Original Research Article

EVALUATION OF TITANIUM MINI PLATES FOR REPAIR OF MANDIBULAR FRACTURES IN CLINICAL CASES OF DOGS

Abstract: The efficacy of straight, 4 holed titanium miniplates for repair of mandibular fractures in six dogs was evaluated. Mandibular fractures accounted for about 4.8% in the present study, commonly occurred in shih tzu and non-descript, male dogs of less than one year of age. The common site of fracture was the premolar region and unilateral fractures were more compared to bilateral fractures. The physiological and hematological parameters were within normal physiological range and statistically non-significant, except the leucocyte count, which showed significant variations and higher values at the beginning of the study due to presence of infection, which reduced with administration of antibiotics. Biochemical parameters namely serum calcium, phosphorous, creatinine and ALT showed non-significant variations. However, alkaline phosphatase showed significant variations. Immediate post-operative radiographs showed good alignment of the fractured mandible with adequate reduction. At the end of the study the mandible healed with minimum or no callus formation. This technique provided excellent stability, early return to normal function and normal occlusive alignment was maintained throughout the study.

Keywords: Dog, Mandibular fracture, Mandibular plating, Titanium miniplates, monocortical screws.

Introduction Dogs are not our whole life, but they make our lives whole. As both people and dogs are social beings and co – dependent on each other. Mandibular fractures in dogs represents about 3 – 6 percent which may be due to vehicular trauma, falls, kicks, gunshot wounds and fight with other animals (Smith and Kern, 1995) Mandibular and maxillary fractures in dogs and cats may result in severe functional deficiencies (inability to eat and drink) and gross disfigurement. Surgical repair of mandibular and maxillary

fractures may be required for restoration of not only function, but also the cosmetic appearance (Boudrieau, 2012). The primary objectives of fracture fixation of the mandible or maxilla are to restore normal occlusion and masticatory function.

Mandibular fractures can be diagnosed by clinical evaluation which includes signs like presence of blood tinged saliva, asymmetry of mouth and difficulty in chewing of food and radiographic evaluation. The different methods for management of facial fractures are tape muzzles; intraoral splinting; aluminium rod splinting; interdental wiring; internal fixation with bone plates, screws, and orthopaedic wires; and external fixation devices (Davidson and Bauer 1992)

In this study miniplates were applied to the alveolar margin of the affected side, on the aboral surface for repair of maxillary and mandibular fractures in dogs which healed without any complications.

Materials and methods

All six dogs with difficulty in eating, blood-stained saliva and inability to close mouth were subjected to detailed physical and orthopaedic examination for signs of swelling at the mandible region, discontinuity in mandible, pain upon palpation, crepitation at the fractured site and deviation from normal alignment of the mandible were recorded. The physiological parameters viz. rectal temperature (^{0}F), respiratory rate (breaths per minute) and heart rate (beats per minute), haematological parameters viz. Haemoglobin (Hb) (gm/dl), Total Erythrocyte Count (TEC) (10^6 cells/cmm), Total Leucocyte Count (TLC) (10^3 cells/cmm), and Differential Leucocyte Count (DLC) (%) and biochemical parameters

viz. Calcium (mg/dl), Phosphorus (mg/dl), Alkaline Phosphatase (ALP) (IU/l), Alanine Amino Transferase (ALT) (IU/l) and Creatinine (mg/dl) were recorded and radiographic views of mandible fracture (dorsoventral, lateral and oblique views) were evaluated prior to surgery and on 0^{th} , 7^{th}, 15^{th}, 30^{th}, 45^{th} and 60^{th} post-operative days. The radiographs were evaluated for fracture stabilization with titanium miniplate fixation and progress of healing was evaluated.

