



Evaluation of modified advanced locking plate system and polyaxial locking plate system with plate-rod and plating techniques for femur fracture repair in Dogs

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ABSTRACT

The present study was conducted in twenty-four clinical cases of femoral fracture in dogs were divided into four Groups. The femoral fractures in dogs of Group I were repaired using mALPS plating, Group II were repaired by PAX plating, Group III were repaired using mALPS plate-rod construct and Group IV were repaired with PAX plate-rod construct. Based on clinical, physiological and radiological analysis, healing of the fractures was studied at intervals of 0, 15th, 30th, 60th and 90th post-operative days. Dog's performance in fracture healing techniques with PAX plating, PRC – PAX, PRC – mALPS and mALPS plating Groups showed better weight-bearing on the fractured limb, immediately after the surgical repair while standing. Lameness grading in all the Groups showed that PAX had a statistically superior healing time in both PRC and plating techniques when compared with mALPS. Physiological parameters were fluctuated within normal physiological limits in all the Groups of animals suggesting that fracture healing period did not produced any changes in physiological parameters. Radiographic evaluation revealed that, fracture healing was slightly better in PAX plate when compared to mALPS and the comparison between the mALPS - PRC and the PAX - PRC revealed that PAX – PRC had slightly more rigid fixation when compared to mALPS – PRC.

Keywords: Dogs, Femur fracture, mALPS, PAX, Plate-rod

Long bone fractures are common in canines. Femur is the most commonly fractured long bone in dogs accounting for 37% (Kallianpur *et al.* 2018). The incidence of diaphyseal fracture is approximately 25%. The femoral fracture has higher incidence of non-union and osteomyelitis as reported by Wong (1994). External skeletal fixators and co-optation techniques for femoral fracture repair are not suitable and have limited usage. The internal fixation involves wide range of implants with varying degree of successes.

Advanced locking plate system was designed to preserve the periosteal blood supply, increase resistance to infection and promotes accelerated healing (Tepic *et al.* 2007). The advanced locking Plate System integrates the point contact fixator which enhances the biological fracture healing by preservation of the periosteal blood supply (Perren 2002).

Polyaxial locking plate system was designed to offer benefits of locking plate technology with additional provision for polyaxial insertion of screws in multi-directions up to 15 degrees forming a cone of 30 degree still maintaining the locking strength and not posing a problem of cross threading. This system has been used for the treatment of atlantoaxial luxation using specially designed butterfly plate; however, there is paucity of literature on the femoral fracture repair in dogs (Dickomeit *et al.* 2011).

The femoral fractures in young animals are quite

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common. Use of plating alone quite often fails due to the screw pullouts, also use of thicker plates produces stress induced osteopenia and fusion of growth plates if the screws are fixed in the vicinity. Hence, lighter plates with moderate supports and maintenance of alignment with intramedullary rods (IMR) is the treatment of choices in young animals. In the present study, modified advanced locking plate system and polyaxial locking plate system were compared with the plating and plate-rod techniques in order to evaluate a suitable treatment for femoral fractures in dogs.

MATERIALS AND METHODS

The study was conducted in 24 clinical cases of femoral fractures which were divided randomly into four Groups with 6 animals in each Group. The femoral fractures in dogs of Group I were repaired using mALPS plating, Group II were repaired by PAX plating, Group III were repaired using mALPS plate-rod construct and Group IV were repaired with PAX plate-rod construct. The clinical cases of dogs presented with the history of lameness, unable to bear body-weight on the affected limb, loss of function, abnormal motility and change in angulation of fractured limb (Raouf *et al.* 2017). After the clinical assessment, the dogs were subjected to pre-operative radiographic examination in two orthogonal views, *i.e.* medio-lateral and cranio-caudal views (Langley-Hobbs 2003) including the proximal and distal joints were obtained (Raouf *et al.* 2017,

Macri *et al.* 2021). The supportive Robert-Jones bandage for immobilization of fractured fragments was stabilized temporarily till the day of surgery.

By measuring the medio lateral view, the required length of plate, pin and bone marrow width were ascertained and by cranio-caudal view the required length of screw was ascertained. This procedure helped to avoid the usage of depth gauge intra-operatively.

