



# Evaluation of Titanium Mini Plates for Repair of Mandibular Fractures in Clinical Cases of Dogs

**K. M. Srinivasa Murthy<sup>a++</sup>, H. Rashmitha<sup>a#</sup>,  
B. N. Nagaraja<sup>a†</sup>, V. Mahesh<sup>a++</sup> and Girish M. Halemani<sup>b++</sup>**

<sup>a</sup> Department of Veterinary Surgery and Radiology, Veterinary College, Karnataka Veterinary, Animal and Fisheries Sciences University (KVAFSU), Bangalore, India.

<sup>b</sup> Department of Veterinary Clinical Medicine, Veterinary College, KVAFSU, Bangalore, India.

## Authors' contributions

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## 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.

<sup>++</sup> Associate Professor;

<sup>#</sup> M. V. Sc. Scholar;

<sup>†</sup> Professor and Head;

\*Corresponding author: E-mail: rashmithaheerekar@gmail.com;

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.

## 1. 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 [1] 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 [2]. 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 [3].

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.

## 2. 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 ( $^{\circ}$ F)(degree Fahrenheit), respiratory rate (breaths per minute) and heart rate (beats per minute), haematological parameters viz.

Haemoglobin (Hb) (gram/decilitre)(gm/dl), Total Erythrocyte Count (TEC) (cmm-cubicmillimeter) ( $10^6$  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 statistically analyzed using computer based statistical programme, using one way analysis of variance (ANOVA), Graph pad prism, and interpreted as per the procedure described by Snedecor and Cochran (1996). Radiographic views of mandible fracture (dorsoventral, lateral and oblique views) were evaluated prior to surgery and on 0<sup>th</sup>, 7<sup>th</sup>, 15<sup>th</sup>, 30<sup>th</sup>, 45<sup>th</sup> and 60<sup>th</sup> 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 and lateral recumbency with affected side upper most for ramus of the mandible.



**Fig. 1. Dorsal recumbency positioning of dog for repair of rostral mandibular body fracture**



**Fig. 2. Lateral positioning of the dog with the affected mandible at the top for mandibular fracture repair**

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 [4].

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 30° 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.

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

Postoperatively, the surgical wound was cleaned daily with povidone iodine solution for one week. Ceftriaxone and Tazobactam 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 14<sup>th</sup> postoperative day. The postoperative complications if any during the study period were recorded.



**Fig. 3. Titanium miniplate fixed at the fractured site after tightening of mini screws placed monocortically**



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

### 3. RESULTS

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 presented to the department, 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 Indie breeds were commonly affected comprising of 37.5% (n = 6) and 37.5% (n = 6) respectively.

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.

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.

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 %).

#### 3.1 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.

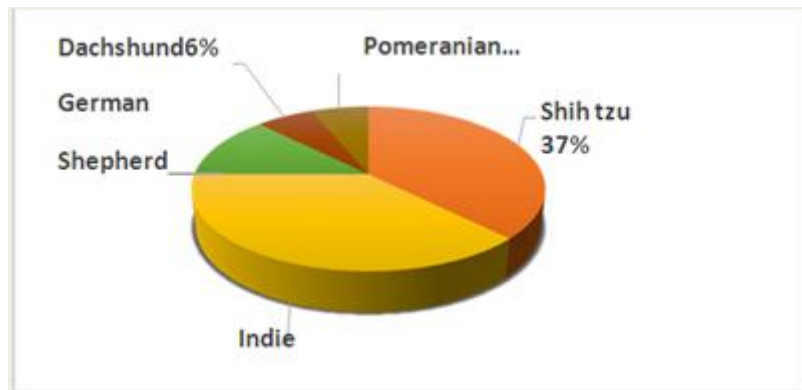


Fig. 5. Breed-wise occurrence of mandibular fracture in dogs (%)

