

A Clinical and Radiological Comparative Assessment of Transverse Mid-Diaphyseal Femur Fractures in Cats After Osteosynthesis with Mini Titanium and Resorbable Plates**

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Abstract: The aim of this study is to make a clinical and radiological assessment of whether titanium mini plates and resorbable plates are sufficient to provide a functional recovery for the treatment of femur fractures in cats. Animals used in this study were 10 cats brought with complaint of fracture caused by various traumatic reasons and diagnosed on transversal mid-diaphyseal femur fractures by clinical and radiological examination. In all cases, the procedures were performed under general anesthesia. Osteosynthesis was performed by placing mini titanium plate and resorbable plate with appropriate technique. During the first post-operative day, in all cases, recurrent fractures were observed in various ways. The operation performed again with same technique by replacing implants with the new and the same one. At the first post-operative day of new operation, fractures were observed in all cases. Consequently; even the increased chance of success due to low loading level (eg. Craniomaksillofasial surgery) along the operation regions and the positive effects of preventive measures like bandage usage, it is unable to sustain the stabilization in the femur diaphysis where the force has too much influence on it. Additionally it was concluded that the application of 2.0 mm mini titanium plates and 2.5 mm resorbable plates that we used for mid-diaphyseal femur fractures in cats are clinically not useful because these materials are expensive and require special tools during the application.

Keywords: Femur, Fracture, Mini titanium plate, Resorbable plate.

Kedilerde Orta Diyafizer Transversal Femur Kırıklarının Mini Titanyum ve Rezorbe Olabilen Plak ile Osteosentezi Sonrası Klinik ve Radyolojik Olarak Karşılaştırılmalı Değerlendirilmesi**

Özet: Bu çalışmanın amacı titanyum mini plak ve rezorbe olabilen plağın kedilerde femur kırıklarının sağaltımalarında fonksiyonel bir iyileşme sağlayabilecek yeterlikte olup olmadıklarının klinik ve radyolojik olarak değerlendirilmesidir. Çalışmanın hayvan materyalini değişik travmatik nedenlere maruz kalmaları sonucu oluşmuş kırık şikâyeti ile getirilen, klinik ve radyolojik muayenelerini sonucunda femurun orta diyafizer transversal kırığı tanısı konulan 10 adet kedi oluşturdu. Tüm olgularda, işlemler genel anestezi altında yapıldı. Mini titanyum plak ve rezorbe olabilen plak tekniğine uygun şekilde yerleştirilerek osteosentez işlemi gerçekleştirildi. Postoperatif 1. günde tüm olgularda çeşitli şekillerde tekrar kırık oluşumu gözlemlendi. Operasyon aynı şekilde tekrarlandı ve bölgeye aynı implantların yenileri yerleştirildi. Tekrar postoperatif 1. günde tüm olgularda kırık şekillendiği saptandı. Sonuç olarak; özellikle uygulandığı bölgelerdeki yüklerin az olması (örn. Craniomaksillofasial cerrahi) ve bandaj gibi koruyucu önlemler alınması bu implantlarda başarı şansını arttırsa da, kuvvetin çok fazla etkilediği femurun diyafiz bölgesinde stabilizasyonu koruyamamaktadırlar. Ayrıca pahalı olmaları ve uygulanmaları sırasında kendilerine özgü ekipman gerektirmeleri gibi nedenlerden dolayı kullandığımız 2.0 mm mini titanyum plak ve 2.5 mm rezorbe olabilen plak kedilerde femurun orta diyafizer kırıklarında klinik olarak kullanımlarının yararlı olmadığı kanısına varılmıştır.

Anahtar Kelimeler: Femur, Kırık, Mini titanyum plak, Rezorbe olabilen plak

Introduction

The damage in the anatomic continuity of the bone tissue caused by trauma or pathological reasons related to bone is called fracture. In veterinary orthopedics, the aim of fracture fixation is to ensure the fracture healing in the shortest time and in the most correct way. For this purpose, several fixation techniques have been developed until now and studies still continue ceaselessly in

this field (Aslanbey, 2002). Long bone fractures in cats can be caused by falls from height, injury with firearms, traffic accidents, traumas made by humans and other creatures. Long bone fractures can be compound fracture or closed fracture and fractures also can be in the form of one-piece or multiple-pieces. In cats, 50% of the fracture cases encountered are long bone fractures and it is

reported that the femur fractures constitute 45% of long bone fractures in cats (Harari, 2002; Piermattei et al., 2006).

