**Indian J Anim Health (2026)**
DOI: https://doi.org/10.36062/ijah.2026.18825

**Research Article**

# Functional outcome of avulsion fractures in dogs stabilized using tension band wiring technique

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## Abstract

**The study was aimed to surgically manage the avulsion fractures of the tibial tuberosity (n=5), olecranon (n=2) and fibular tarsal (n=3) bones in 10 dogs with a mean age and body weight of 13.3±14.4 months and 13.7±8.5 kg, respectively. Falls from the height were the most common (60%) aetiology of avulsion fractures in these dogs, followed by automobile trauma (20%) and running on the track and dog fight (10% each). All fractures were repaired using tension band wiring technique with one or two K-wires/pins combined with a stainless-steel orthopaedic wire in a 'figure-of-8'. Functional outcome was assessed based on radiographs, weight bearing score, and goniometry of the joint involved. Minor complications included migration of one K wire/pin (n=3), breakage of stainless-steel wire (n=1) and splitting of the avulsed bone fragment (n=1) that lead to increased inter-fragmentary gap, mild malalignment and wound, but the final functional outcome remained acceptable in all the dogs. In conclusion, TBW construct using 2 or 1 K-wire/pin with a 'figure-of-8' wiring provides adequate fixation for the tibial and olecranon avulsion fractures. Minor implant-related complications associated with the technique, irrespective of the bone, had no adverse effect on the final functional outcome. Removal of the implant following completion of fracture healing further improved joint movement.**

**Keywords:** Canine orthopaedic surgery, Fibular tarsal fracture, Monteggia fracture, Tibial tuberosity fracture, Weight bearing

## Highlights

- Tibial tuberosity fracture occurs more frequently compared to fibular tarsal and olecranon in dogs.
- The TBW offers stable fixation for olecranon and tibial tuberosity avulsion fractures.
- Tension band wire construct removal after healing improves joint motion.
- Final functional outcome of avulsion fractures in dogs is not affected by minor implant-related complications.

## INTRODUCTION

Avulsion fractures occur when a fragment of bone gets detached from its parent bone by the pull of ligament or tendon. These injuries mostly occur due to high-energy trauma, and certain breeds are more prone to it due to their athletic working (the Grey Hounds). Avulsion fractures are biomechanically unstable due to the constant pull of the tendon on the proximal fragment and thus pose a challenge in its repair. There are various techniques described in the literature for the management of avulsion fractures which include conservative and surgical management (pinning, screw fixation, wire fixation). The avulsion fractures of tibial tuberosity are mostly seen in immature dogs (Cruz et al., 2020), due to high stress placed on by the patellar ligament on the physis of the tibial tuberosity (Pratt, 2001).

Tension band wiring (TBW) is one of the popular and recommended techniques for the stabilization of avulsion fractures (Piermattei et al., 2015; Morawska-Kozlowska et al., 2023) as it successfully converts tensile forces of the wire into compressive forces (Pratt, 2001; Von Pfeil et al., 2009), and thus provides a stable fixation to the biomechanically unstable fracture. This allows early motion and weight bearing and thus prevents joint stiffness, which is a common complication observed during prolonged immobilization of peri-articular fractures. The TBW technique is a cost-effective and less invasive technique.

International literature reports the short- and long-term outcomes of avulsion fractures in dogs repaired using the TBW technique, but Indian Veterinary literature cites sporadic case reports on the surgical management of avulsion fractures in dogs (Raghunath et al., 2008; Srinivasa Murthy et al., 2010). Certain queries regarding the TBW technique still remain unanswered; duration of functional recovery

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and potential complications specific to canine patients, such as implant migration or irritation due toquadrupedal gait and active lifestyle.

Considering the above facts, this study was aimed to address the gaps to assess the functional recovery and potential surgical complications in dogs treated for avulsion fractures using the tension band wiring technique.

## MATERIALS AND METHODS

The study included 10 dogs suffering from avulsion fractures: tibial tuberosity (n=5, Group TT), olecranon (n=2, Group O) and fibular tarsal (n=3, Group FT). The study was duly approved by IAEC and CCSEA.

**Pre-operative phase:** Signalment and history were noted in all the dogs.

Radiography- Two orthogonal radiographic views of the affected bone and contralateral healthy bone were obtained in a non-sedated state to confirm the condition and for comparison. The length and width of the avulsed fragment were measured and noted. The inter-fragmentary distance or the gaping, was recorded and was compared with the contralateral healthy bone. The pre-operative radiographic classification for tibial tuberosity avulsion fractures was done as per Von Pfeil et al. (2012): Type I - the least severe type, less than 2 mm gap between the fractured fragments and a widened growth plate. Type II – more than 2 mm gap and the fracture line might also extend through the growth plate and sometimes even reaching towards the posterior aspect. Type III - most severe type, with a significant step-off of greater than 2 mm within the joint itself with extensively detached growth plate.

