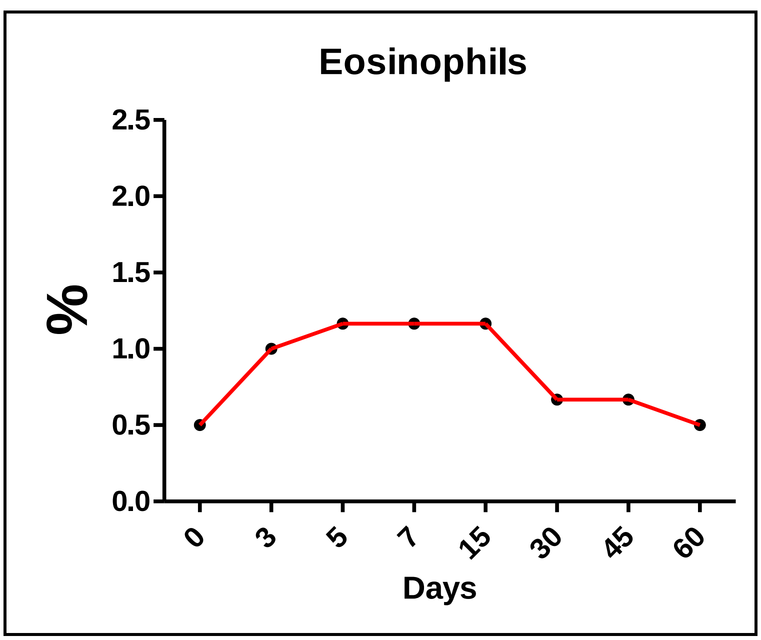


Table 11: Serum calcium, phosphorus and potassium in dogs subjected to ventral plate fixation technique for lumbar spine stabilization

Days	Calcium (mg/dl) Mean±SE	Phosphorus (mg/dl) Mean±SE	Potassium (mg/dl) Mean±SE
0 day	10.51 ± 0.04	4.72 ± 0.06	4.04 ± 0.01
3rd day	10.66 ± 0.05	4.65 ± 0.08	4.10 ± 0.01
5th day	10.74 ± 0.05	4.56 ± 0.04	4.16 ± 0.01
7th day	10.88 ± 0.04	4.50 ± 0.04	4.22 ± 0.01
15th day	11.03 ± 0.04	4.39 ± 0.05	4.25 ± 0.01
30th day	11.15 ± 0.04	4.31±0.04	4.32 ± 0.01
45th day	11.00 ± 0.02	4.42 ± 0.04	4.35 ± 0.01
60th day	10.86 ± 0.03	4.62 ± 0.05	4.39 ± 0.01

Fig. 69: Graph showing Serum calcium in dogs subjected to ventral plate fixation technique for lumbar spine stabilization.

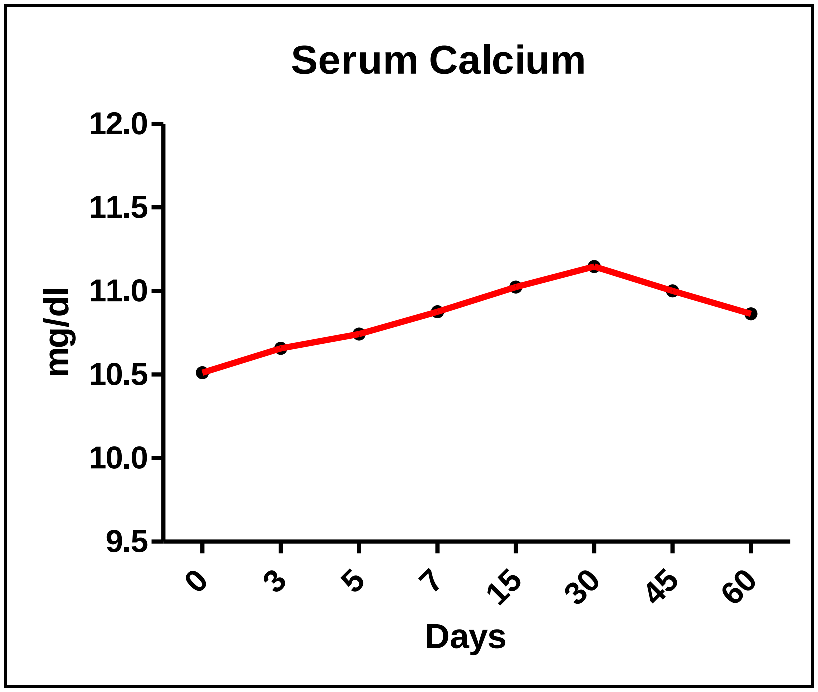
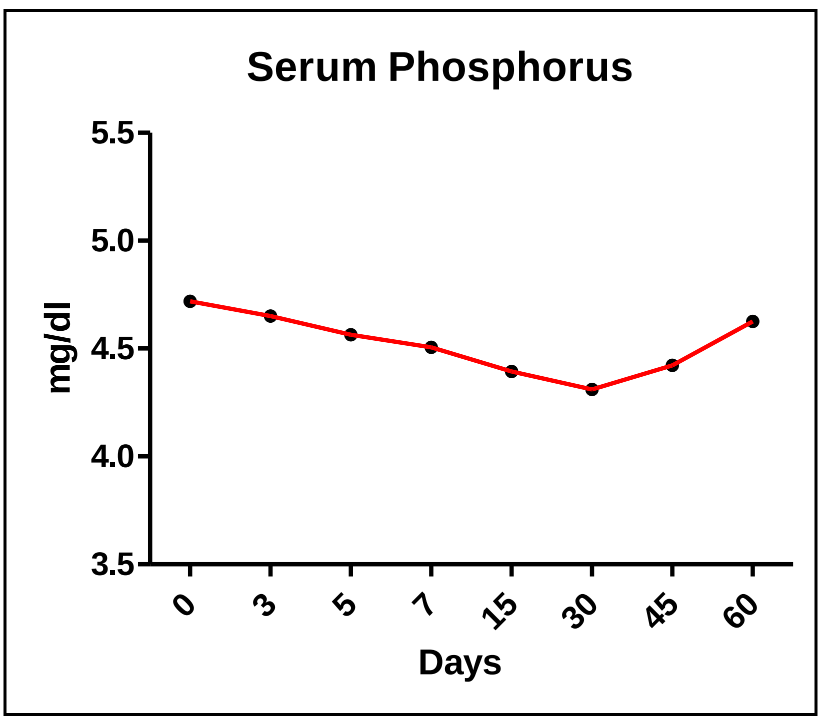


Fig. 70: Graph showing Serum Phosphorus in dogs subjected to ventral plate fixation technique for lumbar spine stabilization.