In this study straight Titanium miniplates of sizes 1.5 mm and 2 mm, four holed and the screws were selected depending on the size of the plate with a diameter of 1.5 mm or 2 mm with varied lengths of 6 mm, 8 mm, 10 mm, 12 mm depending on the thickness of the mandible. All the dogs were withheld food for twelve hours and water for six hours prior to surgery. All dogs were premedicated with atropine sulphate and Xylazine hydrochloride at the dose of 0.04 mg / kg and 1 mg / kg body weight I/M (intramuscularly) respectively. After 15 minutes, the general anaesthesia was induced with intravenous (I/V) administration of 2.5% solution of thiopentone sodium at the dose of 12.5 mg / kg body weight and maintained to effect with the same. All the animals were administered with ceftriaxone at the dose rate of 25 mg / kg body weight I/V as prophylactic antibiotic and tramadol was given as pre-emptive analgesic at the dose rate of 2 mg / kg body weight I/V. The surgical procedure required the dog to be positioned in dorsal recumbency with head extended for fracture repair of rostral shaft of the mandible.

fig1: **Dorsal recumbency of dog for repair of rostral mandibular body fracture.**

and lateral recumbency with affected side upper most for ramus of the mandible.

fig 2: **Lateral positioning of the dog with the affected mandible at the top**

The skin incision started dorsally just below the temporomandibular joint and extended rostro ventrad to end over the mandibular shaft at the level of the last molar. The incision was deepened through subcutaneous tissue and platysma muscle. An incision was made across the fibres of the superficial layers of the masseter muscle, roughly paralleling the caudal border of the mandible. After cutting through the superficial layers of the masseter muscle, the middle and deep layers were elevated from their insertion on the caudal and ventral parts of the masseteric fossa. Careful dorsal dissection and retraction allowed exposure of the ramus to the level of temporomandibular joint. (Kenneth a. Johnson, In Piermattei Atlas of Surgical Approaches to bones and joints. 2014).

On exposure of the fractured segments the titanium miniplate was applied to the caudal fracture segment near the alveolar margin of the mandible by positioning the plate and drilling holes into the cortex of the bone using 1.5 mm drill bit. The plate was fixed to the fractured segment using 2 mm screws into the pre drilled holes using special screw driver for mini screws *i.e*. screw driver with sleeve. Size of the screw (length) was relative to the thickness of bone, thicker the bone lengthier screws were placed and the screw placement up to a 30º angle relative to the plate avoided impingement to the tooth roots. Further the rostral segment was aligned to anatomical alignment and the screws were applied in the similar manner to stabilize the fractured bone.

fig 3: **Titanium miniplate fixed at the fractured site after tightening of screws.**

Thus the fracture bone was rigidly immobilized with titanium miniplates. The surgical site was closed routinely.

fig 4: **Closure of skin using non – absorbable suture after stabilization of mandibular fracture using titanium miniplate**

Postoperatively, the surgical wound was cleaned daily with povidone iodine solution for one week. Ceftriaxone and Tazobactum was administered I/M at the dose rate of 25 mg / Kg body weight for 7 days post operatively and meloxicam at dose rate of 0.2

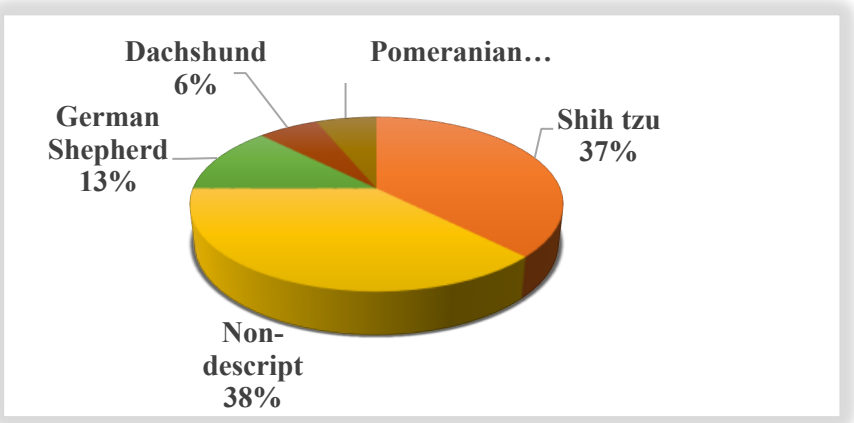
mg / Kg body weight I/M for 5 days. The patient was kept off feed for 5 days and maintained on I/V fluids. Further, the liquid diet was advised for a period of 45 days in order to minimize the movement of the fractured segments. The skin sutures were removed on 14th postoperative day. The postoperative complications if any during the study period were recorded. All the results of clinical, haematological, and biochemical parameters were statistically analyzed.