Owners were advised to off-feed the dogs for 12 hours and withhold water for 6 hours prior to surgery. The affected limb was aseptically prepared as per standard surgical protocol. Atropine sulphate @0.045 mg/kg body-weight was administered subcutaneously as pre-anesthetic medication followed by xylazine hydrochloride 5 minutes later @0.50mg/kg body-weight intramuscularly. Fifteen minutes later general anaesthesia was induced with thiopental sodium @12.50 mg/kg body-weight and initial 1/3rd dose was administered rapidly and remaining 2/3rd dose was administered slowly through intravenous route as an induction dose based upon relaxation of reflexes, *viz.* ventro-medial displacement of eyeball and relaxation of jaw muscle tone reflex. Endotracheal intubation was carried out with appropriate size and connected to the gaseous semi-opened circuit of isoflurane as maintenance anaesthesia.

Surgical approach to fractured femur was carried out as per the standard procedure described by Guiot *et al.* (2017). Fractured femur bone was repaired either by mALPS or PAX with or without plate-rod construct, the tensor *fascia lata* and subcuticular layers were closed with continuous lockstitch and simple continuous pattern respectively by using 0 poly glycolic acid. The skin was closed with 2-0 mono filament polyamide black in all the groups.

Suture line was cleaned by applying 5% povidone-iodine solution and covering it with a thin layer of sterile gauze bandage. Over this, a layer of cotton padding was applied, covered with gauze bandage and was supported by crepe bandage. The dressing was changed every alternate day until the sutures were removed on the 14th post-operative day. E-collar was applied to prevent self-mutilation at the surgical site until the sutures were removed. Amoxicillin-cloxacillin was administered intravenously @10 mg/kg body weight b.i.d for 7 days. Tramadol was administered intravenous @4 mg/kg body weight s.i.d for 2 days followed by meloxicam @0.2 mg/kg body weight b.i.d for 3 days PO. Owners were advised to provide rest and restrict the movement of the dog for 1 week of surgery and then to allow for early ambulation with leash walking for the next few weeks.

Fracture healing was evaluated clinically, physiologically and radiographically on post-operative days. Clinical on 0th, 15th, 30th, 60th and 90th post operated days. Evaluation was performed to assess the weight-bearing for lameness grading as 1- Normal weight bearing on all limbs at rest and while walking; 2- Normal weight bearing at rest, favours affected limb while walking; 3-

Partial weight bearing at rest and while walking; 4- Partial weight bearing at rest, does not bear weight on affected limb while walking; 5- Does not bear weight on limb at rest or while walking as recommended by Vasseur *et al.* (1995). Physiological parameters such as respiratory rate (breaths/minute), heart rate (beats/minute) and rectal temperature (°F) were recorded in all the Groups of animals. Based on the periodic radiographs, implant position, union of fragments and callus formation were studied. Fracture healing was evaluated and recorded through these radiographic signs. A radiographic scoring was carried out to each radiograph to evaluate the fracture healing as given by Cook *et al.* (1999).

Quantitative data such as clinical and physiological parameters were analyzed using student's 't' test, as outlined by Snedecor and Cochran (1994). Qualitative parameters were analyzed by arbitrary score card method.

RESULTS AND DISCUSSION

Details of clinical evaluation for post-operative lameness grading are recorded in Table 1.

The Mean± SE values of the lameness grading in Group I (mALPS) animals on 0th, 15th, 30th, 60th and 90th days were 5.00 ± 0.00, 3.00 ± 0.10, 2.67 ± 0.02, 2.17 ± 0.47 and 1.67 ± 0.63 respectively.

Lameness decreased significantly ($p \leq 0.01$) from 15th day to 90th day when compared to 0 day, suggesting that mALPS provided stable fixation at the fracture site in five animals out of six. However, in one animal fixation was not stable due to the poor purchase of distal two screws.

The fixation by mALPS results concurred with the findings of earlier workers who had used ALPS for long bone fracture repairs (Nojiri *et al.* 2015 and Guerrero 2018). However, if the screws are improperly placed in such cases it could lead to complications and failure. Similar complications were also observed in repair of tibial fracture using ALPS in dogs by Pooja (2023).

The Mean ± SE values of the lameness grading in Group II (PAX) animals on 0th, 15th, 30th, 60th and 90th days were 5.00 ± 0.00, 2.00 ± 0.09, 1.50 ± 0.04, 1.67 ± 0.03 and 1.67 ± 0.03 respectively.

