Indian J. Vet. Surg. 46(1): 42-47 June 2025

ijvs

Stainless steel elastic intramedullary nailing of radius-ulna fractures in dogs

Kusum Meghwal[1], A.K. Bishnoi[2†], Jyoti[1], Sonu Meena[1], Shivraj Bishnoi[1], Anita Kumari[3], Mohan Lal[3], Mahendra Tanwar[2] and P. Bishnoi[4]

Rajasthan University of Veterinary and Animal Sciences, Bikaner-334 001 (Rajasthan)

[1]MVSc Scholar, [2]Assistant Professor, [3]PhD Scholar, [4]Professor and Head, Department of Veterinary Surgery and Radiology, College of Veterinary and Animal Science, Bikaner

DOI: 10.5958/0973-9726.2025.00009.9 *Received: May, 2024*

Internal fixation of radius-ulna fractures was done in 9 dogs using stainless steel elastic intramedullary nail (EIN). The mean age and body weight of the animals were 26.44±6.93 months and 18.41±3.61 kg, respectively. Fracture fixation was done by open reduction by applying single nail in radius. In two cases, ulnar fracture was also fixed using EIN along with the radius. The mean percentage of medullary cavity occupied by the implant was 55.83±4.44% and the mean duration of surgery was 100.88±13.80 min. The median period of initiation of weight bearing on the operated limb was 4 days. In final outcome, limb function was excellent in 2 cases, very good in 5 cases, and good in 2 cases. Among 7 cases with intact nail, radiographic bone union was achieved in 6 cases and apparent callus with discernible fracture line in one case. Postoperative complications noted were exudative discharge from the suture line (n=3), suture dehiscence (n=2), carpal joint stiffness (n=3), backward migration of nail from inserted site (n=4), nail breakage at fracture site (n=1), carpus valgus (n=1), and osteomyelitis (n=3). From this study it was concluded that intramedullary fixation with elastic nail provided stable fixation of radial fractures in light weight dogs, but the technique was time consuming and care was needed to avoid complications during the fixation of nail. .

Key words: *Dog, Internal fixation, Radius-ulna fracture, Stainless steel elastic intramedullary nailing*

In dogs and cats, radius-ulna fractures most commonly occur at the distal portion of the bone (Haas *et al*., 2003; Simon *et al*., 2011). In distal fractures in growing dogs, the smaller distal fragment and open physis limit the adoption of stiff fracture repair procedures such as bone plates (Sodhi *et al.,* 2021). Standard intramedullary (IM) pinning is usually not recommended due to impingement on joint surfaces, limited medullary canal diameter and cranial bowing of the radial bone (Schrader *et al*., 1991). Whereas the flexible IM nails can act as internal splints to align the fracture ends (Johnson *et al.,* 2009), and it can withstand angular, compressive, and rotational stresses due to the elasticity of the material (Prabhukumar *et al.,* 2020). The advantages of elastic IM nail include immediate fracture stabilization, early mobilization, little soft tissue disruption, low infection and re-fracture rates, and faster return to daily function than conservative treatment. Sufficiently elastic fixation can allow for controlled mobility at the fracture site, which can promote healing by external callus (Reddy *et al*., 2021). Keeping these in view, the present study was done to evaluate the use of elastic IM nailing in the fixation of radius-ulna fractures in dogs.