RESULTS AND DISCUSSION

The present study on evaluation of titanium miniplates for repair of mandibular fractures was carried out among six clinical cases of dogs. Out of the 8635 canine cases, the cases with orthopaedic affections were 331 and (3.83 %). Among the 331 orthopaedic cases, mandible bone fractures were 16 (4.8%)

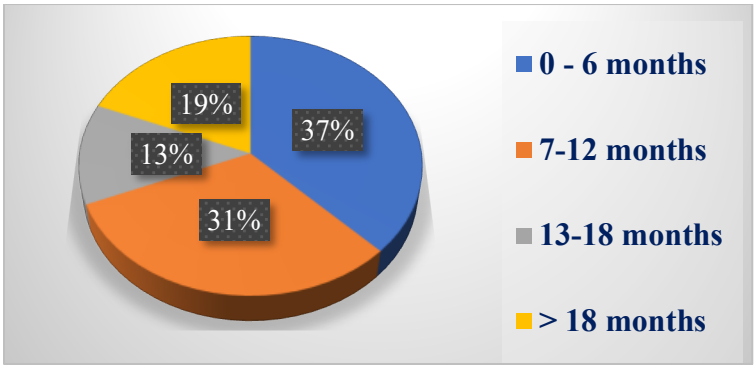
Among the breeds of dogs, the Shih Tzu and Non-descript breeds were commonly affected comprising of 37.5 % (n = 6) and 37.5 % (n = 6) respectively.

fig 5: **Breed-wise occurrence of mandibular fracture in dogs (%)**



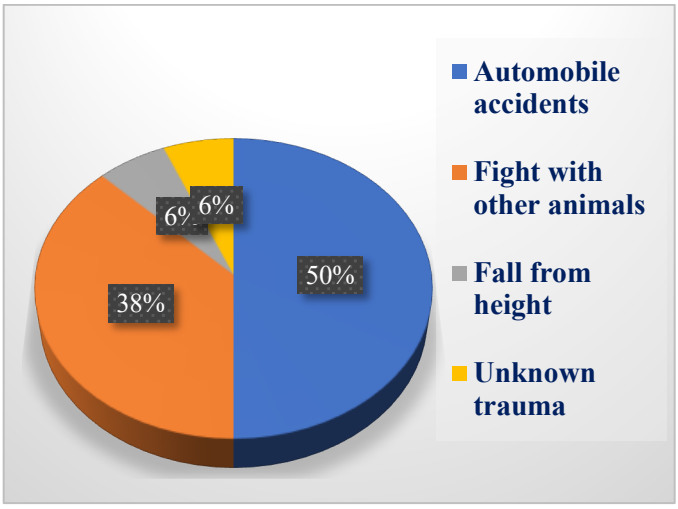
Most of the dogs affected with mandibular fractures were within one year of age. The male dogs (about 75%) were commonly affected with mandibular fractures.