Lameness decreased significantly ($p \leq 0.01$) from 15th day to 90th day when compared to 0 day, suggesting that PAX provided stable fixation at the fracture site in five animals out of six. However, in one animal fixation was not stable due to the osteopenia condition resulted in bone dissolution.

These results suggested that polyaxial locking plate system provided stable fixation for femoral fractures in dogs. These results were in agreement with the findings of earlier workers who had used PAX for long bone fracture repairs (Nojiri *et al.* 2015, Kaczmarek 2019, Guerrero 2018). However, if the screws were improperly placed in such cases it could lead to complications and failure. Similar complications were observed in repair

Table 1 Post-operative lameness grading of dogs in Groups I, II, III and IV study

Group	Case No.	Day 0	Day 15	Day 30	Day 60	Day 90
I (mALPS)	1	V	II	II	II	I
	2	V	II	II	I	I
	3	V	IV	IV	V	V
	4	V	IV	II	II	I
	5	V	IV	II	II	I
	6	V	II	II	I	I
			5.00±0.00	3.00±0.10**	2.67±0.02**	2.17±0.47**
II (PAX)	1	V	II	I	I	I
	2	V	I	I	I	I
	3	V	I	I	I	I
	4	V	II	II	I	I
	5	V	IV	III	V	V
	6	V	II	I	I	I
			5.00±0.00	2.00±0.09**	1.50±0.04**	1.67±0.03**
III (mALPS plate-rod construct)	1	V	II	II	II	I
	2	V	IV	II	II	I
	3	V	II	II	I	I
	4	V	III	III	IV	IV
	5	V	IV	II	II	I
	6	V	II	II	I	I
			5.00±0.00	2.83±0.08**	2.17±0.41**	2.00±0.10**
IV(PAX plate-rod construct)	1	V	III	II	I	I
	2	V	II	II	I	I
	3	V	II	I	I	I
	4	V	III	II	I	I
	5	V	III	II	I	I
	6	V	III	III	IV	IV
			5.00±0.00	2.67±0.52**	2.00±0.03**	1.50±0.22**

Means bearing the superscript** differ significantly ($p \leq 0.01$) with the Group from the 0th day

of femur fracture using PAX in dogs by Bassanino *et al.* (2021).

The Mean \pm SE values of the lameness grading in Group III (mALPS + PRC) animals on 0th, 15th, 30th, 60th and 90th days were 5.00 ± 0.00 , 2.83 ± 0.08 , 2.17 ± 0.41 , 2.00 ± 0.10 and 1.50 ± 0.22 respectively.

Lameness decreased significantly ($p \leq 0.01$) from 15th day to 90th day when compared to 0th day, suggesting that plate-rod construct technique by using mALPS plate provided stable fixation at the fracture site in five animals out of six. However, in one animal fixation was not stable due to the migration of pin on the proximal aspect leads to non-usage of limb. These results suggested that Plate-rod construct by using modified advanced locking plate system provided stable fixation for femoral fractures in dogs. These results were in agreement with the findings of earlier workers who had used PRC for long bone fracture repairs (Yadav *et al.* 2021). However, if the screws were improperly placed in such cases it could lead to complications and failure. Similar complications were also observed in repair of femur fracture using PAX in dogs by Bassanino *et al.* (2021).

The Mean \pm SE values of the lameness grading in Group IV (PAX+PRC) animals on 0th, 15th, 30th, 60th and

90th days were 5.00 ± 0.00 , 2.67 ± 0.52 , 2.00 ± 0.03 , 1.50 ± 0.22 and 1.50 ± 0.22 respectively.

Lameness decreased significantly ($p \leq 0.01$) from 15th day to 90th day when compared to 0 day, suggesting that plate-rod technique by using PAX plate provided stable fixation at the fracture site in five animals out of six. However, in one animal fixation was not stable due to the screw pull-out and pin migration from distal fragment.

These results suggested that plate-rod construct by using polyaxial locking plate system provided stable fixation for femoral fractures in dogs. These results were in agreement with the findings of earlier workers who had used PRC for long bone fracture repairs using LCP (Bassanino *et al.* 2021). However, if the intra medullary pinning was improperly placed in such cases it could lead to complications and failure. Similar complications were observed in repair of femur fracture using PAX in dogs by Bassanino *et al.* (2021).