Hematobiochemical observations- Haematology for complete blood count and serum biochemistry for calcium, phosphorous, alkaline phosphatase, and creatinine and blood urea nitrogen were doneas part of pre-operative/pre-anaesthetic assessment.

Goniometry- using a universal goniometer of the affected joint and the contralateral healthy joint was recorded at pre and follow up intervals to calculate the range of motion.

The weight bearing score (standing and walking), as described by Cook et al. (1999) and lameness scores, as described by Gill et al. (2018) were assigned to the dogs at preoperative and postoperative follow-ups.

**Operative phase:** All the dogs were operated under general anaesthesia which included pre-anaesthetization with BAG (Butorphenol @0.2 mg/kg, Atropine @ 0.04 mg/kg and Acepromazine @ 0.05 mg/kg, intramuscular) and induction with propofol @ 4 mg/kg slow Intravenous till effect and maintaining with Isoflurane mixed in 100% oxygen. The fracture site was aseptically prepared for surgery, and the affected limb was placed up during surgery.

**Technique of fracture fixation:** A hole was drilled in the distal fragment, below the fracture site to pass the wire {22G (n=9), 20G (n=1)} through it (Fig. 1a). A combination of K-wires/pins [1.5 mm (n=9) and 2 mm (n=1)] were inserted through the avulsed/proximal fragment in either retrograde (Olecranon and fibular tarsal) or normograde (tibial tuberosity and fibular tarsal) manner (Fig. 1b), which were further seated in the distal fragment (medullary canal) after alignment (Fig. 1c).

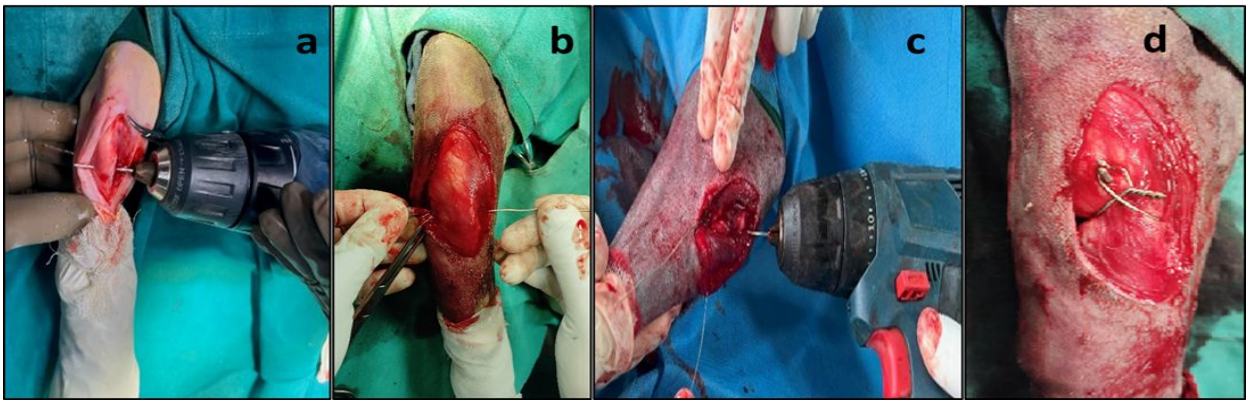



**Fig. 1. Serial photographs showing technique of tension band wiring in tibial tuberosity avulsion fracture (Group TT). Drilling of hole in the distal fragment close to the fracture (a), passing of wire through that hole (b), insertion of 1 or 2 pins/K wires in the proximal fragment in normograde manner (c), tightening of wire over the pins in a 'figure-of-8' (d)**

The wire was taken over the proximal outside part of the pin in a 'figure-of-8' and was tightened (Fig. 1d). The surgical wound was closed by applying subcutaneous sutures using polygalactin 910, no. 2-0 or 3-0 (as per the dog size) and skin sutures using nylon thread.

**Post-operative phase:** The operated limb was immobilized using modified Robert John bandaging (Fig. 2) along with the placement of the PVC splint {tibial tuberosity (medial splint), olecranon (caudal splint) and fibular tarsal (cranial and caudal splint)} for 10-14 days. The post-operative care included antibiotics, inj. Cefotaxime @ 25 mg/kg bwt, and twice a day for 5 days, analgesic inj. Meloxicam @ 0.2 mg/kg, once daily for 3 days and calcium and phosphorous-containing syrup 1-2 tsf orally for 15 days. No joint supplements were given to any of the dogs. The immediate post-operative radiograph was done in both lateral and anterio-posterior views and was graded as 0 (anatomical reduction), 1 (minimal, <1 mm malreduction), 2 (moderate, 1-3 mm malreduction) and 3 (severe, >3 mm malreduction) as described by Cook et al. (1999). Follow-up radiographs and functional outcome was recorded as and when the dog was presented or telephonically.

**Complications:** The radiographic or clinical complications observed were recorded and evaluated.

**Statistical analysis:** The Student t-test was applied to tibial tuberosity goniometry and weight bearing scores to determine significant difference at $p<0.05$ at different follow up intervals. Other subjective parameters were compared on percent basis between the groups. The mean±SD was calculated for the objective parameters.