4.11.3 Serum Potassium

The mean potassium (mg/dl) in dogs before and after surgical procedure is depicted in Table 11 and Fig. 71. The mean potassium (mg/dl) before and on 3rd, 5th, 7th, 15th, 30th ,45th and 60th post operative days were 4.04 ± 0.01, 4.10 ± 0.01, 4.16 ± 0.01, 4.22 ± 0.01, 4.25 ± 0.01, 4.32 ± 0.01, 4.35 ± 0.01 and 4.39 ± 0.01 respectively. The mean value of potassium level was statistically non significant.

4.11.4 Serum Alkaline Phosphatase (ALP)

The mean serum alkaline phosphatase (U/L) in dogs before and after surgical procedure is depicted in Table 12 and Fig. 72. The mean serum alkaline phosphatase (U/L) before and on 3rd, 5th, 7th, 15th, 30th ,45th and 60th post operative days were 112.50 ± 1.87, 124.20 ± 4.02, 129.2± 2.40, 167.20 ±4.26, 176.00 ± 4.64, 162.00 ± 3.74, 137.70 ± 3.98 and 128.50 ±4.23 respectively. There is significant increase in the mean serum alkaline phosphatase from 7 to 30th postoperative day which subsequently came back to normal range. The variations in mean serum alkaline phosphatase levels were statistically significant.

4.11.5 Serum Aspartate Aminotransferase (AST)

The mean serum aspartate aminotransferase (U/L) in dogs before and after surgical procedure is depicted in Table 12 and Fig.73. The mean serum aspartate aminotransferase (U/L) before and on 3rd, 5th, 7th, 15th, 30th ,45th and 60th post operative days were 34.83 ± 1.42, 38.17 ± 1.47, 39.33± 1.05, 39.17 ± 1.32, 40.33 ± 1.86, 38.83 ±1.72, 39.00 ±2.75and 35.17 ±3.06 respectively.

Table 12: Serum alkaline phosphatase (ALP), Serum aspartate aminotransferase (AST), Serum alanine aminotransferase (ALT) in dogs subjected to ventral plate fixation technique for lumbar spine stabilization

Days	(ALP) (IU/L) Mean±SE	(AST) (IU/L) Mean±SE	(ALT) (IU/L) Mean±SE
0 day	112.50 ± 1.87	34.83 ± 1.42	40. 33 ± 0.91
3rd day	124.2 ± 4.02	38.17 ± 1.47	43.17 ± 1.53
5th day	129.2 ± 2.40	39.33± 1.05	46.17 ± 1.10
7th day	167.20 ± 4.26**	39.17 ±1.32	46.00 ± 1.26
15th day	176.00 ± 4.64**	40.33 ± 1.86	44.17 ± 1.13
30th day	162.00 ± 3.74**	38.83 ± 1.72	41.83 ± 1.01
45th day	137.70 ± 3.98*	39.00 ± 2.75	41.67 ± 1.17
60th day	128.50 ± 4.23	35.17 ± 3.06	40.50 ± 0.84

***** Indicates moderately significant

** Indicates highly significant

Fig. 71: Graph showing Serum potassium in dogs subjected to ventral plate fixation technique for lumbar spine stabilization

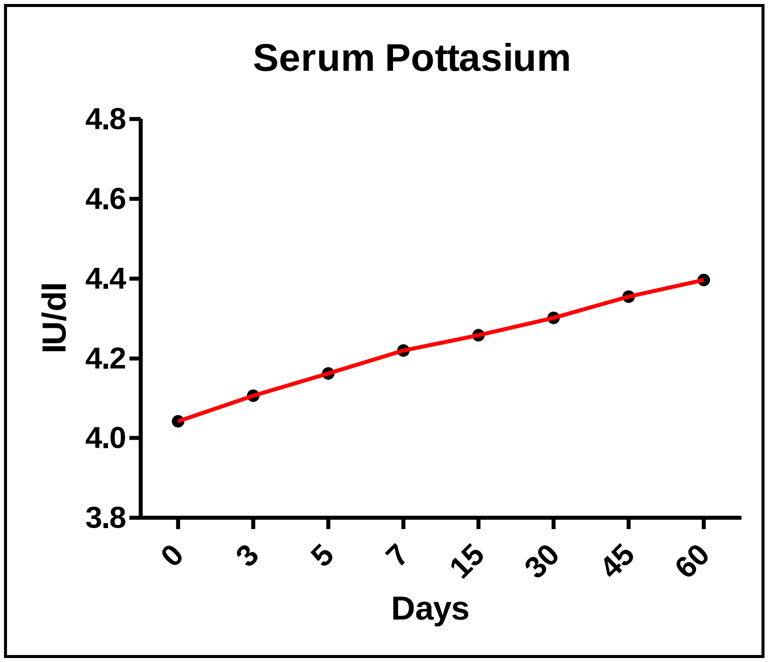
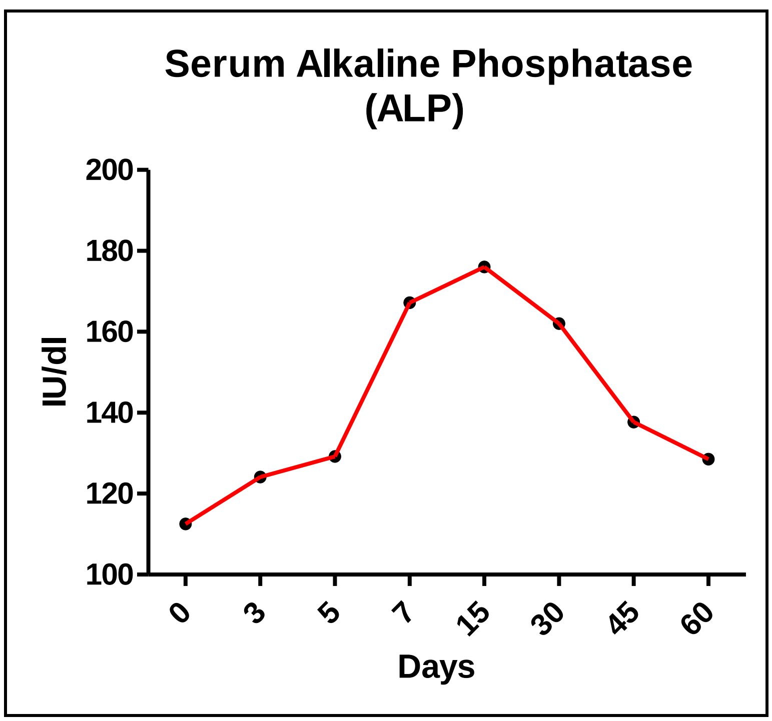