Physiological parameters *viz.*, heart rate, respiratory rate and rectal temperature values fluctuated within normal physiological limits in all the Groups of animals suggesting that fracture healing period does not produced any changes in physiological parameters. The details of physiological parameters are shown in Table 2. The

changes were statistically non- significant ($p>0.05$) at different intervals when compared to 0 day in all the Groups of animals. Similar results were absorbed by several earlier workers (Ojus *et al.* 2022, Pooja 2023).

On 0th day pre-operative, cranio-caudal and medio-lateral radiographs in Group I (mALPS) showed distal metaphyseal slightly dentate transverse femoral fracture.

On 0th day post-operative, cranio-caudal and medio-lateral radiographic observations, showed angulation of the bone was properly maintained, there was proper reduction and alignment maintained with mALPS plate was in close contact with cis-cortex proximal three screws crossed the trans-cortex whereas remaining screws just touched the trans-cortex.

On 15th day post-operative, cranio-caudal and medio-lateral radiographs showed that, the angulation of the bone was maintained properly and proximal screws traversed the trans-cortex and remaining screws were just in contact with the trans-cortex, soft tissue surrounding the bone showed increased density. The implant was well maintained in situ, initiation of callus formation was observed of the fracture site.

On 30th day post-operative, cranio-caudal and medio-lateral radiographs showed a proper angulation of bone with cortical line alignment in both the cortices, excessive callus formation was observed round the fractured bone. The implant was in close contact with the cis-cortex, distal screws showed slight elevation from the plate hole.

On 60th day post-operative, cranio-caudal and medio-lateral radiographs showed well maintained angulation with good cortical alignment; bridging callus was observed at the fracture site excess callus formed around

the bone showed resorption and initiation of remodeling.

On 90th day post-operative, cranio-caudal and medio-lateral radiographs showed well maintained angulations with re-established cortical line indicating osteosynthesis. The excess callus was resolved and a slight callus line was observed from upper 4th screw to distal 8th screw, distal screws showed slight elevation of their head from the plate holes, remaining all the screws were intact. There was a slight gap between the plate and cis-cortex between the 2nd and 3rd screw of distal metaphyseal region.

The above observations were recorded in five out of six animals whereas; remaining one animal had complication which was due to the poor fixation of distal two screws.

The results of stable fixation were in agreement with the earlier workers who had used ALPS for long bone fracture repair (Nojiri *et al.* 2015, Guerrero 2018). However, if the screws were improperly attached in such cases it could lead to complications and failure. Similar complications were observed in repair of tibial fracture using ALPS in dogs by Pooja (2023).

On 0th day pre-operative, cranio-caudal and medio-lateral radiographs in Group II (PAX), showed proximal diaphyseal caudal cortical transverse femoral fracture.

On 0th day post-operative, cranio-caudal and medio-lateral radiographs showed that, the angulation of the bone was properly maintained, there was proper reduction and alignment with PAX plate was in close contact with the majority of the cis-cortex of the bone. However, between 1st and 2nd proximal screw there was a slight gap between the cis-cortex and plate was observed. All the screws had passed through the trans-cortex indicating

Table 2 Physiological parameters (Mean±SE) values for femoral fracture repair of dogs

Parameter	Group	0 th Day	15 th Day	30 th Day	60 th Day	90 th Day
Respiratory rate (Breaths/min)	I	23.50±1.10	22.83±2.16	24.17±2.50	22.67±2.32	23.53±0.04
	II	24.62±1.02	22.92±1.15	23.92±1.62	23.42±0.82	23.92±0.92
	III	25.14±0.72	22.38±0.82	24.04±0.82	22.53±1.14	24.06±1.13
	IV	26.00±2.18	20.33±1.20	22.67±1.69	21.50±0.99	23.73±2.14
Heart rate (Beats/min)	I	83.67±1.76	84.83±2.26	84.83±1.95	79.83±2.17	84.93±1.32
	II	83.13±2.56	82.79±2.04	83.63±2.97	81.17±1.30	84.72±0.62
	III	82.92±1.73	83.42±1.42	84.24±1.86	82.13±1.42	85.13±0.72
	IV	82.42±0.62	83.49±1.84	85.73±2.14	82.51±2.42	83.38±0.84
Rectal temperature (°F)	I	101.45±0.19	101.10±0.37	101.25±0.40	100.25±0.24	101.14±1.11
	II	101.64±0.23	100.71±0.28	100.64±0.26	100.73±0.39	101.38±0.64
	III	101.76±0.72	100.42±0.32	101.32±0.52	100.21±0.84	100.84±0.15
	IV	101.12±0.41	101.22±0.14	100.92±0.61	101.15±0.99	101.64±0.72

bi-cortical fixation.