Plating of fractures began long ago. It is reported that the first plates were used by Hansmann (Germany) in 1886. These plates made from compound of nickel, copper and tin which is called "German silver". Titanium has been used as biomaterial since 1930. Mini plate osteosynthesis was first introduced by Michelet in 1973 and further modified by Champy in 1975 (Deangelis, 1975). Titanium plates has properties such being inert, non-toxic, anti-magnetic, lightweight and small sizes, high biocompatibility, corrosion resistant, similar elasticity modulus to bone. It is emphasized that titanium plates meet the requirements with these properties to become a preferred material in orthopedic surgery (Bilgili, 2002). Even though osteosynthesis with resorbable implants were introduced in late 1960s, however, more complex materials like plate and screw were manufactured between late 1970s and early 1980s. Even though first produced materials mechanical resistance was insufficient for orthopedic applications, implants currently used are made from polymer matrix composite of same material reinforced with fiber suture (Seber, 1997). In this study, it is aimed to make a clinical and radiological assessment whether the usage of titanium mini plates and resorbable

plates for the treatment of femur fractures in cats provides sufficient functional recovery.

Material and Methods

Ethical Committee: This study was approved by Uludağ University Animal Experiments Local Ethics Committee (HADYEK) on January 17th 2012 with decision number 2012-01/03 and conducted in the Department of Surgery of Uludağ University Faculty of Veterinary Medicine.

Animals: Animals used in this study was 10 cats brought to Department of Surgery of Uludağ University Faculty of Veterinary Medicine between October 2012 and February 2014 with complaints of fracture caused by various traumatic reasons and diagnosed with transversal mid-diaphyseal femur fractures by clinical and radiological examination.

Selection of mini titanium plate and screw: 2mm mini titanium plate and screw set was used in the cases. 1 mm thick, 10 holes plates with 2 screw hole length space between 5th and 6th holes were specially manufactured (Trimed®, Trimed A.Ş, Turkey). A specially manufactured fixation set was used to implement plates and screws onto bones (Figure 1).



Figure 1.A: Surgical instruments used for routine operations, B: Mini titanium plate fixation tool set, C: Resorbable plate drill, diestock and screwdriver tool set, D: mini titanium plate, E: Resorbable screw, F: Mini titanium screw, G: Resorbable plate.

Selection of resorbable plates and screws: 10 holes 2.5mm resorbable plate and screw sets were used for the cases (Inion CPS® 2.5 mm, Inion Oy, Finland). A specially manufactured fixation set was used to implement plate and screws onto bones.

Anaesthetic Method: 8 hour preoperative food and water restriction applied in all cases. For the purpose of prophylaxis 20mg/kg Cephazolin sodium (Cefozin®, Bilim; İstanbul) was administered half an hour before surgical applications intramuscularly. 2 mg/kg xylazine hydrochloride (Alfazyne®, 2%, Alfasan International B.V., Woerden, Holland) was administered to each cat intramuscularly (i.m) for premedication. For induction of anesthesia 7 mg/kg ketamine hydrochloride (Alfamine®, 10%, Alfasan International B.V., Woerden, Holland) was administered intramuscularly (i.m). The maintenance of anesthesia was continued by closed-circuit anesthesia machine (AMS 200, Turkey) with a vaporizer setting of 2% inhalation anaesthetic isoflurane. For the purpose of analgesia 4 mg/kg carprofen (Rimadyl®, Pfizer Inc., Zventem, Belgium) was applied subcutaneously.

Method of Operation: After shaving and disinfection, the operation area was surrounded with sterile operation drapes. Craniolateral approach was used for the application. After fracture reduction, screw holes were drilled with proper drill. Length of screws were determined with depth gauge and screws were inserted into all of the holes. Mini titanium plates and screws used for the 5 of the 10 cases. Plates were placed with a position suitable to use 5 screws for each of the proximal and distal fragments. In the cases resorbable plates and screws used, 2 of the screw holes in the middle left empty because these holes are so close to the

fracture and the implementation of the screws to these holes are not possible, and the remaining 8 screws applied to the proximal and distal fragments 4 for each. Operation site was closed in accordance with the technique. After to operation, with taking new radiography of the operated extremities, reduction of fractures, stabilization and position of the implant has been checked.

Postoperative Care: After the operation, patients are kept under surveillance in cat hospitalization unit. Supported bandage has not applied to any of the patients. 20mg/kg Cephazolin sodium (Cefozin®, Bilim; İstanbul) was administered intramuscularly two times a day, 7 days long. For the purpose of analgesia 4 mg/kg carprofen (Rimadyl®, Pfizer Inc., Zventem, Belgium) was applied subcutaneously one a day, 3 days long.