Fig. 72: Graph showing Alkaline phosphatase (ALP) in dogs subjected to ventral plate fixation technique for lumbar spine stabilization.



There were variations in mean serum aspertate aminotransfertate throughout study period and the variations were within the normal range and statistically not significant.

4.11.6 Serum Alanine Aminotransferase (ALT)

The mean serum alanine aminotransferase (U/L) in dogs before and after surgical procedure is depicted in Table 12 and Fig.74. The mean serum alanine aminotransferase (U/L) before and on 3^{rd}, 5^{th}, 7^{th}, 15^{th}, 30^{th} ,45^{th} and 60^{th} post operative days were 40. 33 ± 0.91, 43.17 ± 1.53, 46.17 ± 1.10, 46.00 ± 1.26, 44.17 ± 1.13, 41.83 ± 1.01, 41.67 ± 1.17 and 40.50 ± 0.84 respectively. An increase in serum alanine aminotransferase was observed on 3, 5, 7, 15 and 30^{th} post operative days when compared to pre surgical value. However, these changes were within the normal range and were statistically not significant.

Fig. 73: Graph showing Serum aspartate amino transferase (AST) in dogs subjected to ventral plate fixation technique for lumbar spine stabilization.

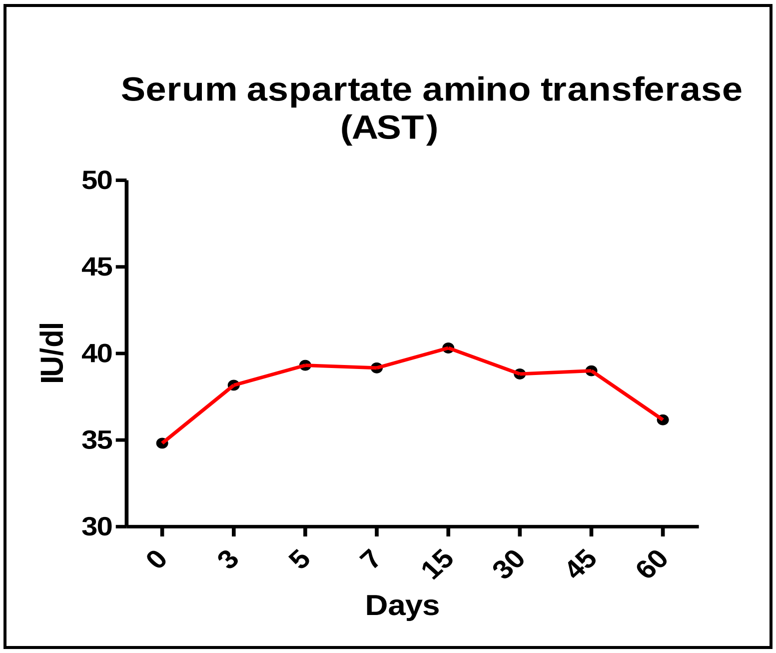
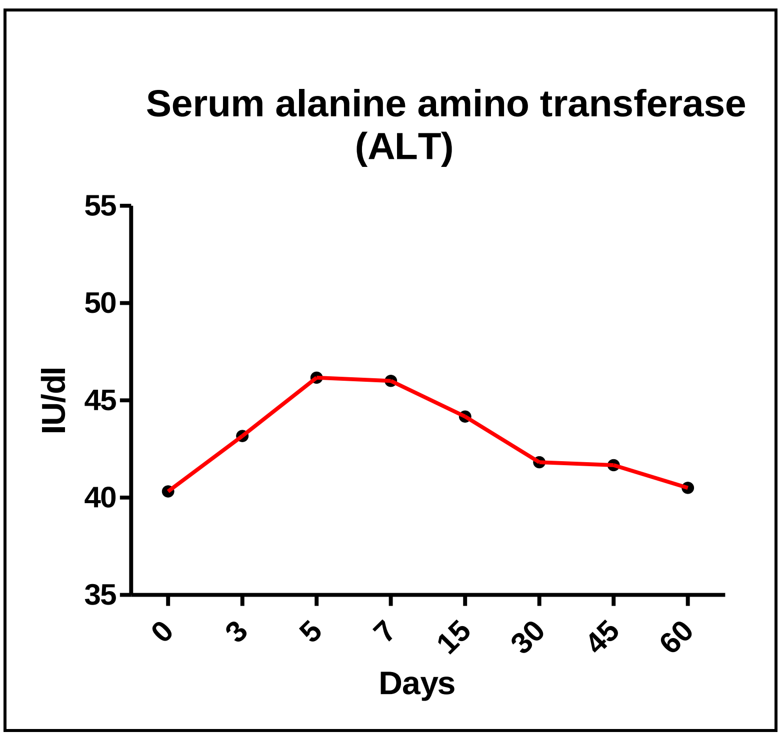


Fig. 74: Graph showing Serum alanine amino transferase (ALT) in dogs subjected to ventral plate fixation technique for lumbar spine stabilization.