Materials and Methods

A clinical study of IM fixation of radius-ulna fractures in dogs with stainless steel elastic nails was done to evaluate the application of the fixation technique, and to clinically and radiographically evaluate the outcome of treatment. Nine apparently normal client-owned dogs affected with unilateral simple closed transverse or slight oblique radius-ulna fracture (excluding the severely comminuted fractures), irrespective of age, body weight, and breed were included in the study (Table 1). Based on radiographic assessment of the fracture, the cases having optimum cortical bone density and medullary cavity length of proximal and distal fragments were selected to secure both ends of elastic IM nails. Medullary cavity diameters at isthmus of radial and ulnar bone were measured using both cranio-caudal and medio-lateral radiographic views, to select an appropriate diameter IM nail (Tables 2 and 3). The elastic nails used in this study were of stainless-steel, having bent curved tip, and of 440 mm length. The fracture fixation was done with open reduction method, with single IM nail without pre-bending in all cases, with the insertion of nail in radius from the distal fragment in all but one case. IM fixation of 7 cases was done in radius only, while in 2 cases (No. 6 and 9), ulnar fixation was also done along with radius. For radius, the diameter of the nail selected was 50% of the medullary cavity diameter, while for ulna the nail was selected to occupy its maximum medullary cavity at isthmus. The nail was inserted into the medullary cavity of radius through a bone awl created hole in the cortex on the medial aspect of the cranial surface of the distal metaphysis, just proximal to physeal region. In case of ulnar fracture fixation,

[†]Correspondence; E-mail: bishnoisurge@gmail.com

IM nail was inserted from its proximal end, near the caudal border below the point of olecranon process. After achieving fracture reduction, the IM nail was advanced manually using slight rotatory movements or by hammering the nail against the striking surface of the nail inserter. To ascertain the proper position of nail tip in the medullary cavity of opposite fragment, same length reference nail was used from external body surface and/or examined under C-arm fluoroscopy. After inserting the nail as far as possible in the opposite fragment, the external end of nail at the insertion site was bent and cut near to the bone and the surgical wound sutured.

Table 1: Individual case details: age, sex, weight (kg), breed, aetiology, limb affected, fracture location and configuration, period from trauma to surgery, and associated injuries.

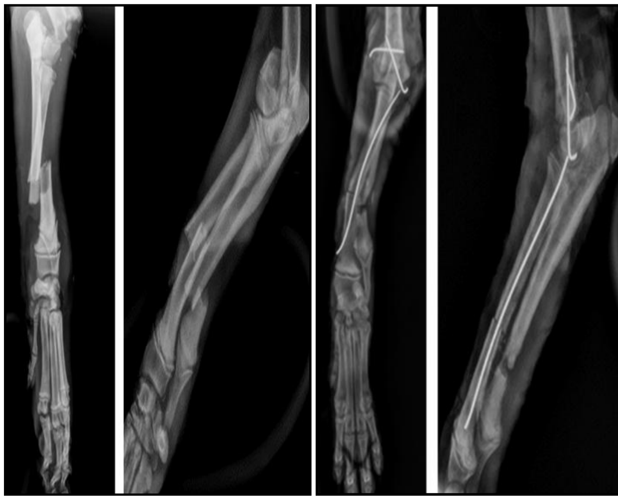
Case No.	Age (months)	Sex	Weight (kg)	Breed	Aetiology	Limb Location surgery (days)	Fracture Configuration	Fracture trauma to	Period from injury	Associated
RU-1	24	F	17	ND	Automobile accident	RF	Mid-shaft	Short oblique	6	Lacerated wound on left forelimb
RU-2	4	F	4.2	GSD	Automobile accident	LF	Mid-shaft	Transverse	12	Condylar fracture of left humerus
RU-3	48	M	20	Mudhol Hound	Automobile accident	LF	Mid-shaft	Transverse	6	NIL
RU-4	60	F	20	GSD	Jump from height	LF	Distal 1/3	Transverse	9	NIL
RU-5	10	M	14	ND	Automobile accident	RF	Distal 1/3	Transverse (slight comminution)	5	NIL
RU-6	36	M	35	Pakistani Bully	Automobile accident	LF	Mid shaft	Transverse	3	Right limb femur fracture and hip dislocation of left limb
RU-7	42	F	14	Beagle	Automobile accident	RF	Mid shaft	Transverse	1	NIL
RU-8	6	M	6.5	Pomer-left limb	Jump from height	RF	Mid-shaft	Transverse	5	NIL
RU-9	8	M	35	Husky	Automobile	LF	Distal 1/3	Transverse	2	Left limb femur and tibia fracture, and right limb hip dislocation
Mean ±SE	**26.44 ±6.93 months**		**18.41 ±3.61**	-	- -	-	-		**5.68 ± 0.72**	-

Postoperatively, the operated limb was kept covered and provided external support with Robert Jones bandage with incorporation of bamboo splint on the caudal flexor side of the forearm, carpal joint, and manus. The animal owner was advised to restrict the movement of the animal until the bone union. Postoperatively, the treatment outcome was regularly assessed both clinically and radiographically at regular intervals.