fig 6: **Age-wise occurrence of mandibular fractures in dogs**



In the present study, most common cause of mandibular fracture was by automobile accidents (n = 8, 50 %), followed by trauma due to fight with other animals, fall from height and unknown trauma

fig 7: **Aetiology for mandibular fractures in dogs**



TYPE AND LOCATION OF FRACTURE

Out of 16 mandibular fractures, bilateral fractures were common, followed by unilateral fracture and the symphysis and mandibular body. Out of 22 fractures, the common region affected was Premolar region (n = 18, 81.81 %) , Molar region (n = 3, 13.63 %) and Symphyseal region (n = 1, 4.54 %). Orientation of fracture was Oblique (n = 14, 63.63 %), Transverse (n = 7, 31.81 %) and Splintered (n = 1, 4.54 %)

PHYSICAL EXAMINATION

All the animals included in the study underwent physical examination to determine dropping of jaw or asymmetry of the jaw and crepitation or open wound or any concurrent abnormalities related with the trauma. The most common clinical sign was drooping of lower jaw (bilateral fractures) and asymmetry of the lower jaw. The plates were selected based upon the bone thickness which varied according to the age of the dog. The titanium mini screws of varied lengths placed monocortically were used to fix the plate to the mandible to stabilize the fracture.

SURGICAL TECHNIQUE

The ventral midline approach to the affected mandibular body and symphysis was adequate to expose the fracture in case 1 and 2. Whereas in case 3 and 4 ventrolateral approach was needed for bilateral mandibular body fractures, whereas, case 5 and 6 had unilateral fracture which was approached ventrolaterally. The titanium miniplates were able to contour to fit the mandibular body against the surface of the bone to aid in adequate contact of the plate to the bony surface and stabilization of the fracture segment. A minimum of two screws applied monocortically to the titanium miniplates on either side of the fractured line was adequate to immobilise the fracture until healing.

In the present study, six dogs with mandibular fractures were selected.

table 1: **Details of dogs with mandibular fractures selected for the study**

Case no	Age	Breed	Sex	Cause of mandibular fracture	Site of mandibular body operated
1	4 years	Dachshund	Male	Automobile accident	Right side of mandibular body (404 & 405) along with symphysis
2	6 months	Non-descript	Male	Automobile accident	Left side of mandibular body (306 & 307 , 301 & 401)
3	5 ½ years	Non-descript	Female	Pig fight	Bilateral mandibular body fracture (408 & 409 , 308 & 309)
4	6 months	German shepherd	Female	Automobile accident	Bilateral mandibular body fracture (405 & 406 , 305 & 306)
5	6 months	Shih Tzu	Female	Fall from height	Right mandibular body fracture (408 & 409)
6	1 ½ years	Shih Tzu	Female	Dog fight	Right mandibular body fracture (408 & 409)

POST-OPERATIVE CARE AND MANAGEMENT

In the present study in all the six dogs, the wound was dressed with povidone iodine solution was done until no discharge was noticed from the surgical site. Post-operatively the antibiotic (Ceftriaxone and Tazobactum) and analgesic (Meloxicam) provided good antimicrobial prophylaxis and anti-inflammatory and analgesic effect respectively. The liquid diet for a period of 45 days provided additional support for immobilizing the fracture and maintain implant stability.

CLINICAL EVALUATION

The physiological parameters evaluated prior and post-surgery were the rectal temperature, heart rate and respiratory rate which were in normal physiological range and statistically non – significant.

The dogs were subjected for haematological evaluation and the parameters evaluated were haemoglobin, erythrocyte count, total leucocyte count and differential leucocyte count. The haemoglobin and erythrocyte count was in normal physiological range and were statistically non-significant. Whereas the total leucocyte count was slightly higher during the initial days of the study which later became normal and was statistically significant. The differential leucocyte count parameters included neutrophils, basophils, eosinophils, lymphocytes and monocytes were in normal physiological range and were statistically non- significant .