Radiological Examination: After the clinical examination of all cases, double-sided chest radiography and double sided radiography of the fractures detected extremities were taken. After the operation, a new double-sided graph of these extremities were taken in order to control reduction.

Results

It is found that 5 of the 10 patients enrolled in the study were between 1-2 years old (50%), 4 patients were between 2-3 years old (40%), and 1 patient was above the 3 years old (10%). It is determined that the reason of the fractures are fall from height, traffic accident and unknown, and number of patients are 7, 2 and 1, respectively. It is seen that 6 of the fractures were on right extremity and 4 were on left extremity (Table 1).

Table 1. Information about the cases.

Case No	Species	Breed	Age (years)	Sex	Cause of the Lesion	Extremity	After the First Operation 1 st post-operative day	After the revision 1 st post-operative day
T1	Cat	Crossbred	1≈2	Male	Traffic accident	Left femur	Fracture of the plate. through screw hole	Fracture of the plate. through screw hole
T2	Cat	Scottish fold	1≈2	Male	Falling down from height	Right femur	Angulation and rotation on the plate	Fracture through screw hole of the plate.
T3	Cat	Persian	2≈3	Female	Unknown	Left femur	Plate angulation	Plate angulation
T4	Cat	Crossbred	1≈2	Male	Traffic accident	Left femur	Angulation of the plate through the screw hole Deformation on the plate from screw hole	Fracture through screw hole of the plate.
T5	Cat	Crossbred	2≈3	Male	Falling down from height	Left femur	Fracture through plate screw hole	Angulation and rotation on the plate
R1	Cat	Persian	2≈3	Female	Falling down from height	Right femur	Fracture through the empty screw hole	Fracture through the empty screw hole
R2	Cat	Crossbred	1≈2	Male	Falling down from height	Right femur	Fracture through the empty screw hole	Fracture through the empty screw hole
R3	Cat	Crossbred	2≈3	Male	Falling down from height	Right femur	Fracture through the empty screw hole. One of the screws broken from its neck part	Fracture through the empty screw hole
R4	Cat	Crossbred	1≈2	Male	Falling down from height	Right femur	Fracture through the empty screw hole. Two of the screws partly broken from its neck and bent.	Fracture through the empty screw hole
R5	Cat	Siamese	≥3	Female	Falling down from height	Right femur	Fracture through the empty screw hole. A screw broken from neck	Fracture through the empty screw hole

On the one hand the operation process of treatment of femur fractures with mini titanium plate takes a period of time about 45 to 60 minutes, on the other hand the application of resorbable plate takes about 60-90 minutes because resorbable screw implementation requires precision during the implementation. In all cases, refracture has been seen in the first postoperative day, and same, new

implants have been applied to all cases with new operations. Then in the first postoperative day, in the same way in all cases, refracture formed depending on the tensile strength inadequacy of the implants (Figure 2). Intramedullary pin fixation is performed to the patients and after recuperation patient has been discharged after implant removal.