Results and Discussion

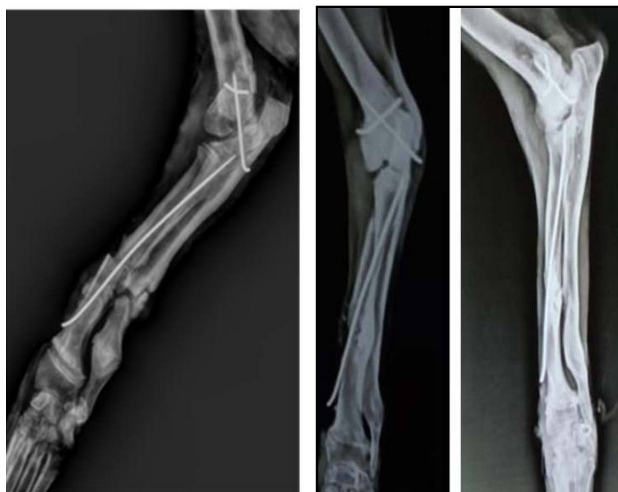
In the present study, in most cases of radius-ulna fracture, single IM nail insertion was done in radius bone. Similarly, Kang *et al*. (2011), Kumar *et al.* (2022) and Prabhukumar *et al.* (2020) used single nail in the IM fixation of radius fractures in humans and dogs. Poutoglidou *et al.* (2020) reported that there was no clear advantage of one over another in single versus double nailing in forearm fractures in human patients. Nail insertion was performed in the present study without nail prebending, as also reported in earlier study by Sodhi *et al.* (2021). Barry and Peterson (2004) also reported insertion of single nail in the radius-ulna fractures in children and they found that straight nails were equally effective as precontoured nails. In contrast, Ruhullah *et al*. (2016) performed EIN of radius and ulna bones with prebending of proximal 5 mm of nail to about 15°-30° for its easy passage through the medullary cavity.

In the present study, except in two cases, in all



A. Pre-operative rediographs showing mid shaft transverse fracture

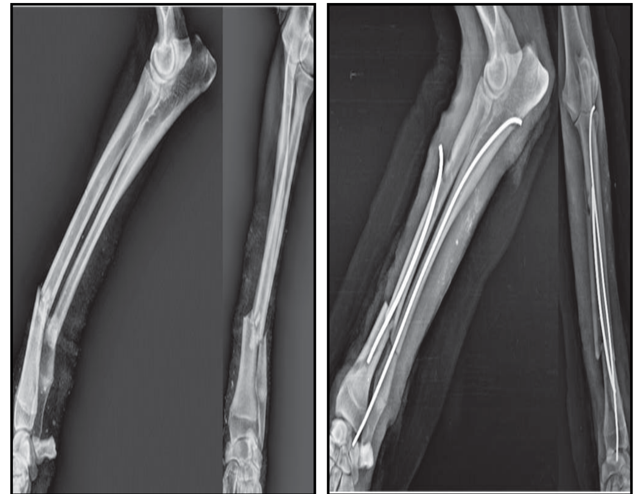
B. Immediate postoperative radiographs: The end of the nail slightly pierced out of the cortex from the far fragment