## RESULTS

**Signalment and history:** The most commonly presented breeds were Greyhound (n=3) and Pomeranian (n=3), with a mean age of 13.3±14.4 months (range 4 - 48 months), and 70% of the dogs were skeletally immature. Relatively younger dogs were affected in Group TT (5.4±1.7 months), followed by in Group FT (9.3±2.5 months) and Group O (39.0±12.7 months). The mean±SD weight (kg) of dogs of Group FT was non-significantly heavier (15.3±9.0) than in Group TT (14.7±10.2) and Group O (8.8±3.2). Both males and females were equally represented in the study. The mean body weight of the dogs was 13.7±8.5 kg (range 5-30 kg), and the mean age of the fracture was 5.0±6.3 days (range 0 - 22 days), with the majority (60%; n=6) of the dogs were presented within 5 days following the trauma. The most common aetiology was fall from the height (60%) followed by automobile trauma (20%), running on a track (10%) and dog fight (10%). The right side was affected in 60% of the dogs.

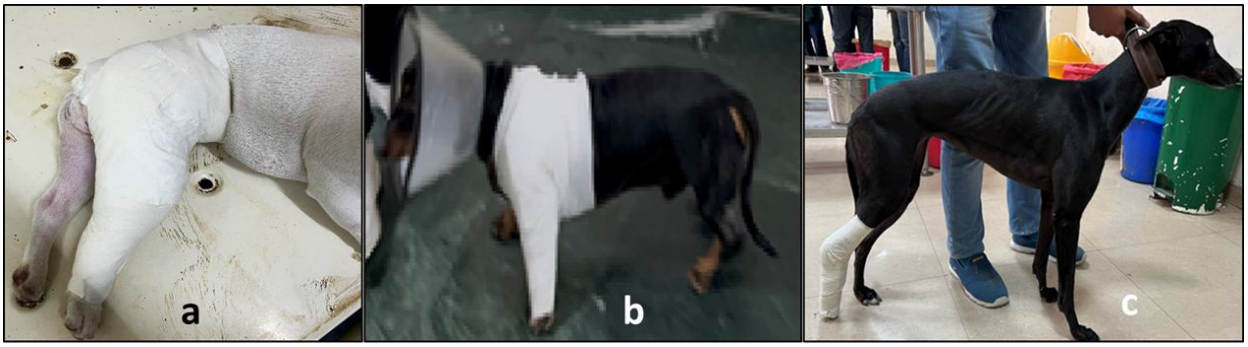



**Fig. 2. Photographs showing bandaging support for avulsion fracture of tibial tuberosity (a), olecranon (b) and fibular tarsal (c)**

**Evaluation of functional outcome:** All dogs were evaluated for functional outcome using weight grade (Gill et al., 2018) in walking and standing (Table 1).

**Table 1. Table showing the weight bearing score while standing and walking**

| | Weight bearing while standing | Weight bearing while walking and running |
|---|---|---|
| Grade 0 | Carrying limb off the ground | Carrying limb off the ground |
| Grade 1 | Touching toe on ground | Occasional touching toe/paw on ground |
| Grade 2 | Touching paw on ground | Frequent touching toe/paw on ground |
| Grade 3 | | Partial weight bearing |
| Grade 4 | | Full weight bearing |

**Orthopaedic examination:** Marked crepitus was recorded in 30% (Group FT) dogs, mild in 60% and 10% had no crepitus (>20 days old).

**Pre-operative haematology:** The mean±SD haemoglobi was 13.76±2.11 g/dL (range 10.5-17.2g/dL), PCV 38.52±5.61% (range 30.2-48.1%), total leucocyte count (TLC) 13400±5643/µL, total erythrocyte count (X $10^6$/µL) 5.70±0.98, Neutrophils (%) 78.6 ±11.58, and platelet (x$10^3$/µL) 280.66±98.48.

**Pre-operative biochemistry:** The mean ALKP (U/L) was slightly raised 133.10±57.13 (normal values 10.6-101 U/L). The creatinine, BUN, serum calcium, and serum phosphorus were within the normal range (0.97±0.31, 11.55±3.9, 9.52±1.43 mg/dL and 4.96±1.70 mg/dL, respectively).

**Pre-operative radiographic findings:** The mean±SD dimensions of the avulsed fragments were comparatively shorter in length and width in Group TT (16.8±7.3 mm and 7.9±2.2 mm, respectively) followed by Group FT (24.5±12.8 mm and 11.7±2.3 mm, respectively) and Group O (26.0±1.4 mm and 14.8±2.5 mm).

In Group TT, 3 fractures were of type II and 2 of type III.

The Group TT and O had a higher fracture gap (Fig. 3) on the cranial side (15.9±7.2 mm and 7.95±0.07 mm, respectively) as compared to the caudal side (5.1±3.2 and 7.3±6.6 mm, respectively), whereas Group FT had more fracture gap on the caudal side (11.1±4.0 mm) of the fracture line as compared to the cranial side (5.3±2.08 mm). One case in Group TT and 2 in Group O were associated with fracture of fibula and radial dislocation, respectively.

