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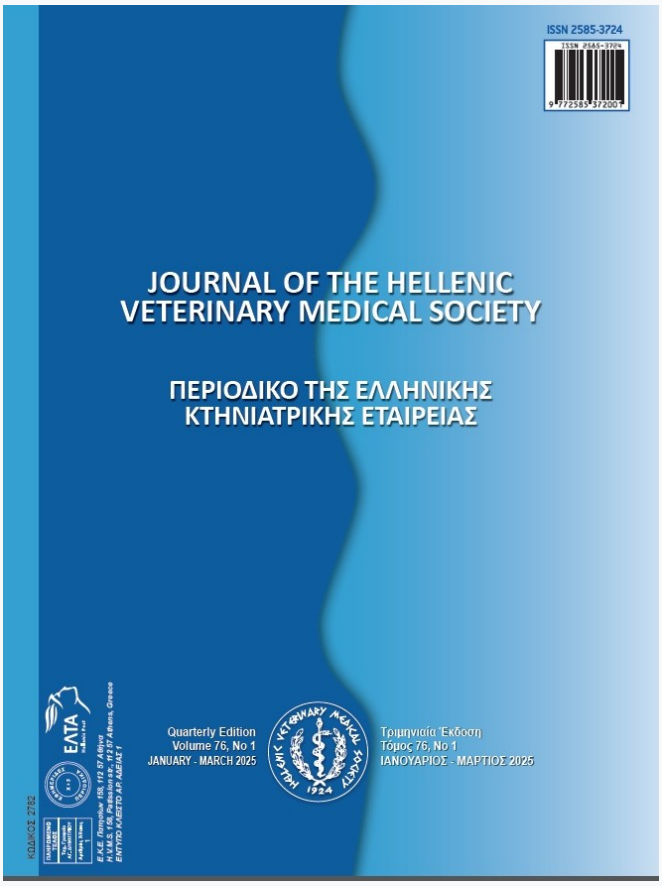


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# Treatment of Long Bone Fractures with Locking Kuntscher Nail in Dogs

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(This study is summarised from the first author's Master's thesis of the same title.)
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**ABSTRACT:** The purpose of this study was to evaluate the treatment of long bone fractures in dogs with Küntscher locking nails, based on clinical and radiographic findings. The study material consisted of 16 dogs of different breeds, ages, and sexes diagnosed with diaphyseal fractures of the femur or tibia. Fractures treated with standard surgical techniques which were operated on with Küntscher locking nails and cortical locking screws of sizes determined by preoperative radiographic findings. Cases were radiographed weekly for 4 weeks postoperatively and lameness scores were obtained. In one case, callus exuberance was observed at postoperative day 7 and the lameness score was determined to be grade 4. In one case, during surgery, it was observed that the nail had broken in the medulla after passing the fracture line, and the lameness score on the 7th postoperative day was recorded as grade 1. In one case, the cortical screws used were found to have missed the distal holes and the lameness score was recorded as 1. In another case, the distal part of the nail was broken on postoperative day 15 and the lameness score was recorded as 1. As a result, based on the clinical and radiographic findings, it was concluded that the Küntscher locking nail may be preferred for long bone fractures in dogs because of its advantages over current treatment methods with its high success and low complication rates, especially the fact that it eliminates pin migration and allows early use of the limb.

***Keyword:*** Femur; tibia; dog; fracture; locking Küntscher nail.

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## INTRODUCTION

It has been reported that long bone fractures are common in dogs, with approximately 50% being femoral (Unger et al., 1990; Whitehair et al., 1992) and 20% tibial (Seaman and Simpson, 2004). It has been reported that femoral fractures most commonly occur in the diaphysis (56%), followed by epiphyseal-metaphyseal regions (20%) (Boudrieau and Sinilbaldi, 1992), and approximately 73% of tibial fractures occur in the diaphysis (Zaal and Hazewinkel, 1996).

Various methods such as intramedullary nails, plates and external fixators are used to treat long bone fractures in dogs. Factors relating to the owner, such as cost and post-operative care, as well as factors relating to the fracture and the animal, should be considered when deciding which method to use. The most cost-effective method with the fewest complications should be chosen. From this point of view, the option of intramedullary nailing for long bone fractures in dogs has been preferred more often. However, although conventional intramedullary pins are resistant to bending, it's clear that they do not adequately prevent rotational movement in the fracture line and are associated with significant complications such as pin migration (Lillich et al, 1999; McLaughlin, 1999).