Discussion

V. DISCUSSION

The present research was carried out to study the occurrence of traumatic posterior paralysis in dogs and to standardize the technique of ventral plate fixation for stabilization of lumbar vertebral fractures in dogs.

5.1 Occurrence

During the study period (April 2012 to March 2013), a total of 10,043 dogs were presented to Veterinary College Hospital, out of which 432 (4.30 %) cases had posterior paralysis. Among 432 cases, 224 were cats (51.8%) and 208 were dogs (48.1%). Among 208 dogs, 35 cases had spinal fractures with an overall incidence of 0.34 %. Vertebral column was more prone to fractures by accidents or fall from height. Shores (1992), Jeffery and Blakemore (1999) also reported the similar observations. Nagaraja *et al*. (2007[b]) observed 0.38% and Nandeesh (2013) observed 0.29% of traumatic posterior paralysis in dogs in the same Hospital over a study period of one year. In the present study males had incidence of 77.14% and females had incidence of 22.85%. The higher incidence in male dogs could be due to preference of people to keep male dogs as pets rather than females and could be due to their hyperactivity and aggressiveness as compared female dogs. The findings of the present study are similar to that reported by Aithal *et al.* (1999) who also recorded more fracture incidence in males than females and opined that, males due to more aggressiveness and tendency to wander more were vulnerable to fracture than females. Nagaraja *et al*. (2007[b]) and Nandeesh (2013) also made similar observations. In the present study among the 35 cases, breed wise incidence was highest in non descriptive dogs 12 (34.28%) followed by Labrador Retriever 7

(20%), Pomeranian 6 (17.14%), German Shepherd 4 (11.42%), Doberman pincher 3 (8.57%) and Dachshund 3 (8.57%).

In the present study, the higher fracture incidence of 34.28% in Non-descript breeds compared to other breeds might be due to their large population, stray nature and tendency to meet with accidents. Similar observation has been made by Aithal *et al.* (1999), Nagaraja *et al.* (2007[b]), Nandeesh (2013). The other possible reason could be increased awareness among people about compassion to animals and more active involvement of animal welfare organizations in the rescue and treatment of stray animals.

Analysis of age-wise incidence indicated that 15 dogs (42.85%) were within one year of age, 10 (28.57 %) were between one to three years, 6 (17.14%) were between three to five years, and 4 (11.42%) were more than five years of age. Higher incidence of spinal fracture in young ones could be due to their hyper activity and inexperience in avoiding accidents and falls. Aithal *et al.* (1999) reported that younger dogs, aged less than one year were more frequently affected than adults which may be due to higher activity and inability to cope with hazards unlike adults. Rani *et al*. (2004) and Dilip (2007) reported maximum incidence of fracture in young animals. The observation of the present study is in accordance with their observations.

Age of occurrence ranged between four months to three years in the present study. Reported age of occurrence ranged from 2m - 13 yrs by Chandy and Vasanth (2006), 21/2m - 14 yrs by Nagaraja *et al*. (2007[b]), 6m – 5 yrs by Nandeesh (2013). Carberry *et al*., (1989) reported higher occurrence of traumatic spinal injuries in younger dogs and they also reported that the mean age of occurrence of the condition in 12 dogs as two years.

5.2 Etiology of traumatic posterior paralysis

In the present study highest occurrence of traumatic posterior paralysis was due to automobile accidents. This might possibly be due to dog's nature of free life on the streets, increased density of vehicles. Similarly Carberry *et al*. (1989) reported 88.24 %, McKee (1990) reported 58.82 % and Nagaraja *et al*. (2007[b]) reported 36.92 % of spinal injuries in dogs following automobile accidents.

5.3 Physical examination

5.3.1 Palpation of spine

Physical examination by palpation of the affected part of the vertebral column was helpful in tentatively determining the tentative site of vertebral injury based on disalignment of the spine at the site of injury along with pain elicitation in dogs with fractures or luxations. Wheeler and Sharp (1994), Rathod *et al.* (2010[c]), Nandeesh (2013) were also of the same opinion.

5.3.2 Bladder function

Out of six cases studied two dogs had upper motor neuron (33.33%) and four dogs had lower motor neuron (66.33%) bladders at the time of presentation. Upper motor neuron bladder function improved well following surgery. Five out of six dogs returned to normal bladder function by 7th post operative day. One dog with lower motor neuron problem showed improvement on 15th postoperative day. This suggests that return of voluntary urination could be considered as an early indicator for return of neurological function in paraplegic animals.

Chandy and Vasanth (2006[b]) reported three dogs with upper motor neuron bladder, two dogs with lower motor neuron bladder on the day of presentation and all dogs had normal bladder function by day 60th following surgical treatment of spinal fixation without hemileminectomy. Nagaraja (2007) reported five dogs with upper motor neuron bladder and one dog with lower motor neuron bladder on the day of presentation out of which 5 dogs had normal bladder function by day 60th following surgical treatment of spinal plating without laminectomy. Nandeesh (2013) reported that out of a total of six cases studied three dogs had upper motor neuron (50%) and three dogs had lower motor neuron (50%) bladders at the time of presentation. Upper motor neuron bladder function deteriorated on post operative days. Among three dogs with lower motor neuron problem, all three dogs had improvement.