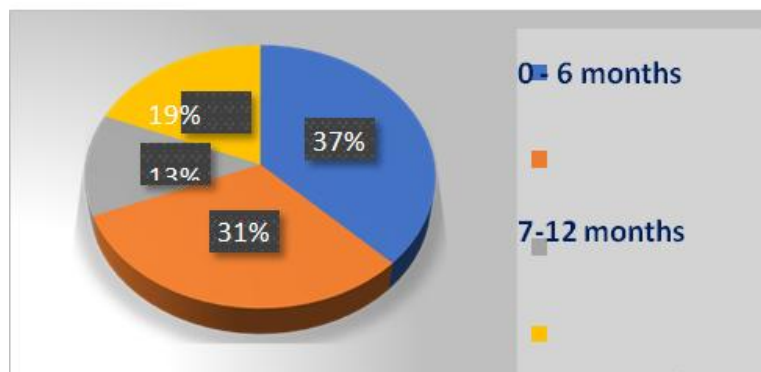
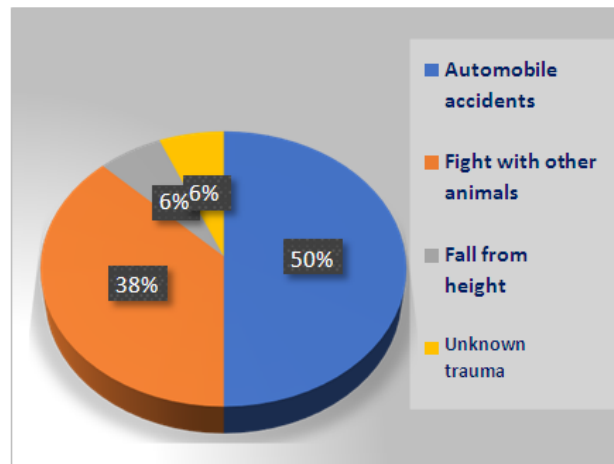


Fig. 6. Age-wise occurrence of mandibular fractures in dogs



**Fig. 7. Aetiology for mandibular fractures in dogs**

### 3.2 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.

### 3.3 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 Tazobactam) 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.

### 3.4 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 which was done through ANOVA.

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 15<sup>th</sup> to 30<sup>th</sup> post operative day and later decreased during 45<sup>th</sup> post operative day and was within normal physiological range.

### 3.5 Radiograph and Clinical Evaluation (Case IV)

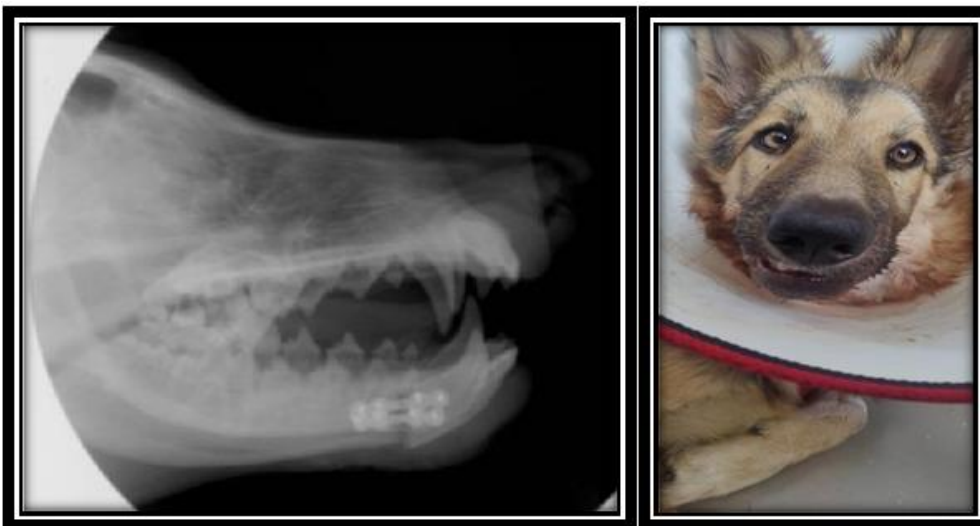
The preoperative radiograph showed bilateral transverse fracture at the level of 405 and 406 on right side, and between 305 and 306 on left side of case (iv). There was drooping of mandible and blood tinged saliva. The immediate post-operative radiograph showed adequate fixation of fractured fragments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

**Table 1. Details of dogs with mandibular fractures selected for the study**

<b>Case no.</b>	<b>Age</b>	<b>Breed</b>	<b>Sex</b>	<b>Cause of mandibular fracture</b>	<b>Site of mandibular bodyoperated</b>
<b>1</b>	4 years	Dachshund	Male	Automobileaccident	Right side of mandibularbody (404 & 405) along withsymphysis
<b>2</b>	6 months	Indie	Male	Automobileaccident	Left side of mandibularbody ( 306 & 307 , 301 & 401)
<b>3</b>	5 ½ years	Indie	Female	Pig fight	Bilateral mandibular bodyfracture (408 & 409 , 308 & 309)
<b>4</b>	6 months	German shepherd	Female	Automobileaccident	Bilateral mandibular bodyfracture (405 & 406 , 305 & 306)
<b>5</b>	6 months	Shih Tzu	Female	Fall from height	Right mandibular bodyfracture (408 & 409)
<b>6</b>	1 ½ years	Shih Tzu	Female	Dog fight	Right mandibular bodyfracture (408 & 409)