C. 2nd Postoperative week (R.G.=2)

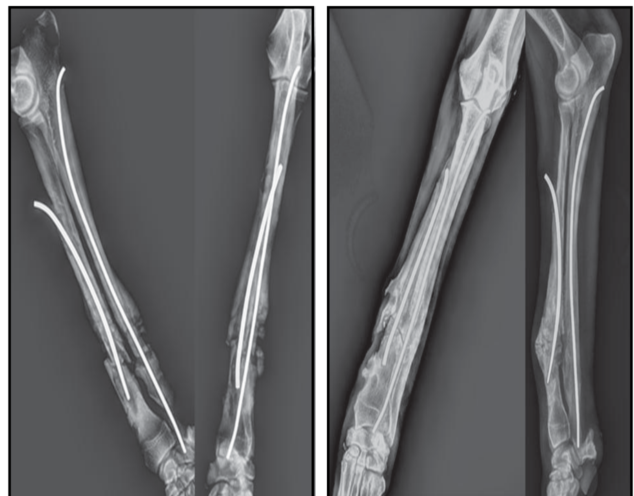
D. 10th Postoperative week (R.G.=5)

Fig. 1: Pre- and post-operative radiographic findings of radius-ulna fracture in case RU2



A. Preoperative rediographs showing Distal 1/3 transverse fracture

B. Immediate postoperative radiographs: Ulnar nail slightly pierced out cortex of far fragment



C. 4th Postoperative week: (R.G.=2)

D. 11th Postoperative week: (R.G.=4)

Fig. 2: Pre- and post-operative radiographic views of radius-ulna fracture in case RU9.

other cases of radius-ulna fractures, IM fixation of only radial bone was done (Fig. 1). In two cases, along with radius bone, ulnar fixation was also done with EIN (Fig. 2); both these cases were of adult heavy breed and suffering from concurrent fractures of other long bones, and due to availability of wider intramedullary cavity in ulnar bone, ulnar fixation was also done to enhance fixation stability. In contrast, Sodhi *et al.* (2021) opined that as radius is the weight bearing bone in dogs, two nails can be inserted into the radial bone to achieve the better stability. However, Myers *et al*. (2004) reported that ûxation of both bones using an EIN is not always necessary in children with unstable diaphyseal fractures of both bones of the forearm, and it is possible to manage selected patients satisfactorily with single bone ûxation followed by cast immobilization.

In the present study, in all cases the nail was inserted from the distal end of radius and proximal end in ulna except in one case in which radial fracture fixation was done from proximal metaphyseal region (antegrade method) due to formation of abnormal tract in distal end of radius by piercing of nail. Similarly, in the study of Sodhi *et al.* (2021), nail insertion was done from distal end of the radius except in two cases where drilling was performed from the site of fracture towards distal end of bone due to formation of abnormal misdirection/tract. Also, Calder *et al.* (2003) have reported retrograde insertion of nail in radius and antegrade in ulna in children. Poutoglidou *et al. (*2020) performed IM nailing of the forearm fractures of radius (antegrade) and ulna (retrograde), where ulna was nailed first as it was relatively easier due to its straight medullary canal.

Among the 9 dogs treated for radius-ulna fractures inn this study, 3 dogs also had concurrent

Table 2: Preoperative radiographic measurement of medullary cavity isthmus diameter, bone length and total percentage of nails occupancy in radius cases

Case No.	Medullary Cavity diameter at isthmus (mm)	Bone length (mm)	Diameter of implant used (mm)	Medullary cavity occupancy (%)
RU1	4.00	128.19	2.5	62.50
RU2	3.20	105.01	1.5	47.00
RU3	4.00	138.03	3.0	75.00
RU4	5.80	140.55	3.0	30.00
RU5	3.40	115.60	2.0	60.00
RU6	5.20	152.43	2.5	50.00
RU7	2.90	95.23	2.0	70.00
RU8	2.70	107.50	1.5	56.00
RU9	4.81	137.32	2.5	52.00
Mean ±SE	**4.00±0.35**	**124.42±6.45**	**2.27±0.18**	**55.83±4.44**

Table 3: Preoperative radiographic measurement of medullary cavity isthmus diameter, bone length and total percentage of nails occupancy in ulna fixation cases