On 15th day post-operative, cranio-caudal and medio-lateral radiographs showed angulation of the bone and maintained properly; all the screws were adhered bi-cortically indicating of rigid fixation, soft tissue showed normal radiographic density. The implant was well maintained in situ.

On 30th day post-operative, cranio-caudal and medio-lateral radiographs showed proper angulation of bone, cortical line alignment was observed in both the cortices. Osteosynthesis was observed in bridging the cortical line. The implant was in close contact with the cis-cortex. Soft tissue showed normal density, suggestive of intact blood supply to the bone.

On 60th day post-operative, cranio-caudal and medio-lateral radiographs showed well maintained bone angulation, cortical lines were well alignment; bridging callus was observed at the fracture site showing end-on healing.

On 90th day post-operative, cranio-caudal and medio-lateral radiographs showed that angulation was well maintained, cortical lines were re-established indicating of osteosynthesis. Screws were properly fixed during this period of study indicating that implant fixation was very rigid. Implant fixed was static and maintained the same counter throughout this period of study.

The above records were observed in five out of six animals whereas, remaining one animal had complication which was due to the osteopenia condition resulted in bone dissolution.

These results suggested that polyaxial locking plate system provided stable fixation for femoral fractures in dogs. These results were in agreement with the findings of earlier workers who had used PAX for long bone fracture repairs (Klug *et al.* 2018; Kaczmarek 2019; and Guerrero, 2018). However, if the screws were improperly fixed in such cases it could lead to complications and failure. Similar complications were also observed in repair of femur fracture using PAX in dogs by Bassanino *et al.* (2021).

On 0th day pre-operative, cranio-caudal and medio-lateral radiographs in Group III (Plate-rod Construct using mALPS) showed proximal short oblique over-riding diaphyseal femoral fracture.

On 0th day post-operative, cranio-caudal and medio-lateral radiographs showed that, the angulation of the bone was properly maintained, there was proper reduction and alignment maintained with PRC by using mALPS plate was in close contact with cis-cortex proximal; 1st screw showed bi-cortical fixation; rest all showed uni-cortical fixation. Soft tissue showed normal density.

On 15th day post-operative, cranio-caudal and medio-lateral radiographs showed angulation of the bone. Proximal screws traversed the trans-cortex; remaining screws were in just incontact with the trans-cortex, soft tissue surrounding the bone showed increased density indicative of increased blood supply to the fracture site.

The implant was well maintained in situ, initiation of callus formation was observed of the fracture site.

On 30th day post-operative, cranio-caudal and medio-lateral radiographs showed proper angulation of bone, cortical line alignment was observed in both the cortices, excessive callus formation was observed around the fractured bone. The implant was in close contact with the cis-cortex, proximal screws showed slight elevation from the plate hole.

On 60th day post-operative, cranio-caudal and medio-lateral radiographs showed well maintained angulation, cortical lines were well alignment with bridging callus at the fracture site. Soft tissue density was increased.

On 90th day post-operative, cranio-caudal and medio-lateral radiographs showed that angulation was well maintained, cortical lines were re-established indicating of osteosynthesis. The proximal 1st screw elevation was observed and the head of the screw was away from the plate holes, remaining all the screws and pins were intact. There was a gap between the plate and cis-cortex at 1st screw of proximal diaphyseal region.

Trocar point of the intramedullary pin was properly fixed in the epiphyseal region through-out the study.

The above observations were recorded in five out of six animals whereas; remaining one animal had complication which was due to the pin migration on the proximal aspect leads to non-usage of limb.

These results suggested that Plate-rod construct by using modified advanced locking plate system provided table fixation for femoral fractures in dogs. Results were in agreement with the findings of earlier workers who had used PRC for long bone fracture repairs (Yadav *et al.* 2021). However, if the screws were improperly fixed in such cases it could lead to complications and failure. Similar complications were also observed in repair of femur fracture using PAX in dogs by Bassanino *et al.* (2021).

Group IV (Plate-rod Construct using PAX): On 0 day pre-operative, cranio-caudal and medio-lateral radiographs in showed long oblique extending from proximal to distal metaphyseal region with over-riding, splintered femoral fracture.