5.4 Neurological function

In the present study neurological evaluation of the dogs based on attitude, posture, gait, locomotor status, conscious proprioception and deep pain sensation was done and evaluation of spinal reflexes viz., panniculus, patellar, flexor and anal sphincter response were studied to assess the degree of spinal cord injury and prognosis of the patients. Wheeler and Sharp (1994) reported the method of neurological examination which was highly efficient in assessing the degree of spinal cord injury and prognosis of the patients and also helpful in localization of spinal injuries and in assessing the neurological recovery of dogs. This was in accordance with Chandy and Vasanth (2006[b]), Nagaraja *et al*. (2007[c]) and Nandeesh (2013).

Mckee (1990) opined that an animal with traumatic spinal injury should be assessed based on neurological examination rather than radiographic findings, as in some cases there was poor correlation between the degree of displacement of vertebrae noted and severity of neurological dysfunction recorded. Ferreira *et al*. (2002) stated that the paralytic dogs have excellent outcome following treatment if they regained the ability to walk without proprioceptive deficits. A dog was considered to have recovered completely, if it could stand up on its own, ambulate and engage in basic activities like feeding, defecation and urination on its own. According to Bali (2009) 'Poor' outcome was defined as death, euthanasia due to grave prognosis, lack of improvement in neurological status and/or permanent dysfunction of micturition. The grading and evaluation procedure used in the present study were good prognostic indicators to assess the neurological status of the animal. In the present study five of the dogs recovered completely and one dog did not show complete recovery during the study period.

5.5 Radiographical examination

5.5.1 Survey radiography

In the present study lateral view radiographs were obtained without any difficulty in all the dogs with or without sedation. This was in accordance with observations made by Lanz *et al*. (2000), Chandy and Vasanth (2006[e]) and Nandeesh (2013). Vertebral subluxatins, vertebral body fractures, fracture - subluxations, fracture - luxations, bilateral cranial articular process fracture and intervertebral disc space reduction were the lesions that could be identified on survey radiographs of the spine of the dogs included in the study. Similar conditions were diagnosed by McKee (1990) and Voss and Montavon (2004) on survey radiographs. However, Carberry *et al*. (1989) opined that radiographs might be of limited value as prognostic indicators for dogs with spinal trauma as they might not show the maximum displacement that occurred at the time of injury. They noted that spontaneous reduction of subluxations, luxations and fractures might occur prior to radiography. Moreover, inherent stability of any fracture or luxation was difficult to appreciate radiographically. Similar opinions were put forth by McKee (1990) and Lanz *et al*. (2000).

A consistent pattern in the healing of vertebral fractures could not be identified radiographically during the study period. This was in accordance with the findings of Carberry *et al*. (1989) who reported variable callus formation during healing of vertebral fractures. Moreover, each fracture type was different and could not be expected to heal in a predictable manner. The time from sustaining the injury to presentation of the paraplegic dogs to the Hospital also varied because of which each animal was at a different stage of healing at the site of vertebral injury.

Periodic post operative radiographic evaluation revealed screw loosening in one young dog this could be because of the soft bone and inability of the bone to hold the implant. The same opinion was shared by Voss and Montavon (2004). Nandeesh(2013) also recorded implant failures in post operative radiographs.

5.5.2 Myelography

The anaesthetic protocol used was adequate for myelography in all dogs. The method adopted in the study for locating the site for successful tapping of cisterna magna was suggested previously by Wheeler and Sharp (1994). The dose of Iohexol, the contrast material used in the present study provided excellent demarcation of the spinal cord on myelograms. Riaz *et al*. (2006), Chandy and vasanth (2006[a]) and Nandeesh (2013) used the same dose of contrast material during their study.

None of the dogs in the study showed post-myelographic complications and recovered uneventfully from the anesthesia. The findings were in line with Wheeler and Davis (1985), Scott (1997), and Nandeesh(2013). Widmer and Blevins (1991) reported that, side effects such as seizures, respiratory arrest and worsening of neurological signs were greatly reduced when iohexol was used as a contrast material.

5.6 Surgical treatment

5.6.1 Premedication with anaesthesia.

In the present study, administration of atropine sulphate sub cutaneously and diazepam intravenously as preanesthetic produced good sedation. Prophylactic use of amoxycillin and potassium clavulanate antibiotic provided good results in overcoming post operative infection. The observations were in line with Nandeesh (2013). After 15 minutes a 2.5 Per cent solution of thiopentone sodium provided smooth induction in all animals and maintenance of general anesthesia using isofluorane provided good depth of anesthesia and muscle relaxation sufficient for surgery and recovery was smooth and uneventful. Wheeler and Sharp (2005) opined that Isofluorane is the usual inhalation agent of choice, because it is both less depressant to the cardiovascular system and less arrhythmogenic than halothane.

5.6.2 Surgical procedure

Mid ventral incision provided an easy approach to the spine without much dissection of the tissue. The blunt dissection of sublumbar facia and seperation of muscles prevented unwanted trauma to the muscles, provided clear bone surfaces for implant application. Bleeding during the procedure could be effectively controlled by crushing the small bleeding vessels with artery forceps or ligation of larger ones with No. 1-0 catgut. The osseous bleeding was controlled by the use of small cotton buds soaked in calcium borogluconate solution. The use of three pronged muscle retractors provided satisfactory retraction of muscles for adequate working space and exposure of the vertebrae during the surgery. The displaced vertebrae were reduced manually. When the displacement was too much, the reduction was assisted by an assistant raising the site of injury by lifting the vertebral column of the animal from underneath, and simultaneous manipulation of the affected vertebrae. Fracture reduction in heavy animals was difficult because of more sublumbar fat. As there are major and minute blood vessels in the sublumbar region, use of instruments for fracture reduction was limited. However with patience and persistent effort fracture reduction was possible. The inclusion of two vertebrae cranial and caudal to the fracture site provided optimum stability to the locking plate fixation on the fractured vertebra. Nagaraja *et al*. (2007[e]) had included three vertebrae cranial and caudal to the fractured site.