The biochemical studies serum calcium , serum phosphorous, serum alkaline phosphatase, serum alanine transferase and serum creatinine were evaluated prior and post-surgery which were in normal physiological range and were statistically insignificant except alkaline phosphatase which

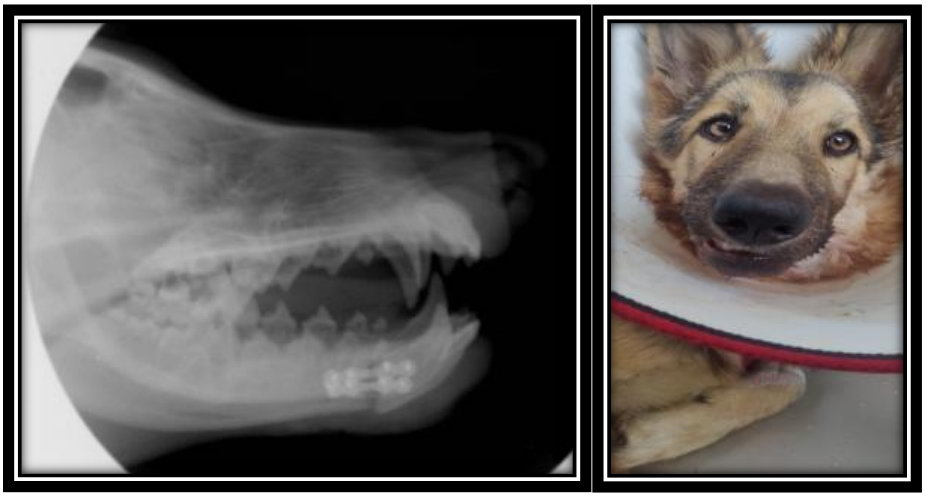
was significantly increased from 15th to 30th post operative day and later decreased during 45th post operative day and was within normal physiological range.

RADIOGRAPH and CILINICAL EVALUATION (CASE IV)

The preoperative radiograph showed bilateral transverse fracture at the level of 405 and 406 on right side, and between 305 and 306 on left side of case (iv). There was drooping of mandible and blood tinged saliva. The immediate post-operative radiograph showed adequate fixation of fractured fragments with titanium miniplate. There was perfect alignment of fractured mandible.

fig 8: **Day 0 The pre-operative radiograph showing complete transverse rostral mandibular body fracture (left) and drooping of mandible (right)**

fig 9:**Post-operative**



Day 7: There was no alteration in alignment of the miniplate and fractured bone and dog was able to close the mouth. Slight discharge was noticed from surgical site. In case 5 there was loosening of plate and displacement of screw.

fig 10: **Day 7**

fig 11: **Displacement of screw and displacement of plate in case 5**

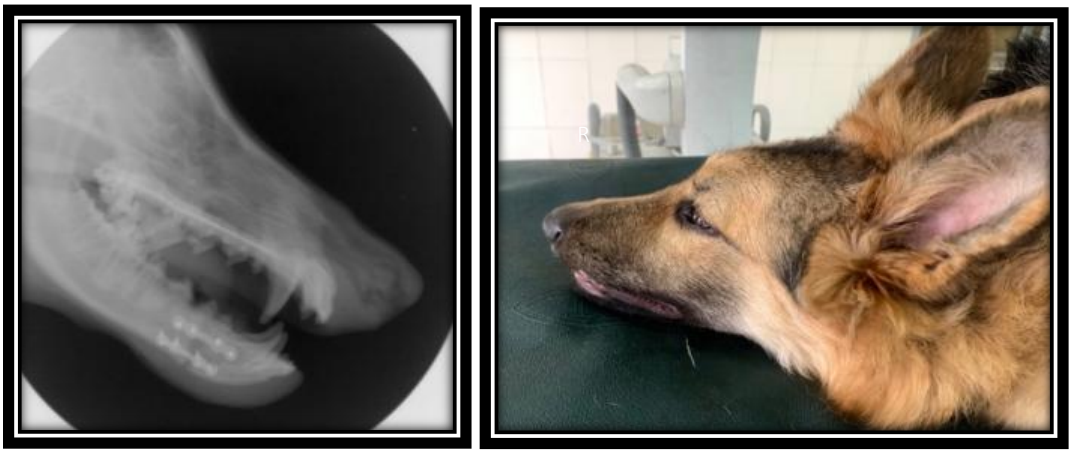
Day 15: There was no alteration in alignment of the miniplate. There was appearance of decrease in the width of fracture line which indirectly indicated the initiation of endosteal and periosteal callus. No discharge from surgical site. Dog started taking soft food. However in case 3 due to continuous champing of the jaw loosening of screws was observed along with displacement of the plate.