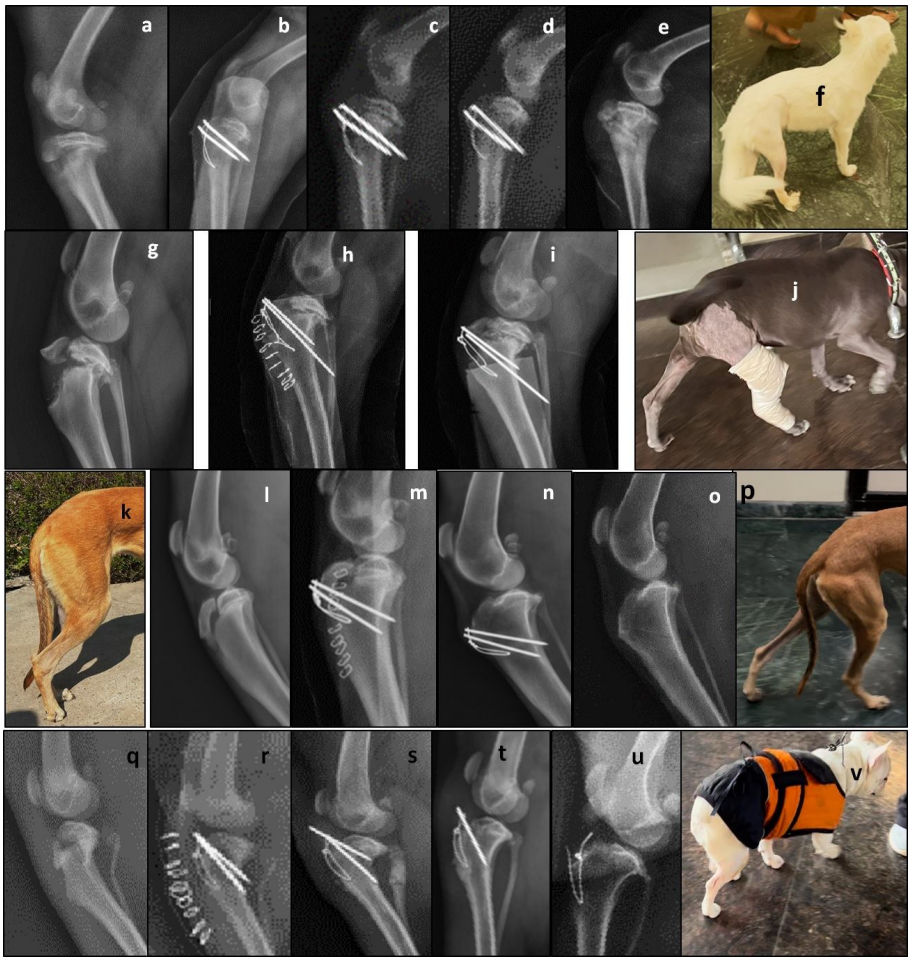



**Fig. 3. Serial radiographs and photographs of the cases operated for tibial tuberosity avulsion fractures (Group TT)**

**Case 1: A 6-month-old Pomeranian dog showing pre-operative radiograph (a), immediate post-operative (b), 15-day post-operative (c) 30-day post-operative (d), after pin removal on 38 days (e) and full weight bearing at day 15 (f).**

**Case 2: A 5-month-old American bully showing pre-operative radiograph (g), immediate post-operative (h), 15 day post-operative (i) and full weight bearing on day 15(j).**

**Case 3: An 8-month-old grey hound dog showing toe touching at arrival (k), pre-operative radiograph (l), immediate post–operative (m), 4.5-month post-operative (n), after implant removal (o), full weight bearing at 4.5 months (p).**

**Case 4: A 4-month-old French bulldog showing pre-operative radiograph (q), immediate post-operative (r), 15 day with migration of one pin which was removed (s), day 60 with complete healing (t), after implant removal, where the wire could not be removed (u), full weight bearing on day 60 (v)**

**Immediate post-operative radiographic findings:** In Group TT, each pin engaged a mean±SD length of proximal (6.94±3.1 mm and 7.58±0.2 mm) and distal (20.7±9.6 mm and 23.9±7.7) bone fragment. The mean±SD of total length of loop of wire used was 27.2±4.9 mm.

In Group O, the pins engaged a mean±SD length of proximal (26.9±4.4 mm and 24.0±0 mm) and distal (31.6±16.4 mm and 37.0±0 mm) fragments. The mean±SD of the total length of the loop of wire used was 57.7±10.4 mm. In case 2, the pin appeared engaging the mid-diaphyseal medullary canal of the ulna and in the case 1, both K-wires /pins appears to be protruding the ulnar bone cortex and engaging in the cortex of the radial bone fragment (Fig. 4).