**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 radiograph and apposition of lower and upper jaw post-surgery**

**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.

**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.

**Day 30:** The radiograph of 30<sup>th</sup> 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.

**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. 10. Day 7 showing no alteration in miniplate and closing of dog's mouth



Fig. 11. Displacement of screw and displacement of plate in case 5

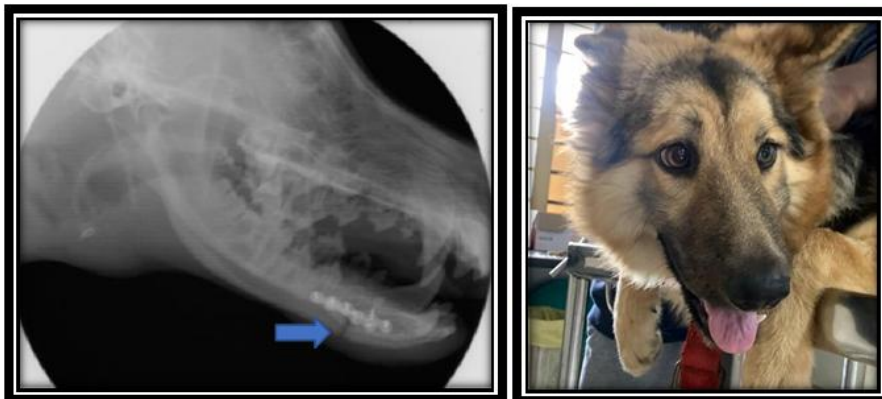


Fig. 12. Day 15 radiograph showing decrease in fracture line

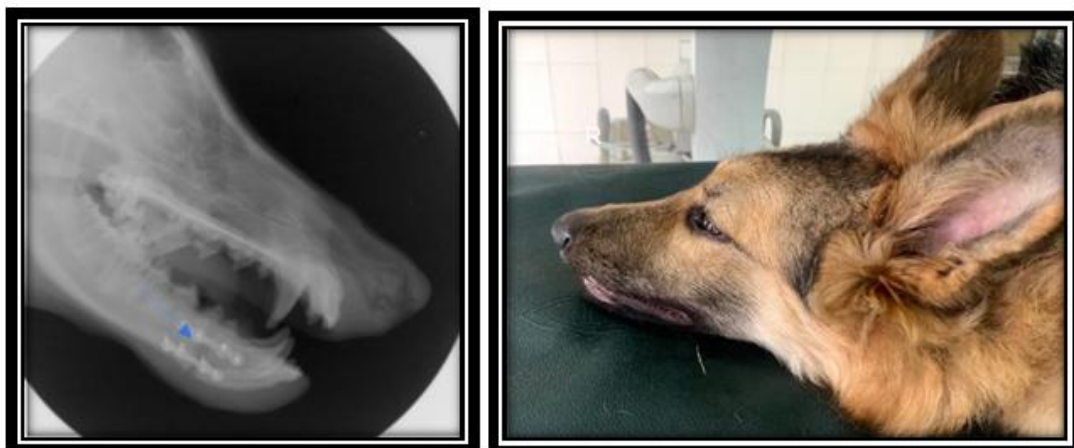


**Fig. 13. Radiograph of case 3 (complication) there is displacement of plate and failure of implant**

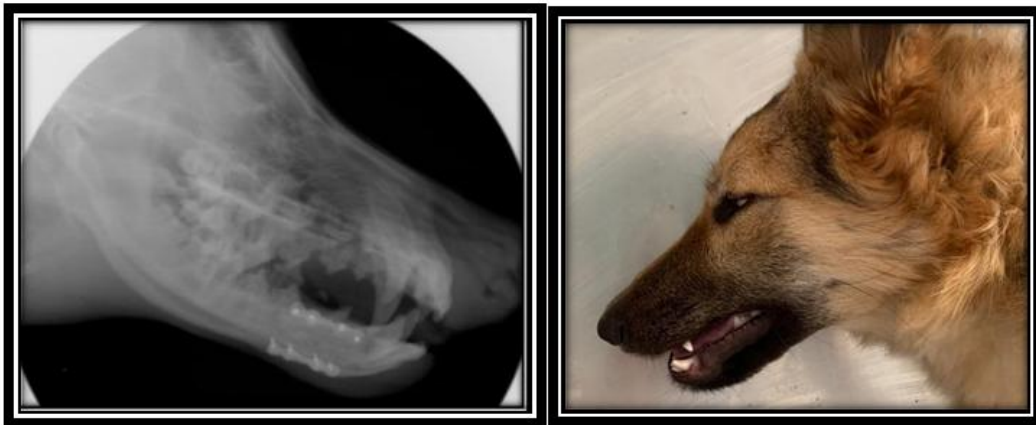
#### **4. DISCUSSION**

Among the 331 orthopaedic cases presented to the department, mandible bone fractures were 16 (4.8%). Similar observations of occurrence of mandible fractures were made by [5-7]. This was as the mandible had lesser impact and required greater force than long bone. The most common breeds affected were shih tzu and indie dogs (37.5%) could be due to its small size advantage and easy maintenance. This was in agreement as 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 [8] and as smaller dogs possessed decreased mandibular bone height compared to M1 height [9]. Young dogs were mostly affected as they were in developing stage, having soft bone in the osteogenesis stage. Similar observations were reported by [10-

14]. Young dogs were over presented as they had relatively low bone density which predisposed to fracture [13]. 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 [8,11,14], Common cause of mandibular fractures was automobile accidents similar findings were seen by [15,16]. 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 [17,18].



**Fig. 14. Day 30 radiograph showing filling of feathery callus**



**Fig. 15. Day 60 radiograph showing apposition of fracture and stabilised mandible of dog**

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 of mandibular fractures were reported by [11] and [19]. 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 [20]. The miniplates provided the advantage of reduced soft tissue dissection, early return to normal function and achieved proper anatomical alignment [2] and [22]. In the present study, the monocortical screws adequately stabilized the plates with the bone until fracture healed [2] 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 [2] and [23] 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 [23] and [24]. 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 15<sup>th</sup> post-operative day indicating a resolution of inflammation and stress. Similar observation were earlier reported by [23-25]. 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 [17,23,24,26]. However there was a significant increase in peak value of serum alkaline phosphatase level observed on the 7<sup>th</sup>, 15<sup>th</sup> and 30<sup>th</sup> 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 [17] and [11].