fig 12:**Day 15**

fig 13: **Radiograph of case 3 (complication)**

Day 30: The radiograph of 30th post-operative day showed further decrease in size of fracture gap. There was apparent filling of fracture line with feathery callus and there was perfect alignment.

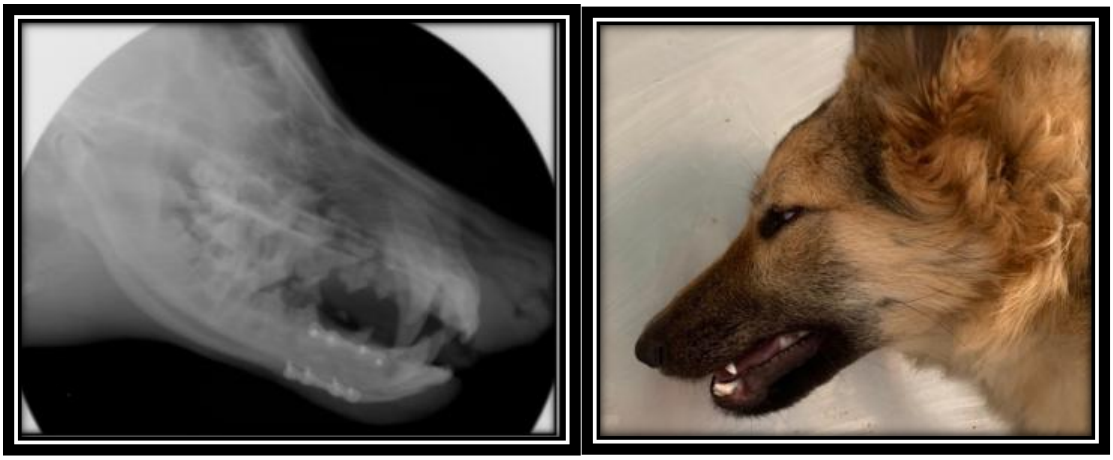
fig 15: **Day 30**



Day 45: The radiograph revealed that the titanium miniplate in position with adequate apposition of the fracture segments and there was normal apposition of the jaw.

Day 60 The radiograph revealed that the miniplate in situ with adequate apposition of the fracture segments. fracture had completely stabilised and dog had no difficulty in eating.

fig 16: Day 60



DISCUSSION

Among the 331 orthopaedic cases, mandible bone fractures were 16 (4.8%). Similar observations of occurrence of mandible fractures were made by Glyde and Lidbetter (2003), Aswathy *et al.* (2019) and Sangamitra and Vijay (2021). This was as the mandible had lesser impact and required greater force than long bone. The most common breeds affected were shih tzu and non-descript dogs (37.5%) could be due to its small size advantage and easy maintenance. Guzu and Hennet (2017) found the reason for mandibular fractures in small and toy breed dogs was due to the small facial bones and teeth that were excessively large relative to the amount of supporting bone and Gioso *et al*. (2001) stated that smaller dogs possessed decreased mandibular bone height compared to M1 height. Young dogs were mostly affected as they were in developing stage, having soft bone in the osteogenesis stage. Similar observations were reported by Umphlet and Johnson (1990), Goswami (2015) and Scherer *et al.* (2018). Kitshoff *et al.* (2013) stated that young dogs were over presented as they had relatively low bone density which predisposed to fracture. Male dogs outnumbered the female dogs as males were territorial and aggressive and had more access to outdoors, mainly in search of females in heat, made them more exposed to accidents or to be involved in fighting. These observations correlated with the findings of Lopes *et al.* (2005). Common cause of