In Group FT, both K-wires/pins engaged a mean±SD length of proximal (26.6±11.8mm and 25.2±11.2 mm, respectively) and distal (11.4±7.2 mm and 15.1±1.7 mm, respectively) bone fragment. The mean±SD of the total length of the loop of wire used was 35.8±14.6 mm. In one case each, both K-wires/pins either engaged in the distal metaphyseal region of the distal bone fragment or protruded it. In case 3, one K-wire engaged in the distal metaphyseal region and the second slightly protruded it (Fig. 5).

The immediate post-operative radiographic assessment revealed, Grade 0 in 6 fractures, Grade 2 in 2 and Grade 3 in 2.

**Radiographic follow-up findings (Table 2)**

Day 1-15: Seven cases were presented for follow-up (3 of Group TT, 2 of Group O and FT each). Wire in all the cases was stable. Four cases (including 2 cases with implant-related complication) had evidence of callus formation (57.14%). Three cases (one from Group TT and two from Group O) had perfect apposition with no inter-fragmentary gap. While 4 cases were reported with an inter-fragmentary gap at the cranial (5-17 mm) or caudal (2-7 mm) aspect of the fracture line (57.14%). Day 15-30: A total of 4 cases were presented in this period. Besides, an increased inter-fragmentary gap was also seen in one case of Group FT (Fig. 5, case 3). The implant in remaining cases was stable. ≥2 months: Three cases (two of Group TT and one of Group O) were presented. No inter-fragmentary gap was seen in the presented cases, and radiographic union was apparent so implants were removed in all 3 cases.

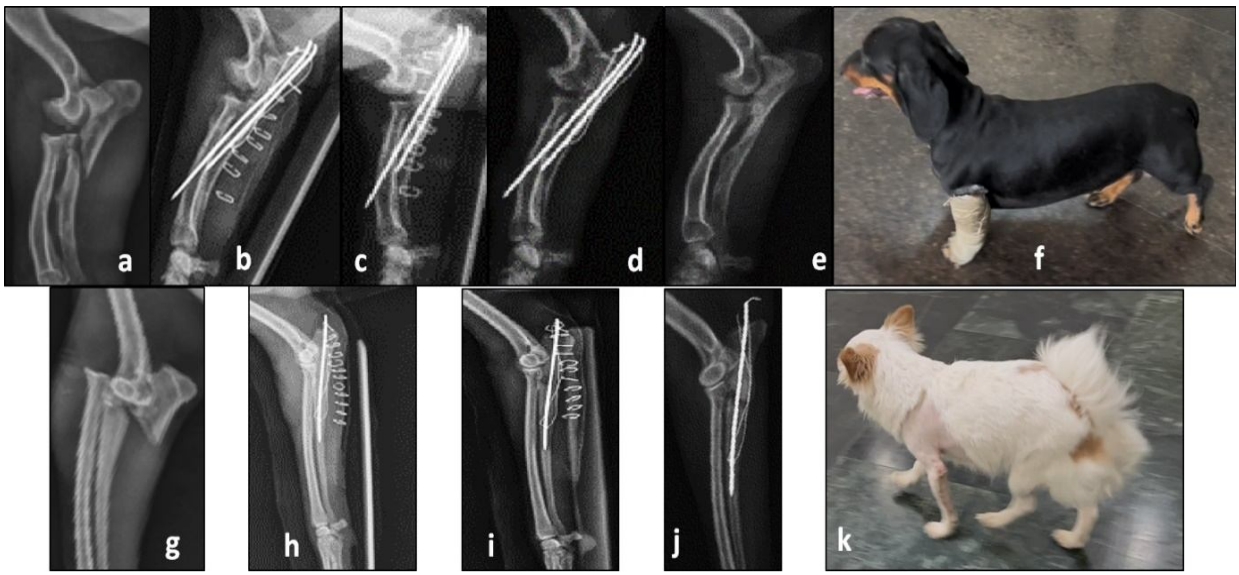



**Fig. 4. Serial radiographs of the dogs operated for avulsion fracture of olecranon (Group O)**

**Case 1: A 30-month-old Dachshund showing pre-operative radiograph (a), immediate post-operative (b), 15th day (c), 1.5-month post-operative (d), after implant removal at 2 months (e), full weight bearing on operated limb at 45th day (f).**

**Case 2: A 48-month-old Pomeranian dog showing Monteggia fracture pre-operative radiograph (g), immediate post-operative (h), 15-day post-operative (i), 53-day post-operative showing unwinding of wire knot and gaping at fracture site (j), dog showing full weight bearing at day 53 (k)**