Locking nails have many advantageous biomechanical properties, although they may be more expensive than conventional intramedullary nails. They are resistant to bending forces, as is the Steinman intramedullary nail, and also provide resistance to axial and rotational forces with transcortical locking screws and prevent nail migration. (Kyle et al, 1991; Dueland et al, 1996; Piermattei and Flo, 1997).

During the Second World War, Gerhard Küntscher developed the first locking intramedullary nail, called the Detensor nail, and used it to treat soldiers with femoral fractures, and the results were first published in1940 (Dueland et al, 1996; Lin et al, 2001; Bong et al, 2007). Locking nails are used in the treatment of diaphyseal fractures of the femur, tibia and humerus, as intramedullary nails with a special guidance system with transverse holes at both ends (Brumback, 1996). Locking nails are used to stabilise closed fractures as well as open, contaminated cases (Moses et al, 2002; Larin et al, 2001). Locking nails can resist axial, rotational, and bending forces when stabilizing unhealed or infected fractures (Moses et al, 2002; Dueland et al, 2001; Muir and Johnson, 1996). This study aimed to evaluate the results of the treatment of long bone fractures in 16 dogs with the Küntscher locking nail in terms of clinical and radiographic findings.

## MATERIAL AND METHOD

### Pre-operative planning

In this study, 7 femoral and 9 tibial fractures in 16 dogs of different breeds, age, and sex were treated with Küntscher locking nails and the results were discussed. Standard soft tissue and orthopaedic surgical equipment as well as the Küntscher locking nail set (Vetlock®, Ortho-Pet, İzmir, Turkey) and cortical screws were used in the operations.

Clinical and systemic examinations were performed on all dogs before surgery. Cases with no problem other than fractures were included in the study and two-way (anteroposterior-AP and mediolateral-ML) radiographs of the relevant extremity were obtained. The location of the fracture, the fracture pattern and the locking Küntscher nails (Vetlock®, Ortho-Pet, İzmir, Turkey) and the screw sizes to be used were determined on the basis of the radiographic findings. Küntscher nails with a diameter of 4.5 mm to 8 mm and a length of 150 mm to 190 mm were used.

### Surgical Technique

The extremity to be operated on was prepared according to routine asepsis-antisepsis rules. Open and infected fractures were cleaned with antiseptic and antibiotic solutions.

The dogs were anaesthetised with isoflurane (Isoflurane-usp, Adeka İlaç San. Tic.) after premedication with 0.045 mg/kg subcutaneous injection of atropine sulphate (Atropin, Vetas) and 1-2 mg/kg intramuscular injection of xylazine hydrochloride (Alfazine, Alfasan International).

The patient, under general anaesthesia, was positioned on the upper side. Femoral fractures were approached laterally and tibial fractures were approached medially. Locking nails were placed on both bones using the retrograde method. The appropriate Küntscher locking nail, prepared preoperatively, was placed in the proximal fragment using the retrograde technique. Fracture reduction was completed and the outer tip of the nail was placed in the distal fragment using a hammer after being connected to the guide. Complete reduction was achieved by using a cerclage wire in place, if necessary. The system was then fixed by locking with cortical screws through holes in the proximal and

distal fragments. After confirmation of the reduction and stability of the system, the guide was disconnected from the nail, the region was routinely closed and the operation was completed.

**Post-operative follow-up**

Post-operative x-rays were taken to check fracture stabilisation and nail position. In all cases, local antibiotics were used in the area of the fracture to reduce the risk of deep infection. Animal owners were advised to use Synulox (Pfizer®) injectable suspension at a dose of 8.75 (7mg amoxicillin and 1.75 clavulanic acid) as parenteral antibiotics for one week and analgesics for 3 days after surgery. During the postoperative period, radiographs were taken on days 1, 7, 14, 21, and 30 and after that to assess the anatomic position and the onset and grade of healing until fracture healing was complete. Clinical follow-up of the patients included assessment of whether or not the extremity was used, pain, joint mobility, and muscle and tendon contractures in the region. Although an attempt was made to follow up each animal post-operatively, it was not possible to follow up 2 patients regularly in the clinic as most of the cases were brought to the clinic from outside the city. In these cases, information about the patients was obtained by telephone. In the post-operative period, pain and lameness in the affected limb were noted in all cases. Lameness scores were determined according to the criteria of Bergmann et al. (Tables 1 and 3).