5.6.3 Post-operative care

In the present study, technique adopted was effective in keeping the surgical site clean and helped in controlling bacterial infection. Amoxicillin and potassium clavulanate were very effective in preventing infection as there was no post operative infection in any of the cases. Rayward (2002), Dunning (2003) recommended use of Cefazolin or other third generation cephalosporins for its good tissue penetration and broad spectrum of activity against staphylococci and other Gram-positive organisms. However Amoxicillin and potassium clavulanate was used considering its broad spectrum antibacterial activity and its efficacy in controlling or treating cystitis and nasocomial infection.

Use of meloxicam for three days was helpful in alleviating the post operative pain. This was in agreement with Ahmed *et al*. (2002) as NSAIDS should not be used for more than few days owning to the tendency of neurosurgical patients developing gastrointestinal disturbances. Removal of urine in dogs with LMN bladders was easy owing to relaxed urethral sphincter, while it was difficult in UMN bladders because of contracted sphincter, which had prevented free urine outflow. Irrespective of the neurological lesion catheterization of the bladder helped to prevent retention of urine and early returning of the bladder function. Turning of recumbent dogs every four to six hours and providing soft bedding was effective in preventing the formation of decubital ulcers in few cases. Physiotherapy with infrared light was helpful in preventing atrophy of hind limb muscles in all dogs. These findings are in accordance with Bagley *et al.* (2000). Physiotherapy was started from third post operative day in the form of massaging of hind limbs and flexion and extension of the joints for ten minutes twice daily. Same physiotherapeutic modality was followed by Nagaraja *et al.* (2007[d]) and Nandeesh

(2013). Rehabilitation of dogs on wheel cart has helped improvement in the mental attitude of the animal, and the risk of the dog coming to rely on the cart is usually outweighed by the stimulus of enhanced mobility in order to encourage the animal to walk. This is in accordance with Wheeler and Sharp (2005). Chandy and Vasanth (2006) rehabilitated a dachshund dog on locally fabricated wheel cart.

5.6.4 Post operative complications

During the study one young dog showed screw loosening on 7th day post operative radiograph. Vertebral body was too soft to retain the inserted implants. Because of this screws might have loosened and caused vascular damage. Voss *et al.* (2006) and Nandeesh (2013) also made similar observations in their study. However a second surgery was carried out to rectify the problem and animal made uneventful recovery.

5.7 Radiographic assessment of fracture healing

In the present study, radiographs taken immediately after operation revealed good apposition and alignment of fracture ends. All the screws were properly placed without penetration into vertebral canal or intervertebral space.

Day 7

Radiographs on 7th post operative day revealed evident fracture gap with no callus formation. There was no change in alignment of fractured segments. Screws and plate were in place. Similar observations were also noticed by Johnson *et al*. (1996), Dilip (2007) and Steffen *et al.* (2011)

Day 15

Fracture line was visible, bone plate was in position. No change in the alignment of fractured segments was noticed without much mineralized callus. These observations are in line with those of Steffen *et al.* (2011).

Day 30

Mild periosteal reaction at the fracture fragments ends with distinct fracture line were observed in the study. Similar observations were recorded by Johnson *et al*, (1996) and Steffen *et al.* (2011).

Day 45

Periosteal reaction was evident at the fractured fragments with in-distinct fracture line. Similar observations were noticed by Steffen *et al.* (2011).

Day 60

The observations include completely healed fracture with no evidence of fracture line with complete bony union. Similar observations were noticed by Nagaraja *et al*. (2007[d]) and Steffen *et al.* (2011).

5.9 Post-operative observation.

5.9.1 Clinical evaluation

5.9.1.1 Rectal temperature

The mean rectal temperature (^{0}F) in dogs ranged from 100.70 ± 0.34 to 101.90 ± 0.23. However the mean temperature was slightly elevated on fifth postoperative day, which may possibly be a manifestation of pyrexia as influenced by inflammatory condition. (Moitra, 1997 Dilip, 2007 and Mathew 2009). The values recorded were within normal physiological range. This is in agreement with the observations of Tennant (1994). However Nandeesh (2013) observed elevated temperature on seventh postoperative day.

5.9.1.2 Heart rate

The mean Heart Rate (beats/min) ranged from 76.17 ± 0.83 to 80.33 ± 1.97. The variations observed were within the normal range, however a slight increase was observed on 30th postoperative day which could be attributed to the excitement of the animal during examination as they will be nearing complete recovery. The variations were minimal and were well within the physiological limits. This suggested that the treatment method adopted did not influence the heart rate. A similar non-significant variation in heart rates were also reported by Chandy and Vasanth (2006[b]) and Nandeesh (2013).

5.9.1.3 Respiratory rate

The mean respiratory rate (breaths/min) ranged from 30.17 ± 2.72 to 32.17 ± 1.19. The variations observed were within the normal range and were not significant, but elevated respiratory rate was noticed on fifth postoperative day in animals which could be attributed to the excitement, reparative inflammatory process occurring at the surgical site. The findings were in accordance with that of Nandeesh (2013). Chandy and Vasanth (2006[b]) also observed no significant variation in respiration rate during their study involving surgical and nonsurgical treatment of paraplegic dogs.

5.10 Haemato-biochemical studies

5.10.1 Haematological studies

5.10.1.1 Haemoglobin

The mean haemoglobin (g/dl) ranged from 12.07 ± 0.12 to 12.86 ± 0.14. The variations observed were within the normal range and were not significant. The values were within the normal range in all stages of the study period. This indicated that none of the dogs included in the study had any internal haemorrhage due to external trauma to cause significant reduction in the haemoglobin values and that neither paraplegia nor the type of treatment caused significant changes in haemoglobin values. These observations are in line with the findings of Chandy and Vasanth (2006[h]) and Rathod *et al*. (2010[a]) and Nandeesh (2013). However, Moore and Withrow (1982) had opined that loss of blood into the gastrointestinal tract could probably cause anaemia before treatment in spinal patients.