**Implant removal**: The implant removal was done in 6 out of 10 cases. Uncomplicated fracture union

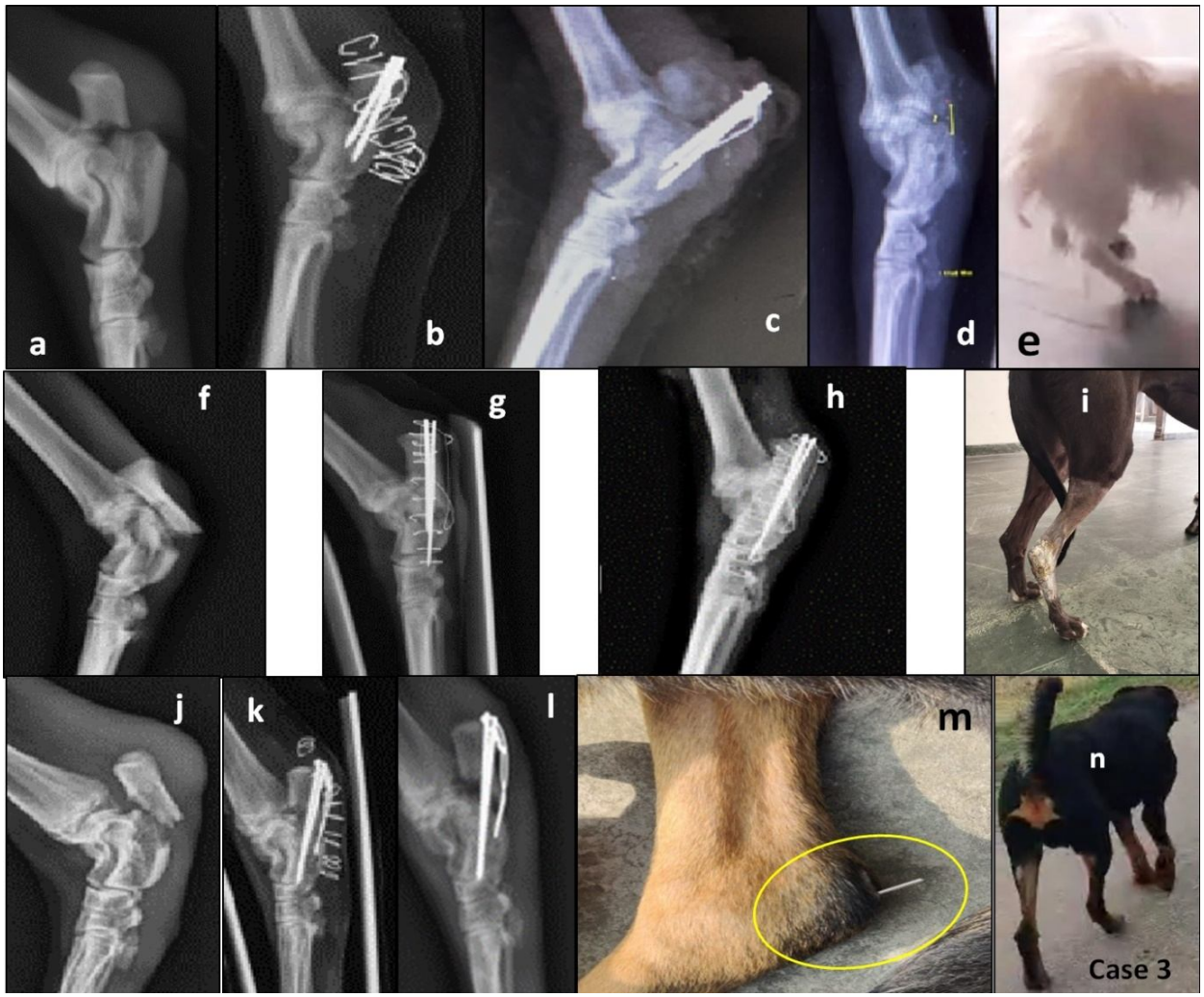



**Fig. 5. Serial radiographs of the dogs operated for avulsion fracture of fibular tarsal (Group FT)**

**Case 1: A 9-month-old Pomeranian dog showing pre-operative radiograph (a), immediate post-operative (b), 30-day radiograph showing splitting of proximal fragment leading to dislodgement of implant (c), after implant removal on 30 days (d), full weight bearing on the limb on one-year follow-up (e).**

**Case 2: A 12-month-old greyhound dog showing pre-operative radiograph (f), immediate post-operative radiograph (g), 15-day radiograph (h), dog showing full weight bearing on day 15 (i).**

**Case 3: A 7-month-old Rottweiler dog showing pre-operative radiograph (j), immediate post-operative (k), 15-day post-operative showing mild gaping at fracture site (l), pin migration and removal at one month (m), full weight bearing at one month (n)**

**Table 2. Table showing the follow-up outcome and implant removal**

| | Group TT (Fig. 3) | Group O (Fig. 4) | Group FT (Fig. 5) |
|---|---|---|---|
| Day 1-15 | Case 4 had one pin migration, which was removed | Case not presented | Case not presented |
| Day 16-30 | Case not presented | Case not presented | Case 1 had splitting of avulsed fracture fragment. Implant was dislodged and thus removed on day 30. Case 3 had one pin migration; implant was removed on day 30. |

**Cont. Table 2.**

Table 2., Cont. ...

| | Group TT (Fig. 3) | Group O (Fig. 4) | Group FT (Fig. 5) |
|---|---|---|---|
| Day 31-60 | Case 1, implant removed on day 38 as fracture healed. | Implant of case one removed on day 60. Wire knot unwinding in case 2 on day 53. Implant not removed. | Case not presented |
| > 60 days | Implant removal in case 3 and 4 done as healing was evident. | Case not presented | Case not presented |

occurred in 2 cases (one each in Groups TT and O) so the implant was removed within 60 days. Implant-related complications occurred in 4 cases (two each in Groups TT and FT) between 15-60 days of surgery, of which implant of 3 were removed (one TT and 2 FT). The mean±SD period of implant removal was 54.4±42.8 days (range 15-143 days), and adequate callus formation was seen in almost all the cases.