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 %). Oblique radiographic view for bilateral mandibular fracture to avoid overlapping [19]. Variations in healing of dentate fracture in which healing was delayed compared to edentulous fractures [27] and [8]. 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 [11] and [17].

In all the six cases adequate healing was observed on 60<sup>th</sup> day post-operatively [17] reported in their studies that on 30<sup>th</sup> post-operative day more periosteal reaction was observed at the fracture site and on 60<sup>th</sup> 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 7<sup>th</sup> 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 15<sup>th</sup> 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 60<sup>th</sup> 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. On 30<sup>th</sup> post-operative day more periosteal reaction was observed at the fracture site and on 60<sup>th</sup> day there was complete union of the fracture site with excessive callus. On 0<sup>th</sup> post-operative day animal had perfect alignment of the fractures mandible, on 3<sup>rd</sup> day animal started taking liquids, 7<sup>th</sup> day semi solid food and from 12<sup>th</sup> day usual dog food. On 15<sup>th</sup> 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 45<sup>th</sup> day there was imperceptible fracture spot and deeply embedded orthopaedic plates and screws [11].

#### 4.1 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 15<sup>th</sup> day when there was optimum wound healing. Most common complications with mandibular fractures were malocclusion, osteomyelitis recorded by [10]. Use of a shorter plate and placement of screws too close to fracture site led to failure of the implant [28]. Mandibular fractures cannot tolerate small malalignments which were well tolerated in diaphyseal fractures [29]. The primary complication following miniplate fixation was screw loosening, plate exposure through oral mucosa and collateral damage to the adjacent anatomical structures [30]. 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 [2].

In this study there was no collateral damage to adjacent anatomical structures and there was no plate exposure through oral mucosa. In this 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 this 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.

#### 5. CONCLUSION

In conclusion, titanium miniplating technique was found to be best suited for the treatment of the mandibular fractures as the technique was easy, to contour the plates to the shape of the bone that were easy to apply, provided excellent stability to the fractured fragments, helped in early return of mandible to normal function and

thereby, increasing the quality life of the dogs. The technique was economical compared to other plating systems for mandibular fracture repair in dogs.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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