Case No.	Medullary Cavity diameter at isthmus (mm)	Bone length (mm)	Diameter of implant used (mm)	Medullary cavity occupancy (%)
RU1	4.00	128.19	2.5	62.50
RU6	4.20	159.23	2.0	50.00
RU9	2.27	144.52	2.0	90.00

fractures/injuries of other long bones; which were ipsilateral humeral condylar fracture (RU2) (Fig. 1), contralateral femur fracture and ipsilateral hip joint luxation (RU6), and ipsilateral tibial and femoral fracture with contralateral hip joint luxation (RU9). Five dogs were males and 4 females, of breed non-descript (n=2), German shepherd (n=2), Mudhol hound (n=1), Pakistani Bully (n=1), Husky (n=1), Beagle (n=1), and Pomeranian (n=1). The mean age of the animals was 26.44±6.93 m (range, 4-60 m), with the mean body weight of 18.41±3.61 kg (range 4.2-35 kg) (Table 1). Successful IM elastic nailing of long bone fractures has been reported in many studies of human patients of adolescent age (Srivastava *et al*., 2008; Razak *et al*., 2008; Reddy *et al*., 2019). Sodhi *et al*. (2021) treated distal radius-ulna fractures in young dogs of mean age 12.60±6.45 m (range, 4-24 m) and body weight 14.09±6.41 kg with titanium elastic IM nails.

In this study, the affected limbs were both of left side (n= 5) and right side (n=4), and the etiology of fractures was automobile accident (n=7) and jump from height (n=2). The fracture location was mid-shaft (n=6) or distal 1/3rd (n=03), with the fracture configuration transverse (n=8) or short oblique (n=1). Previous clinical studies have also shown the use of EIN in fractures of proximal, middle and distal shaft of long bones with transverse or oblique fracture configuration (Sodhi *et al*., 2021; Reddy *et al*., 2021; Kumar *et al*., 2022; Saran, 2023). In biomechanical testing of IM elastic nailing, it was found that the length of nail past the fracture site did not greatly affect the biomechanical properties of the construct (Johnson *et al*., 2009), hence it could be used in all fracture locations of the long bone. Also, by virtue of the elastic quality of the material and the balanced insertion construct, the nail can resist angular, compressive and rotational forces acting on the fractured bone (Barry and Paterson, 2004), thus it can be used in transverse and oblique fracture configurations.

From the preoperative orthogonal radiographic views, the cortical bone density was found optimum in all cases, the mean value of medullary cavity diameter at isthmus was 4.00±0.35 mm for radius (range 2.70-5.80 mm), and 4.20 mm (RU6) and 2.27 mm (RU9) for ulna. Sodhi *et al.* (2021) observed the mean diameter of IM canal at isthmus of radius as 4.40±1.27 mm in 10 dogs having fracture of radius-ulna. In radius fracture fixation, the size of nails used was of 1.5 mm, 2.0 mm, and 3.0 mm diameter in 2 cases each, and 2.5 mm diameter in 3 cases (mean 2.27±0.18 mm), and in ulna the diameter of nail used was 2.00 mm in both the cases (RU6, RU9). The percentage of medullary cavity occupancy at isthmus was 55.83±4.44% in radius, and in ulna it was 47.60% (RU6) and 88.10% (RU9). Sodhi *et al.* (2021) used 2 mm and 1 mm nails in 4 dogs each, while 1.5 mm nail in 2 dogs for fixation of radius fractures, with medullary canal occupancy of 61.98±9.42%.