**Goniometry**: The mean extension angle and range of motion of the stifle joint (in Group TT) were reduced, non-significantly, as compared to contralateral healthy stifle joint while flexion angles remained unaffected (Table 3). In Group O, the mean extension angles appeared unaffected while flexion and range of motion were markedly affected as compared to contralateral healthy elbow joints. In Group FT, the mean extension, flexion and range of motion were affected at immediate postoperative period as compared to the contralateral healthy hock joint.

**Table 3. Statistical analysis of stifle joint goniometry at various follow-up intervals (Group TT)**

| Days | Extension | Flexion | Range of motion |
|---|---|---|---|
| Contralateral normal (n=5) | 154.4±8.3[a] | 45.6±4.3 | 108.8±11.9[b] |
| Day 0 (n=5) | 142.4±11.6[a] | 44.6±13.3 | 97.8±14.4[b] |
| More than 2 months (n=3) | 141±13.9[c] | 54.3±17.2 | 86.7±28.2 |
| After pin removal (n=3) | 153.3±9.8[c] | 45±3.5 | 108.3±6.3 |

Values with the same superscript in the same column differ significantly ($p<0.05$)

At day 10-15: An increase in the extension angle and decrease in the flexion angle was seen, thus increasing the range of motion in Group TT. The dogs of Group O & FT showed a decrease in mean extension and decrease in mean flexion thus increasing the mean range of motion. This could be due to decrease in inflammation and range of motion. At 15-30 days: A total of 5 cases were presented (2 for Group TT and Group O each and one of Group FT). The dogs of Group TT and FT showed an increase in overall range of motion. At day 30-60: Three cases were presented for follow-up and an increase in the range of motion of was seen. At >60 days: Three cases were presented for follow-up with two of Group TT and one of Group O. In Group TT, the range of joint motion reduced as compared to previous follow-ups.

A significant difference was seen in the extension angle of the stifle (Group TT) after implant removal. The range of motion was increased, though non-significantly, in the cases of Group TT dogs. One dog showed a decreased range of motion even at 138 days of follow-up but it improved after the implant was removed at 143 days. A marked improvement in the range of motion was observed following implant removal; thus, implant removal is a necessity in avulsion fractures as the implant affects the joint and thus the range of motion. The goniometric measurements of the elbow (olecranon avulsion) and hock (fibular tarsal avulsion) joints were not tested statistically due to small sample size.

**Weight bearing scores while walking and standing***:* Highest degree of lameness and lowest weight bearing while walking and standing was seen in dogsof Group FT followed by Group TT and least in Group O. At day 1-10: A marked reduction in the degree of lameness and increased weight bearing was seen while standing and walking in Group TT and Group O. At 10-15 days: A further reduction in the lameness grade and increased weight bearing while walking and standing was seen in dogs of Group TT, but increase in lameness and decrease in weight bearing while walking was observed in Group O probably due to decreased weight bearing of one case of Group O. A decrease in the degree of lameness and increased weight-bearing at walking and standing was seen in the dogs of Group FT. At 15-30 days: An

improvement in the degree of lameness and weight bearing scores while walking and standing was seen in Group TT dogs and one case of Group O. However, an increased lameness and decreased weight-bearing scores (standing and walking) were recorded in one case of Group FT due to splitting of the proximal bone fragment and implant dislodgement. At 30-60 days: An improvement in the degree of lameness and weight bearing was seen in Group O, but increased degree of lameness and decreased weight bearing (walking and standing) was seen in one case of Group FT, probably due to migration of the implant. >60 days: The dogs of all the groups showed no evident lameness (Grade 0) and complete weight bearing while standing and walking.

**Post-implant removal**: All the dogs of Group TT, Group O and Group FT showed no evident lameness (Grade 0) with complete weight bearing while walking and standing.

**Complications**: Migration of the implant (n=3; two in Group TT and one in Group FT), breakage of the stainless-steel wire (n=1, in Group O) and splitting of avulsed bone fragment (n=1, in Group FT) were recorded. In overall, two out of 5 cases in Group TT (40%), one out of 2 in Group O (50%) and two out of 3, in Group FT (66%) had implant complications. Despite these complications, the final functional outcome was excellent or acceptable in all the cases.