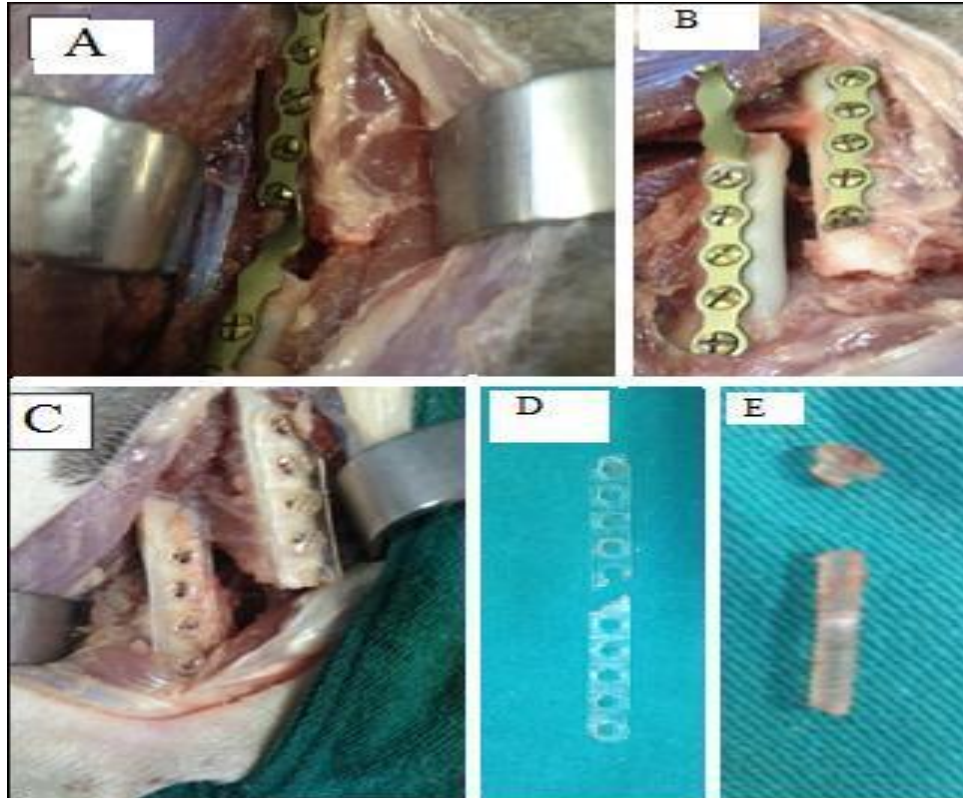


Figure 2. A: Case T4 was partly broken through the first screw hole and plate angulation occurred, B: Case T5 plate was broken through the screw hole and fully separated, C: Case fracture on the plate through the screw hole, D: Case broken resorbable plate, E: Case R5 resorbable screw broken from its neck part.

Mini Titanium Plate and Screws Used Cases

T1: In the first postoperative day, it is determined that the plate was broken through the closest screw hole to the fracture line on proximal fragment. With the same technique, new plate has implemented. The next day, it is found that the plates have been broken in the same way again.

T2: In the first postoperative day, plate rotation and angulation was determined. These deformations were through the closest screw to the fracture line on proximal fragment. In the first postoperative day of second operation, it is found that the plate has been broken through the proximal screw hole.

T3: In the first postoperative day, plate angulation was detected through the first screw hole next to

fracture line on distal fragment. It was operated again. The next day, in the same way, angulation was detected on the plate.

T4: In the first postoperative day, angulation on plate through the first screw hole on the proximal fragment was determined, and it is found that the screw has protected its position but the screw hole was enlarged. It was operated again. During the operation, it is determined that the one side of the plate was broken through the closest screw hole to fracture line on the proximal fragment and the other side of this hole was in good condition. Next day, it was observed that the new implemented plate has rotated, too.

T5: In the first postoperative day, it was determined that the plate was broken through the closest screw

hole to the fracture line on proximal fragment. In the same day, patient again underwent to operation. In the next day, it is determined that there is an angulation and a slight rotation of plate through the screw hole on the proximal.

Resorbable Plates and Screws Used Cases

R1: In the first postoperative day, it was determined that the plate was broken exactly through the closest empty screw hole to fracture line on proximal fragment. Patient again underwent to operation. In the next day, it is observed that in the same way the plate has broken.

R2: In the first postoperative day, it was observed that plate has broken through the empty screw hole that is on the distal. New operation was performed. However, in the following day, it is observed that the plate was broken in the same way.

R3: In the first postoperative day, it was observed that the plate was broken through the empty screw hole distal to the fracture line. It is observed that, at the distal, the first screw next to the empty screw hole was broken from its neck. New operation was performed. Later, it is observed that plate was broken but screws were in good condition.

R4: In the first postoperative day, it is observed that the plate was broken through the empty screw hole that is on the proximal. It is seen that the first and second screws on the distal which are close to fracture line were partly broken and bent. Revision was performed. In the next day, it is observed that plate was broken from the same place but screws were in good condition.

R5: In the first postoperative day, it is determined that plate was broken through the empty screw hole at the proximal. At the proximal, it is observed that the first screw next to the fracture line was broken from neck. After the revision process, it is observed that the plate has again broken through the same line. It is observed that there is no deformation on screws.

Discussion

The prevalence of femoral fractures in cats is reported to be 20-25% (Piermattei, 2006). In another study, it is mentioned that this ratio is higher than 30% (Wallace, 2009). It is reported that, especially falling down from height is a prevalent etiologic factor causes fracture in cats (Jank et al., 2010; Jank et al., 2007; Johnston et al., 1991). In our

study, fall from height (7 patients, 70%), traffic accidents (2 patients, 20%), and an unknown etiologic agent (1 patient, 10%) are the reasons of the cases and these reasons are in accordance with the literature.