5.10.1.2 Packed Cell Volume

The mean PCV (%) ranged from 38.43± 0.90 to 41.17 ± 0.30. The variations observed were within the normal range and were non-significant. The values were within the normal range in all the stages of the study period. This indicated that none of the dogs included in the study had any internal haemorrhage due to external trauma to cause significant reduction in the haemoglobin values and that neither paraplegia nor the type of treatment caused significant changes in haemoglobin values. These observations are in line with the findings of Chandy and Vasanth (2006[h]), Rathod *et al*. (2010[a]) and Nandeesh (2013).

5.10.1.3 Total erythrocyte count

The mean TEC (10^6 cells/cmm) ranged from 6.44 ± 0.08 to 7.01 ±0.38. These values were also within the normal range in all stages of the study period. This also indicated that none of the dogs included in the study had any internal haemorrhage due to external trauma to cause significant reduction in the TEC values and that neither paraplegia nor the type of treatment caused significant changes in haemoglobin values. These observations are in line with the findings of Chandy and Vasanth (2006[h]), Rathod *et al*. (2010[a]) and Nandeesh (2013).

5.10.1.4 Total leukocyte count

The mean TLC (thousands/cmm) ranged from 15.73 ±0.59 to 11.72 ±0.50. Increase in TLC was observed on 0, 3, 5 post operative days and thereafter gradually returned to normal values. All the dogs had stress leukograms on the day of presentation. The variations in mean value of TLC level were statistically significant. The findings were in accordance with the statement of Wheeler and Sharp (1994) that stress leukogram, with leukocytosis was a common finding in spinal disorders in dogs. The increase in leukocytes in stress leukograms has also been indicated by Rebar *et al*. (2005). However, Nandeesh (2013) observed a non-significant increase in the total leukocyte count during the first postoperative day and attributed it to surgical stress and inflammatory changes.

5.10.1.5 Differential Leukocyte Count (DLC) (% of individual cells)

The mean Neutrophil, Lymphocyte, Monocyte, Eosinophil ranged from 73.83 ±1.16 to 82.50 ±1.04, 14.33 ±1.03 to 23.50 ±1.04, 0.66 ± 0.21 to 2.33 ± 0.21, 0.50 ± 0.22

to 1.16 ± 0.30 respectively. Increase in neutrophil and decrease in lymphocyte count was observed on 0, 3, 5 post operative days and thereafter returned to normal values. The variation in mean value of neutrophil and lymphocyte was statistically significant. There was non-significant variation in monocyte and eosinophil count. The increase in neutrophil and decrease in lymphocyte count may be attributed to the stress leucogram in spinal patients. The presence of stress leukograms during the paraplegic state was in accordance with the statement of Wheeler and Sharp (1994), and the picture of the individual types of white blood cells seen as part of the stress leukograms was in accordance with the description of the condition by Rebar *et al*. (2005). Similar observations were made by Chandy and Vasanth (2006[h]).

5.10.2 Biochemical Profiles

5.10.2.1 Serum Calcium

The mean serum calcium levels (mg/dl) ranged from 10.51 ± 0.04 to 11.15 ± 0.04. A non significant variation was observed and the variations were within the normal range. The values were found to be within the normal physiological range in all stages of the study period. The absence of statistically significant difference ($P \leq 0.05$) in the values obtained between the different days of study indicated that paraplegia or the type of treatment did not interfere with the calcium level in the blood. No significant variation in the serum calcium values during fracture healing has been observed by Singh *et al.* (1976) and Chaudhari (1997). No association between serum calcium and paraplegia has been mentioned by Simesen (1980) and Benjamin (2001). Nandeesh (2013) also did not observe any significant variation in the serum calcium values during the healing of vertebral fractures.

5.10.2.2 Serum Phosphorus

The mean phosphorus (mg/dl) ranged from 4.31±0.04 to 4.72 ± 0.06. There was no significant variation observed in serum phosphorus levels and the variations observed were within the normal range. The absence of statistically significant difference ($P \leq 0.05$) in the values obtained between the different days of study indicated that the paraplegia or the type of treatment did not interfere with the calcium level in the blood. No significant variation in the serum phosphorus values during fracture healing has been observed by Singh *et al.* (1976) and Chaudhari (1997). No association between serum phosphorus and paraplegia has been mentioned by Simesen (1980) and Benjamin (2001). Chandy and Vasanth (2006[h]) and Nandeesh (2013) also did not observe any significant variation in the serum phosphorus values during the healing of vertebral fractures.

5.10.2.3 Serum Potassium

The mean potassium (mg/dl) ranged from 4.04 ± 0.01 to 4.39 ± 0.01. There was no significant variation observed in serum potassium levels and the variations observed were within the normal range. Benjamin (2001) reported no change in serum potassium levels and found that they were within normal range in dogs with paraplegia. The levels of Potassium values recorded on specified days were statistically insignificant and a similar non-significant variation was recorded by Chandy and Vasanth (2006[h]), Rathod *et al*. (2010[a]) and Nandeesh (2013)

5.10.2.4 Serum Alkaline Phosphatase (ALP)

The mean serum alkaline phosphatase (U/L) ranged from 112.50 ± 1.87 to 176.00 ± 4.64. There was significant increase in the mean serum alkaline phosphatase from 7 to 30th postoperative day which gradually came down to normal range. The variations in mean serum alkaline phosphatase levels were statistically significant. This could be because of the increased osteoblastic activity at the site of vertebral fractures during the healing period. The values fell after the 30th postoperative day because the stabilization provided by the fixation technique may have been helpful in achieving early healing of the fractures. Similar increase in the serum ALP values during the healing of vertebral fractures were observed by Chandy and Vasanth (2006[h]) and Nandeesh (2013).