mandibular fractures was automobile accidents similar findings were seen by Harasen (2008) and Minar *et al.* (2013).This was due to increase in vehicles traffic and if the dogs were left unattended during walking. Bilateral fractures were more common than unilateral fractures and common location was premolar region. The premolar region was commonly affected as there was reduced musculature at that region. Similar observations were made by Mahesh (2005) and De Paolo *et al.* (2020).

Mandibular fractured dogs showed asymmetry of the lower jaw and drooping of the mandible (bilateral fractures). The dogs were reluctant to eat as they evinced pain and were unable to chew the food. Blood tinged saliva and haematoma at the fracture site was noticed in few cases along with crepitations at the fractured site. Similar observations were reported by Goswami (2015) and Kaur (2016). Thorough intra oral examination was needed to identify concurrent injuries to soft tissue. One case had a history of canine distemper infection and maggot wound in the hard palate region at level of canine tooth could be due delayed presentation of fracture.

The titanium miniplate used in the study were straight and were easily contoured according to the shape of the mandible and the dynamic load from the jaw functions were balanced by static load from the plates as suggested by Champy *et al.* (1978). The miniplates provided the advantage of reduced soft tissue dissection, early return to normal function and achieved proper anatomical alignment Boudrieau (2012). In the present study, the monocortical screws adequately stabilized the plates with the bone until fracture healed. Boudrieau (2012) found the non-reactive, non-toxic, corrosion resistant, high elasticity and antimagnetic properties of the titanium metal.

The titanium miniplate was applied on the alveolar border (tension surface) along the aboral surface of the mandible to counter mandibular bone stresses accorded with tension band principle. Boudrieau (2004) and Boudrieau (2012) suggested the similar application of titanium miniplate to the aboral surface of mandible. The post-operatively dogs were kept on I/V fluids for five days after the surgery this minimized the

movement of the titanium miniplates till the callus was formed. Chewing of any hard objects was avoided until the fracture healed.

The rectal temperature, heart rate and respiration were in normal physiological range indicating that the implant application didn't affect the parameters. Haemoglobin and erythrocyte count were within normal limits similar findings by Gahlod *et al.* (2010) and Srinivasa Murthy (2015). However there was significant variation in the total leucocyte count which was due to corticosteroid release in response to stress, pain, trauma, surgical manipulation and infection. The values returned to normalcy by 15th post-operative day indicating a resolution of inflammation and stress. Similar observation were earlier reported by Patil *et al.* (2017). Neutrophil, Lymphocyte, Monocyte, Eosinophil and Basophils counts were statistically non-significant.

Serum calcium, serum phosphorous, serum alanine aminotransferase and serum creatinine values showed a non-significant variation throughout the study period. The results were in agreement with Mahesh (2005), Gahlod *et al*. (2010), Srinivasa Murthy (2015) and Reddy *et al*. (2020). However there was a significant increase in peak value of serum alkaline phosphatase level observed on the 7th , 15th and 30th postoperative day, after which the values lowered towards the end of the study period. The elevated levels of alkaline phosphatase was attributed to the increased osteoblastic activity leading to increased rate of release of enzyme into the serum. The results were in agreement Mahesh (2005) and Goswami *et al*. (2015).

Post-operative radiographs were evaluated for the fracture apposition, alignment and reduction. Fracture apposition and alignment were noticed anatomical in four cases (66.66 %) and near anatomical in one case (16.66 %) and implant displacement in one case (16.66 %) fracture reduction were excellent in four cases (66.66 %) and good in one (16.66 %). Kaur (2016) suggested oblique radiographic view for bilateral mandibular fracture to avoid overlapping. Freitag and Landau (1996) and Guzu and Hennet (2017) observed variations in healing of dentate fracture in which healing was delayed compared to edentulous fractures.