Gender is an important risk factor for trauma. More wandering and fighting cause tomcat has been affected by trauma more than female cats. Falls, bruises and burns were observed more frequently on females. In addition, female animals are more tended to live in a home environment (Süer and Sağlam, 2006). In our study, it is found that having 7 male and 3 female cats confirms the information in the literature. It is reported that increased operation time increases the risk of infection. Especially shorter operation time means shorter duration of anesthesia for the patient affected with severe trauma. In this instance potential complications related to anesthesia will be reduced (Piermattei et al., 2006). In our study, we can emphasize that mini titanium plates are more advantageous than resorbable plates in terms of their short operating time. Breakage of the resorbable screws during the application or precise manipulations made to prevent deterioration of screw head by screwdriver cause to this advantage. Nowadays polymer materials developed by ongoing scientific research. These materials don't have inflammatory effects on the organism and are biodegradable so it is not necessary to perform a second surgical operation. Research on new materials that are superior to metals with these features are continuing. On the one hand, it is unquestionably proved that polymers are biodegradable in the live environment, on the other hand it has been researched to find wider application areas for the implants which have insufficient mechanical properties for the load-bearing bones (Aslanbey, 2002; Done et al., 1996; Dursun, 2001; Simpson and Lewis, 2002). In order to perform the same stability with titanium plates, resorbable plates must be thicker than titanium plates (Jank et al., 2010). In our study, 2.5 mm resorbable plates and 2.0 mm mini titanium plates sets were used with the thought that these materials are approximately equivalent to each other.

In a study, resorbable OTPS™ 2.0 mm plate and 1.5 mm titanium plate have subjected to tensile tests and as a result, it is concluded that each of the plates have same stability (Jank et al., 2007). Considering the tensile tests, it can be concluded that the Inion CPS 2.5 plate that we used in our study has higher tensile strength than 1.5 mm titanium plate. In a study done with the patients who have an intraarticular or extra articular fracture, mini titanium plates and screws (2 mm diameter and

5, 7, 9, 11, 13 and 15 mm length mini titanium screws) have been applied to the patients. It was determined that mini titanium plates and screws can be used safely as an osteosynthesis material for the treatment of intra-articular and extra articular fractures of the cats and small dogs (Bilgili, 2002). Osteosynthesis with a 2mm thick titanium reconstruction plate was performed to a transverse femur fracture in a cat that has been brought to our clinic and it is observed that it has maintained its strength during recuperation. It is reported that the tensile strength of this 2 mm plate is 48.54 N (Trimed ilaç Medikal San. Tic. Ltd. Şti. 1998). According to data sheet provided by the manufacturer, the tensile strength of mini titanium plate used in our study is 13.28N. Considering these values, it is thought that the tensile strength on the femur is approximately less than 48.54 N.

For a complete adaptation of the plate, one of the points need to be considered during plant application is the necessity to bend the plate specially for bones like femur and humerus because these bones don't have plain anatomic surface. Without bending process, adaptation between plate-bone and plate-screw disrupts and various complications occur (Johnston et al., 1991; Mcduffee et al., 1997). In this study, specially mini titanium plates, they were easily taken shape appropriate for femur surface. However, there are specially produced water bath heaters to bend resorbable plates. In order to give shape to resorbable plates, plates have to wait for a specific time in sterile water. It was observed that manipulations made other than this have a great risk to break plate. It is reported that the distance between fracture line and the closest screw hole must be at least 4-5 mm or equal to diameter of the screw used in application (Piermattei et al., 2006). Similarly, in our study, special mini titanium plates without holes in the middle was ordered and the space between two holes close to center was increased. In this way, it is intended to put a specific distance the fracture line and screws. However, it is not possible to make this process on resorbable plates. It has been tried to create appropriate distance by letting the center 2 holes of these standard production plates and the application has been performed in this way.

In a study, it is reported that one empty screw hole and two empty screw holes left on the fracture line decreases the plate rigidity 35% and 60%, respectively (Olmstead, 1991). In another study, it is mentioned that drilling pilot holes on bones result in 30 to 40 percent decrease in the bending strength of the bone. It has been reported that bone fractures especially occur in these regions for this reason because compressive force focus on this point

(Schmelzeisen et al., 1992). Therefore, in our study, mini titanium plates produced without holes in the middle section. However, it is observed that, plates were broken from the closest screw hole to the fracture line. In all cases, resorbable plates has broken through the empty screw holes.

Conclusions

Consequently; even the increased chance of success due to low loading level along the operation regions and the positive effects of preventive measures like bandage usage, it is unable to sustain the stabilization at the diaphysis of femur where the force has too much influence on it. Additionally it was concluded that 2.0 mm mini titanium plate and 2.5 mm resorbable plates for the treatment of mid-diaphyseal femur fractures in cats are not clinically beneficial because of their high price and requirement of special tools for implementation.

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- ** : This study is summarized in "Clinical and radiological comparative evaluation of fracture healing after osteosynthesis with biodegradable and titanium mini plate of mid diaphyseal transversal fractures of femur in cats 's Doctorate Thesis.
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