On 0th day post-operative, cranio-caudal and medio-lateral radiographs showed that, the angulation of the bone was properly maintained with proper reduction and alignment with PRC by using PAX plate was in closed contact with cis-cortex; all the screws except one that was penultimate at the distal metaphyseal region.

On 15th day post-operative, cranio-caudal and medio-lateral radiographs showed that, the angulation of the bone was maintained properly, soft tissue surrounding the bone showed increased density. The implant was well maintained in situ, initiation of callus formation was observed on the fracture site with a visible fracture gap.

On 30th day post-operative, cranio-caudal and medio-lateral radiographs showed proper angulation of bone with

cortical line alignment in both the cortices. The implant was in close contact with the cis-cortex.

On 60th day post-operative, cranio-caudal and medio-lateral radiographs showed well maintained angulation of bone, cortical lines were well alignment and bridging callus was observed at the fracture site. Soft tissue density was increased resulting in increased blood supply to the fracture site

On 90th day post-operative, cranio-caudal and medio-lateral radiographs showed that angulation was well maintained, cortical lines were re-established indicating of osteosynthesis. All the screws were intact and properly placed.

Trocar point of the intramedullary pin was properly lodged in the epiphyseal region through-out the study.

The above observations were recorded in five out of six animals whereas, remaining one animal had complication which was due to screw pull-out and pin migration from distal fragment.

These results suggested that Plate-rod construct by using polyaxial locking plate system provided stable fixation for femoral fractures in dogs. These results were in agreement with the findings of earlier workers who had used PRC for long bone fracture repairs using LCP (Bassanino *et al.* 2021). However, if the intra medullary pinning was improperly placed in such cases it could lead to complications and failure. Similar complications were also observed in repair of femur fracture using PAX in dogs by Bassanino *et al.* (2021).

There were no intra-operative complications observed in all the twenty-four animals operated. This could be attributed to meticulous planning and following of standard protocol which might eliminated intra-operative complications. No intra-operative complications were observed by several earlier workers (Ojus *et al.* 2022 and Pooja 2023).

Four out of twenty-four animals had post-operative complications with one animal in each Group. In Group I, one dog showed plate bending at the proximal fracture fragment on the 30th post-operative day. The fracture fragments were in proper alignment upto the 30th post-operative day. The dog had good functional limb usage on the 25th post-operative day. Corrective surgery was performed by removing the implant and stabilizing the fracture fragments with other plating systems. The dog had a plate bending on 30th post-operative day; this could be attributed to aggressive behavior of the animal. Such complications were also recorded by earlier worker (Wangchuk *et al.* 2021 and Pooja 2023)

In Group II, one dog showed osteogenic changes to the plate leading to non-union or mal-union of fracture fragments on the 30th post-operative day. The dog had good functional limb usage on the 15th post-operative day. Owner was advised to go for removal of implant; however, he showed little interest, and the animal suffered progressive worsening of lameness and reduced functional limb usage. The dog had non-union which

could be attributed to fracture environment coupled with low oxygen tension at the fracture site. Non-union in plate fixation technique was reported by Nicholson *et al.* (2021).

In Group III, one dog showed refracture proximal to the plate and also pin migration was noticed on 45th post-operative day leading to sciatic nerve damage and reduced functional limb usage. The dog had a complication of pin migration and sciatic nerve injury. Similar complication was observed in plate-rod technique by Reems *et al.* (2003).

In Group IV, one dog showed Malunion of fracture fragments due to hyperactivity behavior of the animal, and immobilization was difficult by the owner leads to pin migration at the distal aspect of the bone and two screws pull-out was observed at distal metaphyseal region on 60th post-operative day. The dog had good functional limb usage upto the 57th post-operative day. The owner was advised to go for removal of implant; however, he showed little interest, and the animal suffered progressive worsening of lameness and reduced functional limb usage. The dog had a complication of pin migration and distal 2 screws were pull-out led to implant failure. The similar complication was reported by Reems *et al.* (2003) and Wangchuk *et al.* (2021).

Based on clinical, physiological and radiographical findings it was concluded that, all the four techniques were good in producing the normal limb usage and reducing the lameness. The sequence of implant fixation techniques was PAX plating followed by PAX-PRC, mALPS-PRC and mALPS plating respectively. Fracture healing was slightly better in PAX plate when compared to mALPS and the comparison between mALPS-PRC and the PAX-PRC revealed that PAX-PRC has slightly more rigid fixation when compared to mALPS-PRC.

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