**Table 1.** Lameness grade (LG)

| Grade | Description |
|---|---|
| 0 | Normal posture position, |
| 1 | Fast walking difficulty and slight lameness |
| 2 | Fast walking difficulty and intermittent lameness |
| 3 | Stiffness and notable pain at each step |
| 4 | Severe pain and difficulty in stepping |

## RESULTS

In this study, the results of the treatment of 16 dogs (6 crossbreeds, 2 German Pointers, 2 Transylvanian Greyhounds, 1 Siberian Husky crossbreed, 1 German Shepherd, 1 Kangal, 1 Darachtar, 1 Kangal crossbreed, 1 Terrier crossbreed) with the locking Küntcher nail were evaluated and presented.

Fourteen of the cases were the result of road traffic accidents, one was the result of a weight fall and the cause of one case was unknown. Seven fractures were femoral and 9 were tibial. Of these, 12 were localised in the mid-diaphysis, 2 in the distal 1/3 diaphysis and 2 in the proximal 1/3 diaphysis. When soft tis-

**Table 2.** Breed, age, gender and body weight distribution of the cases

| Case No. | Breed | Age | Gender | Body Weight (kg) |
|---|---|---|---|---|
| 1 | Drachtar | 1.5 Years | Male | 23 |
| 2 | Cross-breed | 10 Months | Female | 19 |
| 3 | German Shorthaired Pointer | 10 Months | Male | 15 |
| 4 | Kangal crossbreed | 2 Years | Female | 29 |
| 5 | Terrier crossbreed | 6 Months | Female | 12 |
| 6 | Transylvanian Hound | 4 Years | Female | 15 |
| 7 | Transylvanian Hound | 4 Years | Male | 16 |
| 8 | Cross-breed | 8 months | Female | 13 |
| 9 | Siberian Wound Melody | 1.5 Years | Female | 19 |
| 10 | Cross-breed | 1 Year | Male | 14 |
| 11 | German Shorthaired Pointer | 2 Years | Female | 22 |
| 12 | German Shepherd Dog | 1.5 Years | Male | 25 |
| 13 | Cross-breed | 3.5 Years | Male | 18 |
| 14 | Cross-breed | 1 Year | Female | 13 |
| 15 | Kangal | 9 Months | Female | 30 |
| 16 | Cross-breed | 1.5 Years | Male | 15 |

sue integrity was taken into account, 15 cases were classified as closed fractures and 1 as open fractures.

Information on the results of the post-operative radiological examinations and the lameness grades of the cases is given in Table 1.4.

The patient was re-operated in a case (case 1) who had previously undergone intra-medullary pin insertion and broke the pin in the postoperative period by jumping out of the car. However, on examination on postoperative day 10, restriction of movement in the stifle joint was observed and the lameness grade was recorded as 4. As the owner of the patient did not pay attention to the post-operative care, the post-operative care could be started on day 21. Intensive physiotherapy showed that the lameness grade had regressed to 3). One case (case number 15) was brought to the clinic on the 18th day after the trauma and was urgently operated on. Despite this, the lameness grade (LG) was found to be 3 on postoperative week 1, 1 on day 21 and 0 on day 180.

A 4.5mm Küntscher locking nail used in three cases (case numbers 5, 7 and 10) was found to be fractured at the distal hole in the postoperative period (day 14, intraoperative and day 14, respectively). No intervention was performed because it was observed that the patients had no difficulty using their extremities.

In one case (case No 11), although the cortical screws missed the proximal static hole, the patient did not have any problem using the extremity on the postoperative 7th day and the lameness grade decreased to 0 on the 62nd day.

One patient (Case No: 9) was found to have an infectious disease on the postoperative 10th day, and the information available on this patient was that he did not respond to treatment and died.