Dentate fractures healed through cartilaginous callus formation. Healing period for mandibular fractures ranged from 4 to 8 weeks. Immediate after the surgery the normal anatomical symmetry was achieved. There was perfect alignment of upper and lower jaw and there was no hanging out of the tongue.

Similar observation were made by Mahesh (2005) and Goswami (2015). In all the six cases adequate healing was observed on 60th day post-operatively. Mahesh (2005) reported in their studies that on 30th post-operative day more periosteal reaction was observed at the fracture site and on 60th day there was complete union of the fracture site with excessive callus. Immediate after the surgery the normal anatomical symmetry was achieved. There was perfect alignment of upper and lower jaw and there was no hanging out of the tongue. On 7th day the dogs were able to take liquid diet with ease and there was no pain. Sutures were intact and slight discharge was noticed from the surgical site. Symmetry of the mouth was maintained. However in one case there was loosening of screw which did not affect the symmetry and the normal functioning of the jaw. Dogs did not evince any pain. On 15th day sutures were removed and there was no signs of wound dehiscence and normal anatomical symmetry of the lower jaw was present. Except in one case where there was displacement of the implant. At the end of study i.e. on 60th day all the dogs except one had normal symmetry of the lower jaw and fracture was completely stabilized. There was normal apposition of upper and lower jaw in all the cases except one. Mahesh (2005) reported in their studies that on 30th post-operative day more periosteal reaction was observed at the fracture site and on 60th day there was complete union of the fracture site with excessive callus. Goswami (2015) in their studies noticed that on 0th post-operative day animal had perfect alignment of the fractures mandible, on 3rd day animal started taking liquids, 7th day semi solid food and from 12th day usual dog food. On 15th day it was noticed that jaw was in perfect alignment, however in one animal there was halitosis, discharge of sequestrum from fracture site and loosening of screws. On 45th day there was imperceptible fracture spot and deeply embedded orthopaedic plates and screws.

POST-OPERATIVE COMPLICATIONS Post-operative wound dressing was done every alternative day and observed for healing pattern for about 15 post-operative days. Pus discharge at the incision site noticed at early postoperative days which subsided with administration of ceftriaxone and cleaning of the wound with povidone iodine liquid. The sutures were removed on 15th day when there was optimum wound healing. Most common complications with mandibular fractures were malocclusion, osteomyelitis recorded by Umphlet and Johnson (1990). Spiessl (1989) stated that use of a shorter plate and placement of screws too close to fracture site led to failure of the implant. Weigel (1985) stated that mandibular fractures cannot tolerate small malalignments which were well tolerated in diaphyseal fractures. Boudrieau and Kudisch (1996) reported that the primary complication following miniplate fixation was screw loosening, plate exposure through oral mucosa and collateral damage to the adjacent anatomical structures. Boudrieau (2012) repaired maxillofacial fractures using miniplate systems and reported that incorrect placement of plates other than alveolar margin, were of insufficient stress to counteract functional masticatory forces, improper bending of the plate shifted the normal occlusion, improper drilling of holes in the bone resulted in oval shaped holes which finally led to loosening of screws, inadequate soft tissue covering of the plate led to delayed healing and infection, instability of fracture led to delayed or non-union and presence of teeth at fracture site led to pulp necrosis.

In present study there no collateral damage to adjacent anatomical structures and there was no plate exposure through oral mucosa. In present study there was loosening of screw in two cases, one due to continuous champing of the jaw and the stability of the fracture fixation was lost and in other case due to improper drilling of the holes led to screw displacement and implant loosening. In present study non-union was noticed in one case and oval shaped holes led to screw loosening. In all other cases there was adequate soft tissue covering the fracture site which led to satisfactory healing of the mandible fractures.

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