Intraoperatively, haematoma at fracture site in one case and surrounding soft tissue injury observed in 3 cases, and fibrous callus adhesions at fracture site were present in 3 cases. During IM nail insertion in radius, iatrogenic bone splitting or chipping occurred in two cases (RU1, RU4). The bone chipping (RU1) occurred at fracture end of distal fragment with introducing the 3.0 mm nail, hence it was withdrawn and a 2.5 mm diameter nail was inserted. The distal fracture segment splitting occurred in RU4 during nail insertion from the cranio-medial aspect of metaphysis, which was then stabilized with two cerclage wires and the nail was reinserted from a new entry point on the cranial surface of metaphysis. On the cranial surface entry point, the cut external curved end of the nail remained prominent under the skin, which in the later follow up period pierced through the skin, but it did not affect the fracture stability. In one case (RU9), radius nail was inserted from its proximal metaphysis, as it made a tract through the far bone cortex during insertion from the distal end. The total duration of surgery and time taken to complete IM nail insertion were 100.88±13.80 min and 47.66±8.13 min, respectively. More time was required due to resistance in IM insertion of nail in

every case, and development of iatrogenic cortical split at fracture site in 2 cases. Whereas Sodhi *et al.* (2021) have reported relatively less duration (64.50±15.76 min) for fixation of radius fractures with double elastic nailing.

Immediate postoperative radiographs showed good fracture reduction and alignment in all cases, except for slight cranio-caudal malalignment in one case (RU4), but without any adverse effect. Inability to insert full IM nail length due to resistance in far fragment in 2 cases (RU1, RU3), development of curvature in one case (RU5) along the length of the bone with convexity on medial side, and cortical piercing of nail from non-articular cortex at the end of the far fragment in one radius (RU2) and ulnar fixation (RU9) case were recorded.

Postoperatively, the weight bearing on the treated limb started in median period of 4 days, and the lameness gradually decreased up to 8th postoperative week. The long term functional outcome of the limb function was excellent in 2 cases, very good in 5 cases, and good in 2 cases. In 2 cases, due to instability of implant, the nail was displaced in early postoperative period; in these cases, external splinting of limb provided excellent or very good limb function. Among the remaining 7 cases, an excellent limb function was achieved in one case by 8th postoperative week, very good limb functional recovery was achieved in 4 cases at 3rd to 7th postoperative week, and good limb function was achieved in 2 cases at 2nd and 16th postoperative week. Sodhi *et al.* (2021) have reported gradual increase in weight bearing from 12th postoperative day and full weight bearing by 90th day in 10 dogs with radial fractures treated with EIN.

Radiographic healing of fracture improved gradually up to 8th postoperative week. Among 7 cases with long term stability of implant, bone union was achieved in 6 cases, while in one case, there was apparent callus with discernible fracture line at 8th week. In a clinical study of radius fracture fixation using EIN, Sodhi *et al*. (2021) have found that at day 12, six dogs had evidence of uniform callus formation but with visible fracture line and remaining dogs had no callus formation. In further follow up, at day 45 and 60, the length and width of callus was found much improved. Prabhukumar *et al*. (2020) have reported complete union by 6th and 8th postoperative week in radius fracture stabilized by EIN in 2 cases. Flexible IM nails provide fixation that is stable as well as elastic in nature, allowing micromotion at the fracture site when load is applied, which encourages abundant bridging callus formation and facilitates early union (Pankovich, 1987; Ligier *et al*., 1988).