**Table 3**. Distribution of the cases regarding the cause, location, shape and size of the Locking Küntscher nail applied.

| Case No | The cause of the fracture | Location and Shape | Size of Locking Küntscher Nail Applied |
|---|---|---|---|
| 1 | Traffic accident | Right femur, diaphyseal, distal 1/3 transversal fracture | 8x180 mm |
| 2 | Traffic accident | Right femur, mid-diaphyseal oblique fracture | 8x170 mm |
| 3 | Traffic accident | Left femur, proximal diaphyseal, oblique fracture | 6x150 mm |
| 4 | Weight falling on it | Left femur. proximal diaphyseal, transversal fracture | 8x190 mm |
| 5 | Traffic accident | Right tibia, mid-diaphyseal, segmental fracture | 4.5x150 mm |
| 6 | Traffic accident | Right tibia, mid-diaphyseal, segmental fracture | 6x160 mm |
| 7 | Traffic accident | Right tibia, mid-diaphyseal, transversal fracture | 4.5x160 mm |
| 8 | Traffic accident | Right tibia, mid-diaphyseal, transversal fracture | 6x150 mm |
| 9 | Traffic accident | Left tibia, distal diaphyseal, oblique fracture | 8x220 mm |
| 10 | Unknown | Left tibia, mid-diaphyseal, old transversal fracture | 4.5x 150 mm |
| 11 | Traffic accident | Right femur, mid-diaphyseal, transversal fracture | 6x190 mm |
| 12 | Traffic accident | Right tibia, mid-diaphyseal, oblique fracture | 6x190 mm |
| 13 | Traffic accident | Right femur, mid-diaphyseal, segmental oblique fracture | 6x170 mm |
| 14 | Traffic accident | Left tibia, mid-diaphyseal, oblique fracture | 6x160 mm |
| 15 | Traffic accident | Right tibia, d mid-diaphyseal, old oblique fracture | 8x190 mm |
| 16 | Traffic accident | Right femur, mid-diaphyseal, segmental oblique fracture | 6x170 mm |

**Table 4.** Patient's postoperative radiographic findings and lameness scores

| Case No. | Postoperative Radiographic Findings and Lameness Score by Day (TS) | | | |
|---|---|---|---|---|
| | Day 7 | Day 14 | Day 21 | Day 30/ After Day 30 |
| 1 | The fracture line is apparent, callus initiation, LG 4. | Visible fracture line and prominent callus formation, LG 2. | The fracture line filled with exuberant callus, LG 3. | On the 68th day after the operation, the fracture line is visible, and there is an excessive amount of callus formation. By the 180th day after the operation, the fracture line has begun to close, and LG 3. |
| 2 | The fracture line is apparent, callus initiation, LG 2. | Visible fracture line and prominent callus formation, TS 2. | The fracture line is apparent, exuberant callus formation, LG 2. | On postoperative day 48, prominent exuberent callus had formed along the fracture line. By postoperative day 60, the fracture line had started to close with a LG 1. |
| 3 | The fracture line is apparent, callus initiation, LG 2. | Radiographic examination and lameness score could not be obtained. | The fracture line beginning to close, and there's callus exuberant formation, LG 1. | Radiographic examination and lameness score could not be obtained (LG identified as 0 in telephone interview). |
| 4 | The fracture line is apparent, callus initiation, LG 2. | Reduced fracture line visibility and marked callus formation, LG 1. | Radiographic examination and lameness score could not be obtained. | On postoperative day 38, the fracture line began to close, the callus is smooth, LG 0. |
| 5 | The fracture line is apparent, callus initiation, LG 2. | The fracture line visible and prominent callus formation, distal fracture of the nail, LG 1 | The fracture line is apparent, there's exuberant callus formation, LG 1. | On postoperative day 180, the fracture line began to disappear, LG 0. |
| 6 | The fracture line is apparent, callus initiation, LG 1. | The fracture line is visible and there is a pronounced callus formation. LG 1. | Radiographic examination and lameness score could not be obtained. | Radiographic examination and lameness score could not be obtained. (LG identified as 0 on telephone interview). |
| 7 | Visible Fracture line, prominent callus formation, distal fracture of the nail, LG 1. | The fracture line is visible and there's exuberant callus formation, LG 1. | Radiographic examination and lameness score could not be obtained. | Radiographic examination and lameness score could not be obtained. (LG identified as 0 on telephone interview). |
| 8 | The fracture line is apparent, callus initiation, LG 1. | Radiographic examination and lameness score could not be obtained. | The fracture line beginning to close, and there's callus exuberant formation, LG 1. | Radiographic examination and lameness score could not be obtained (LG identified as 0 on telephone interview). |
| 9 | The fracture line is apparent, callus initiation, LG 1. | The fracture line is visible and there's a prominenet callus formation, LG 1. | Radiographic examination and lameness score could not be obtained. | Radiographic examination and lameness score could not be obtained (LG identified as 0 on telephone interview). |