5.10.2.5 Serum Aspartate Aminotransferase (AST)

The mean serum aspartate aminotransferase (U/L) ranged from 34.83 ± 1.42 to 40.33±1.86. A non-significant variation was observed in serum aspartate aminotransferase levels and all the values were within the normal physiological range. The variations were minimal and statistically not significant. This showed that the treatment adopted had no effect on AST value. Similar observations were made by Chandy and Vasanth (2006[h]),Rathod *et al*. (2010[a]) and Nandeesh (2013)

5.10.2.6 Serum Alanine Aminotransferase (ALT)

The mean serum alanine aminotransferase (U/L) ranged from 40. 33 ± 0.91 to 46.17 ± 1.10. A non-significant variation was observed in Serum alanine aminotransferase and the variations were within the normal range. This suggests that the procedure and anesthetic used in the present study did not have any impact on liver.

All the mean values were within normal physiological range. The variations were minimal and statistically not significant. This indicated that neither paraplegia nor the treatment methods adopted caused any change of the ALT values. Similar conclusions were made by Chandy and Vasanth (2006[h]), Rathod *et al*. (2010[a]) and Nandeesh (2013).

Summary

VI. SUMMARY

A study was conducted over a period of one year to evaluate the efficacy of plate fixation by ventral approach for the stabilization of lumbar vertebral fractures in six clinical cases of traumatic posterior paresis or paralysis in dogs belonging to different age, sex, breed and body weight

1. The occurrence of posterior paralysis in dogs among the 10,043 clinical cases presented to the hospital over a period of one year was 208 (2.07%) and among these 35 cases had spinal fractures with an overall occurrence of 0.34 %.

2. Gender wise occurrence was 27 males (77.14 %) and 08 (22.85 %) females.

3. Breed wise occurence was highest in non descriptive dogs 12 (34.28%) followed by Labrador Retriever 7 (20%), Pomeranian 6 (17.14%), German Shepherd Dog 4 (11.42%), Doberman pinscher 3 (8.57%) and Dachshund 3 (8.57%).

4. The age-wise occurrence indicated that 15 dogs (42.85%) were within one year of age, 10 (28.57 %) were between one to three years, 6 (17.14%) were between three to five years, and 4 (11.42%) were more than five years of age.

5. Physical examination was found to be adequate in determining the tentative site of injury especially in dogs with fractures or dislocations of the vertebral column.

6. Myelography using Iohexol at the rate of 80 mg/kg body weight by cisterna magna puncture was useful in pinpointing the seat of lesion causing spinal cord compression. The use of iohexol for myelography was not associated with any post-

procedural complications like seizures suggesting that the drug was safe for the procedure in all clinical cases of paraplegia.

7. Neurological examination including bladder function on presentation was useful in localization of the lesion and was efficient in evaluating the effectiveness of the treatment modalities at different intervals during the period of evaluation.

8. Bladder function was one of the first functions to return in paraplegic dogs. It could be considered as an early prognostic indicator for neurological recovery in a paraplegic dog.

9. Absence of deep pain sensation in the hind limbs on the day of presentation indicated poor prognosis for recovery after surgical or non surgical treatment.

10. Lateral radiographs were easy to obtain compared to dorsovenral view and helped in good assessment of status of the implants postoperatively.

11. Variable levels of callus formation was observed radiographically during the healing of vertebral fractures.

12. Atropine and diazepam were useful in reducing salivation and enhancing muscular relaxation respectively during anaesthesia for surgery. Anaesthesia provided by thiopentone and isoflurane was satisfactory for performance of surgery with uneventful and rapid recovery in all cases.

13. Plate fixation by ventral approach for the stabilization of lumbar vertebral fractures was performed without difficulty in all the cases.

14. Securing the dogs to the grilled cot to prevent movement of the spine helped in preventing implant failure and urine scalding.

15. Haemato – biochemical parameter like haemoglobin, packed cell volume, total erythrocyte count, Serum calcium, phosphorus, potassium, aspartate aminotransferase and alanine aminotransferase were found to be within the normal physiological range in all dogs during the study period.

16. Total leukocyte count and differential leukocyte count indicated stress leukogram in paraplegic dogs.

17. Complete neurological recovery was seen in five dogs (83.33 %) out of six dogs during the period of study.

In conclusion, the technique of mid ventral approach was a simple and efficient technique with high success rate for treatment of lumbar spinal fracture in dogs.

The recommended future studies include evaluation of ventral plating with or without laminectomy or any other decompressive procedures, ventral versus dorsal plating techniques and comparison of different types of plates in ventral approach for spinal fixation.

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Abstract

VIII. ABSTRACT

Lumbar spinal plate fixation was done by mid ventral approach in clinical cases of traumatic posterior paralysis in dogs presented to Veterinary College Hospital, Bangalore. Lumbar fracture was more common in non-descriptive, male dogs and in young dogs which were less than one year of age. Most common cause of traumatic posterior paralysis was automobile accidents followed by fall from height. Radiography was helpful in identification of the fractured site, post operative assessment of the status of implants and healing of the lumbar vertebral fractures. Myelography was performed using Iohexol at the rate of 80 mg/kg body weight by cisterna magna puncture to localize site of lesion.

There was no significant variation in physiological (rectal temperature, heart rate and respiratory rate), haematological (Hb, TEC, PCV) and biochemical parameters (calcium, phosphorus, potassium, ALP, AST, ALT). Stress leucogram was evident in TLC and DLC. Five out of the six cases chosen for the study programme showed complete functional recovery and weight bearing from 15th post operative day onwards. Post operative complications were minimum in this technique. This technique efficiently provided a good stability at the fractured site of lumbar vertebrae in traumatic posterior paralytic dogs and had high success rate.

Key words: Traumatic posterior paraslysis, lumbar spine, ventral approach, plate fixation, myelography, functional recovery, stress leucogram, dog.