The surgical wound healed with primary intention in all except 2 cases, where the development of superficial infection led to suture and wound dehiscence with exudation, and later with regular antiseptic dressing and prolonged administration of antibiotic, wound healed. Few complications recorded in other cases included osteomyelitis (n=3), stiffness of carpal joint (n=3), backward nail migration (n=4), nail breakage at fracture site (n=1), and carpus valgus (n=1). Evidence of osteomyelitis was noted in 3 cases at 3rd and 6th postoperative week, clinically evident as intermittent or non-weight bearing on the affected limb. Later, the osteomyelitis resolved in all the cases (by 8th to 16th week), with excellent or good functional recovery of limb function. Stiffness of carpal joint developed in 3 cases at different time periods, which ultimately resolved in 2 cases. The possible cause of development of joint stiffness in these cases might be due to keeping the external splint for a prolonged period. Joint stiffness was noticed in one case from early 1st postoperative week, which remained till the end of observation period, which could be due to the iatrogenic piercing of ulnar intramedullary nail at the distal end into the joint. Till *et al*. (2000) noted impaired range of motion with limited pro-supination in three children following EIN of forearm fracture. The carpal joint stiffness noted in the present study might be due to surgical trauma to the joint tissue during nail insertion, interference of protruded nail in surrounding joint tissue, and external application of splint on caudal flexor side of limb for a prolonged period. Backward migration of nail from its insertion site was noticed in 4 cases, which was partial in two cases (at 1-3 weeks) and complete in other two cases (at 2 weeks). The partially migrated out nails were hammered back, which later remained stable till complete healing; whereas completely migrated nails could not be replaced back, which were pulled out completely. Sodhi *et al.* (2021) also reported backward nail migration in one case of radius fracture, which was thought to be due to placing of nails without pre-contouring. Saran (2023) also reported the partial or complete backward migration of nail in 6 cases.

In this study, IM nail breakage occurred in one case at 6th postoperative week when radiographic fracture healing of grade 3 was achieved. In this case, the dog was adult with heavy body weight (35 kg), the faultily placed ulnar nail did not provide the adequate stability; further, there were concurrent fracture injury of ipsilateral femur and luxation of contralateral hip joint. Carpus valgus was observed in one case (from first week itself), which was attributed to bending of nail and bowing of the bone at the time of fixation. Salem *et al.* (2006) observed that 4 out of 73 children who were treated for femoral or tibial shaft fractures with flexible IM nailing had clinically apparent out-toeing in femur fracture cases. Sodhi *et al.* (2021), who repaired radius-ulna fractures in dogs with double elastic nailing, reported development of slight angulation at fracture site, which could be due to mal-union and it further led to marked persistent lameness even after nine months.

In one case of radius fracture in that study, nail breakage occurred after 15 postoperative days. Reddy *et al.* (2021) also reported nail breakage in two dogs at 30th postoperative day in the tibial fracture fixation with double elastic nails, due to hyperactivity and heavy body weight of the animals.

From this study it could be concluded that intramedullary fixation with elastic nail can provide stable fixation of radial fractures in light weight dogs, but the technique is time consuming and care should be taken to avoid complications during the fixation of nail.

References

Barry, M.J.M.H. and Paterson, J.M.H. 2004. Flexible intramedullary nails for fractures in children. J. Bone Joint Surg. Br. **86**: 947-953.

Calder, P.R., Achan, P. and Barry, M. 2003. Diaphyseal forearm fractures in children treated with intramedullary fixation: outcome of K-wire versus elastic stable intramedullary nail. Injury **34**: 278-282.

Garg, N.K., Ballal, M.S., Malek, I.A., Webster, R.A. and Bruce, C.E. 2008. Use of elastic stable intramedullary nailing for treating unstable forearm fractures in children. J. Trauma Acute Care Surg. **65**: 109-115.

Haas, B., Reichler, I.M. and Montavon, P.M. 2003. Use of the tubular external fixator in the treatment of distal radial and ulnar fractures in small dogs and cats. Vet. Comp. Orthop. Traumatol. **16**: 132-137.

Jain, R., Shukla, B.P., Nema, S., Shukla, S., Chabra, D. and Karmore, S.K. 2018. Incidence of fracture in dog: A retrospective study. Vet. Pract. **19**: 63-65.

Johnson, C.W., Carmichael, K.D., Morris, R.P. and Gilmer, B. 2009. Biomechanical study of flexible intramedullary nails. J. Pediatr. Orthop. **29**: 44-48.

Kang, S.N., Mangwani, J., Ramachandran, M., Paterson, J.M.H. and Barry, M. 2011. Elastic intramedullary nailing of paediatric fractures of the forearm: a decade of experience in a teaching hospital in the United Kingdom. J. Bone Joint Surg. Br. **93**: 262-265.