**Use of one vs. two K-wire/pin(s) in tension band wiring technique**: In the current study, all except one dog of Group O was repaired with two K-wires/pins combined with figure of eight orthopaedic wire. Due to narrow medullary canal in this case of Group O, it was not possible to place two pins. This dog had unwinding of wire knot and no evident callus on day 53 but very good weight bearing while walking and standing (Fig. 4, Case 2).

Another dog of Group TT (case 4) with tibial tuberosity avulsion fracture documented one pin dislodgement on day 10, which was removed immediately, thus retaining the second pin. Despite the removal of one pin, the fracture healed satisfactorily.

## DISCUSSION

Younger dogs, due to open physis, are prone for avulsion fractures (Gower et al., 2008; Cruz et al., 2020; Morawska-Kozłowska et al., 2023) associated with trauma (Altunatmaz et al., 2006) and have an equal predisposition to male and female dogs (Cruz et al., 2020). Increased osteoblast activity and bone formation during the initial healing process may cause a surge in alkaline phosphatase activity (Komnenou et al., 2005; Patil et al., 2017). This alkaline phosphatase enzyme activity can also be correlated with the age or duration of the fracture (Gill et al., 2018).

Type 2 and 3 are the most common tibial tuberosity avulsion fractures in dogs (Von Pfeil et al., 2012). Asymmetrical gap at the site of avulsion fracture with more on cranial than caudal was recorded in tibial tuberosity fractures, whereas in the case of fibular tarsal fractures, relatively more gap was recorded on the caudal side. This could be correlated with the direction of the pull of the muscle/tendon attaching on the respective avulsed fragment.

Difficulty in the reduction of the fracture fragments is correlating to the age of fracture (Gill et al., 2018). Prolonged disuse of affected limb and muscle/tendon contracture, along with bone reaction in delayed cases, might be the probable reason for it.

Gradual improvement in the weight-bearing grade and reducing lameness may be correlated to satisfactory progression of fracture union with no interference of the tension band wiring implant construct. Degree of callus formation has been reported to be associated with degree of motion at the fracture site (Eastaugh-Waring et al., 2009). Similarly, gradual improvement in the joint(s) functions/goniometry indicated that tension band wiring implant does not interfere with the periarticular structures (Srinivasa Murthy et al.,2010). A latest study by Zweig and Ralphs (2025) reported that surgical intervention to manage avulsion fractures of tibial tuberosity cause tibial tuberosity and patellar position changes radiographically, yet yield excellent outcomes clinically.

Ideally, it is recommended to use two K-wires/pins with an orthopaedic wiring in a figure of eight fashion in tension band wiring for achieving excellent biomechanical stability; however, it in the present study, even use of single K-wire/pin was found adequate for maintaining fracture reduction and implant stability. This may be attributed to delayed migration of the K-wire/pin or to the quadrupedal stance of dogs, which distributes body weight over four limbs and lessens the load on the fractured one (Dyce et al., 2017). Besides use of external support bandage in the form of Robert Jones bandaging help in maintaining construct integrity during earlier phases of the fracture healing (Gill et al., 2018). A recent study

(Welsh et al., 2023) compared one-pin and two-pin fixations in an ex-vivo canine tibial tuberosity model under axial load to failure. Two-pin constructs showed significantly greater strength and stiffness, although single-pin fixation was still adequate to withstand quadriceps forces during walking. Choo et al. (2025) found that the screw with tension band wiring method as an acceptable alternative to pins with tension band wiring in a canine cadaveric model of extra-articular olecranon fracture.

This study concluded that tension band wiring construct using 2 or 1 K-wire/pin combined with a 'figure-of-8' wire provides adequate stabilization with minimal complications, particularly for the tibial tuberosity and olecranon avulsion fractures; however, there is a need to develop alternative fixation techniques for fibular tarsal avulsion fractures. The implant-related complications associated with tension band wiring, irrespective of the avulsion fractures, had no impact on the final functional outcome. Removal of implant is recommended in avulsion fractures in dogs as it further improves the range of motion of the affected joint.

**Conflict of interest:** All authors declare no conflict of interest.

**Author's contribution:** RC: Recorded and analysed clinical data, written first manuscript; AK: Planned work, supervised and scrutinized the clinical research work, checked the manuscript; VS: Anaesthetic management of clinical cases including perioperative and postoperative care; NUD: Radiographic interpretation and manuscript editing.

**Data availability statement:** Data set generated are available with the corresponding author and it can be availed upon reasonable request.

**Ethical approval:** This clinical study was duly approved by the Committee for Control and Supervision of Experiments on Animals, New Delhi, for a period of one year vide letter no. V-11011(13)/2/ 2024-CPCSEA-DAFD dated 07.03.2023.

**Use of artificial intelligence tools:** Grammarly and ChatGPT have been used in some part of the text to improve sentence structure. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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*Received - 30.10.2025*, *Accepted - 13.07.2026*, *Published - 13.08.2026 (Online)*
**Subject Editor:** Dr. Ramesh Tiwary, Editorial Board Member