**Table 4.** Patient's postoperative radiographic findings and lameness scores

| Case No. | Postoperative Radiographic Findings and Lameness Score by Day (TS) | | | |
|---|---|---|---|---|
| 10 | The fracture line is apparent, there's callus formation after the old fracture callus, LG 1. | The fracture line is visible and there's exuberant callus formation, LG 1. | Radiographic examination and lameness score could not be obtained. | Radiographic examination and lameness score could not be obtained (LG identified as 0 on telephone interview). |
| 11 | The fracture line is apparent, callus initiation, LG 1 | The fracture line is visible and there's apparent callus formation. | Radiographic examination and lameness score could not be obtained. | The fracture line on the post-op 40$^{th}$ day is apparent; on the post-op 62$^{nd}$-day fracture line is closed, LG 0. |
| 12 | The fracture line is apparent, callus initiation, LG 1 | The fracture line is visible and there's a distinctive callus formation, LG 1. | The fracture line is visible, callus smooth, LG 1. | Radiographic examination and lameness score could not be obtained (LL identified as 0 on telephone interview). |
| 13 | The fracture line is apparent, callus initiation, LG 2 | The fracture line is visible and there's a distinctive callus formation, LG 1. | The fracture line is visible and smooth callus formation, LG 1. | The fracture line began to close and the callus is smooth LG 0. |
| 14 | The fracture line is apparent, callus initiation, LG 2 | The fracture line is visible and there's exuberant callus formation, LG 2. | The fracture line is visible, there's exuberant callus formation, LG 1. | The fracture line began to close, there's exuberant callus formation, LG 0. |
| 15 | The fracture line is apparent, there's callus formation after the old fracture callus, LG 3 | The fracture line is visible and there's exuberant callus formation, LG 2. | Fracture line visible, exuberant callus formation, loosening of the screw in the distal proximal hole of the nail, LG 1. | Closure of the fracture line has begun and there is exuberant callus formation (LG identified as 0 on site examination on day 180). |
| 16 | The fracture line is apparent, callus initiation, LG 1 | Radiographic examination and lameness score could not be obtained. | The fracture line is visible, there's smooth callus formation, LG 1. | Postoperative day $^{65}$, fracture line closed, callus smooth, LG 0. |

## DISCUSSION

It is emphasised that traffic accidents are the most common cause of long bone fractures in dogs (Yücel et al., 1982; Denny and Butterworth, 2000). In the present study, 75% of the cases were attributed to traffic accidents.

It has been reported that half of all long bone fractures in dogs are femoral and 20% are tibial (Unger et al, 1990; Whitehair and Wasseur, 1992; Seaman and Simpson, 2004). Of the 16 patients we studied, 56.25% had tibial fractures and 43.75% had femoral fractures. It has been reported that most femoral fractures occur in the diaphysis (56%), followed by the epiphyseal-metaphyseal region (20%) (Boudrieau and Sinibaldi, 1992), and approximately 73% of tibial fractures occur in the diaphysis (Zaal and Hazewinkel, 1996). In the present study, the fractures were diaphyseal in all cases, which is consistent with the literature.

Various methods using intramedullary pins, plates and screws, and external fixators are used in the treatment of long bone fractures. Insufficient resistance to axial or rotational loads in the fracture line (Lillich et al., 1999; McLaughlin, 1999) and pin migration are the main disadvantages of cylindrical pins (Schrade, 1991; Yardımc ı[u1] and Çetinkaya, 2007). However, locking Küntscher nails have been reported to be much more successful and predominant in preventing rotational motion (Çaptuğ and Bilgili, 2006; Igna et al., 2011; Kürüm, 2012). In the present study, there was no rotational instability and/or pin migration in any case, which is in line with the literature.


**Figure 1.** Radiographs of case no. 12 (a-b pre-op, c-d post-op 1st day, e-f post-op 7th day, g-h post op 90th-day M/L, h. Post op 90th-day A/P) (R: Right, L: Left).

In plate osteosynthesis, extensive soft tissue injury and the number of screws used may adversely affect bone vascularisation and lead to delayed bone healing (Durall and Diaz, 1996; Dueland et al, 1999). With locking nailing, a smaller operative field is sufficient for the placement of fragments and nails.