Kumar, A., Chaudhary, R.N, Ramniwas and Priyanka 2022. Titanium elastic nail used for repair of radius-ulna fracture in dogs. Pharma Innov. **11**: 1095-1098.

Ligier, J.N., Metaizeau, J.P., Prévot, J. and Lascombes, P. 1988. Elastic stable intramedullary nailing of femoral shaft fractures in children. J. Bone Joint Surg. Br. **70**: 74-77.

Myers, G.J.C., Gibbons, P.J. and Glithero, P.R. 2004. Nancy nailing of diaphyseal forearm fractures: single bone fixation for fractures of both bones. J. Bone Joint Surg. Br. **86**: 581-584.

Pankovich, A.M. 1987. Flexible intramedullary nailing of long bone fractures: a review. J. Orthop. Trauma. **1**: 78-95.

Poutoglidou, F., Metaxiotis, D., Kazas, C., Alvanos, D. and Mpeletsiotis, A. 2020. Flexible intramedullary nailing in the treatment of forearm fractures in children and adolescents, a systematic review. J. Orthop. **20**: 125-130.

Prabhukumar, M.D., Dileepkumar, K.M., Devanand, S.K., Venugopal, Indu, V.R., Anoop, S., Sudheesh, S.N. and Laiju, M.P. 2020. Elastic stable intramedullary nailing for fixation of distal diaphyseal fracture of radius in two dogs. Indian J. Vet. Surg. **41**: 134-136.

Razak, M.Y.A., El-Karef, E.A., Soliman, A.S. and Tanagho, A. 2008. Result of flexible intramedullary nailing in paediatric femoral fractures. Alex. J. Med. **44**: 729-735.

Reddy, S.P., Reddy J.M., Rao, R.K.J., Rao, M.T. and Purshotham, G. 2021. Clinical study on the surgical management of tibial fractures using titanium elastic nails in dogs. Pharma Innovation.**10**: 705-716.

Reddy, V.V. and Malasani, S.T. 2019. Surgical outcome of fracture shaft of tibia in children and adolescents using flexible nails. IOSR J. Dent. Med. Sci. **18**: 7-14.

Ruhullah, M., Singh, K.K., Shrestha, B.A., Gupta, K.M. and Jha, K.R. 2016. Flexible intramedullary titanium elastic nailing of fracture shaft of radius and ulna in children at a tertiary care teaching hospital. Int. J. Orthop. Rheumatol. **2**: 555-584.

Salem, K.H., Lindemann, I. and Keppler, P. 2006. Flexible intramedullary nailing in pediatric lower limb fractures. J. Pediatr. Orthop. **26**: 505-509.

Saran, D.S. 2023. Stainless steel elastic stable intramedullary nailing in long bone fractures in dogs. MVSc Theses, Rajasthan University of Veterinary and Animal Science, Bikaner (Rajasthan), India.

Schrader, S.C. 1991. Complications associated with the use of Steinmann intramedullary pins and cerclage wires for fixation of long-bone fractures. Vet. Clin. North Am. Small Anim. Pract. **21**: 687-703.

Simon, M.S., Ganesh, R., Ayyappan, S. and Kumar, R.S. 2011. Incidence of pectoral limb fractures in dogs: a survey of 331 cases. Tamilnadu J. Vet. Anim. Sci. **7**: 94-96.

Sodhi, H.S., Kumar, A., Anand, A., Sangwan, V. and Gupta, D.K. 2021. Titanium elastic nails for distal radius-ulna fractures in young dogs. Indian J. Anim. Res. **41**: 134-136.

Srivastava, A.K., Mehlman, C.T., Wall, E.J. and Do, T.T. 2008. Elastic stable intramedullary nailing of tibial shaft fractures in children. J. Pediatr. Orthop. **28**: 152- 158.

Till, H., Huttl, B., Knorr, P. and Dietz, H.G. 2000. Elastic stable intramedullary nailing (ESIN) provides good long-term results in pediatric long-bone fractures. Eur. J. Pediatr. Surg. **10**: 319-322.