External fixators are particularly advantageous in that they provide a great advantage in the treatment of open fractures, they are less traumatic than plate osteosynthesis, they apply to all fracture types, and they resist all forces if applied properly. (Gülaydın and Sarierler, 2018). However, postoperative care is difficult (Egger, 1993). In particular, the difficulty of postoperative care negatively affects the patient owner, especially in closed femoral diaphyseal fractures. Due to the good resistance to the bending and rotational forces of the pin, post-operative dressing was not applied in the present study. This allows the dog to return to its normal life more quickly, avoids the muscle atrophy that can be caused by bandaging, and significantly reduces the post-operative care burden on the patient's owner.

In the retrograde application of locking nails, the bone-nail contact is widened and stability is increased by reaming the bone medulla. Still, it has always been a subject of controversy with the claim that endosteal blood supply is impaired. Union is delayed and the issue of fat embolism may occur during the reaming process. In addition, proponents of carving claim that failure to carve the medullary canal may result in inadequate stabilisation, fracture of the nail and locking screw, and delayed healing (Whittle et al, 1992). In all cases, interlocking nails were inserted retrogradely after the medullary canal was carved with a drill bit smaller than the interlocking nail, and there were no complications related to this issue.

The ideal number of screws to be used for proper


**Figure 2.** Radiographs of case no.13 (a-b pre-op, c-d post op 1st day, e-f Post op 7th day, g-h post op 90th-day M/L, h. Post op 90th-day A/P) (R: Right, L: Left)

locking has not been established for all cases. When a locking nail is fixed with a single screw close to the fracture line, axial instability has been reported in biomechanical tests (Acker et al, 1985). Small axial micro-movements can promote callus formation (Moses et al, 2002; Suber et al, 2002). However, motion, especially rotation, has been reported to delay the healing process (Braden et al., 1995). In the present study, 3 screws (1 proximal, 2 distal) were used to fix the nail, restricting horizontal and rotational movement and providing sufficient stability for clinical healing and bone healing.

In the treatment of fractures using locking nails, complications such as the diameter of the nail not suitable for the bone diameter, the proximal hole of


**Figure 3.** Photos of case no. 13 (Clinical appearance in preoperative, postoperative 7thday, postoperative 15th day and postoperative 30thday)

the distal fragment being the most common site of nail fracture, screw holes being the weakest point in the nail, fracture of the nail as a result of the screw hole being at the level of the fracture line, improper placement of the screws or leaving them loose are encountered (Durall and Diaz 1996, Lilllich et al 1999, McLaughlin 1999). In the present study, it was observed that the locking nail fractured at the level of the proximal hole of the distal part in 1 case during the operation and in another case on the 15th postoperative day. However, no intervention was performed because the fractures of the distal tip of the nail did not interfere with the healing process of the bones, the idea that the effort to remove the broken part of the nail would further damage the bone, and also because the patients had no difficulty in using their extremities. Therefore, even if the nail was broken in the distal hole, the remaining part of the nail provided adequate support if the nail was selected for the maximum length that could be used.

Igna et al. (2011) reported that they treated diaphyseal femur fractures in 3 cats and 3 dogs with locking intramedullary nails, and the degree of lameness was scored as 4 preoperatively in all cases, 2 at 2 weeks, 1 at 3 weeks, and 0 at 4 weeks. They also reported that the cases started using their extremities on postoperative day 4 and all cases were healed without lameness after 21-30 postoperative days (mean 24.5 days). In our study, it was observed that the lameness score, which was determined as 4 preoperatively, decreased in 15 patients except one patient after the 2$^{nd}$ week and the patients had no difficulty in walking after the 4$^{th}$ week.

One of the most important factors influencing the fracture healing process is how quickly the fracture

is stabilised. Early surgical treatment of tibial fractures reduces the rate of postoperative complications (Sarmiento et al, 1995). In the present study, one case (no. 15) was referred for surgery 18 days after diagnosis, surgery was performed and abnormal callus formation was observed during surgery. Although this callus prolonged the duration of surgery and fracture healing, it was found that the patient had no difficulty in using the limb and the lameness score was 3 on postoperative day 7 and decreased to 0 on postoperative day 120. It is therefore believed that locking nails can be successfully used in old fractures.

In conclusion, interlocking nail fixation has many advantages for the stabilisation of long bone fractures in dogs. The use of locking nails of appropriate diameter and length is a method that has a low postoperative complication rate, is simpler and more economical than plate and screw applications, and can be successfully used for the treatment of diaphyseal long bone fractures in dogs when appropriate techniques are used.

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