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A retrospective study on the treatment of bone fractures in 14 wild birds of different species and ages by bone muffs

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ABSTRACT

Various kinds of fracture fixation methods have been applied in bird orthopedics. Although each one has comparative advantages and disadvantages, the best results can be obtained with the orthopedic technique chosen according to the location, shape and type of the fracture. In addition, postoperative care of animals, especially rehabilitation of wild birds, will yield positive results. The aim of this retrospective study was to evaluate the advantage of bone muffs in comparison to other routine fracture treatment methods, such as a bandages, intramedullary pins, and cerclage applications. Several wild birds with leg and wing fractures were admitted to the Clinical and Animal Hospital of the F.Ü. Veterinary Faculty between 1986 and 2011, and were treated with bandages, cerclage, and intramedullary pin techniques. Of these, 14 birds were treated with bone muffs. The animals were anesthetized for osteosynthesis with Pentobarbital (Nembutal sodium 50 mg/cc, ABBOTT) or ketamine (ketalar 50 mg/ml PARKE-DAVİS). Appropriately sized cattle and bird bone muffs were firmly fixated onto fractured bone fragments and their recovery was monitored. After the operation, the animals were taken for post-operative care. Animals with muff transplants did not need to be treated with bandages, and hence they were calmer, more comfortable and healed quickly. In birds treated with a bone muff, the bone to which the muff was applied was observed by histopathology to have normal callus formation and it was reported that a bone callus formed at that region. On the other hand, animals treated with other routine fracture management methods and bandaged animals were uncomfortable, aggressive, and were observed to be under stress. These bandaged birds had a longer recovery time, and during this time, most of the animals refused to eat and died. Due to the bandage, the animals could not find their balance on a single wing, they became disturbed psychologically, and did not continue to feed, so began to vomit when fed by hand and died in a short time. From this point of view, bone muffs provided significant advantages over other routine applications, as they did not cause psychological stress to animals because they were light and the birds did not require bandages, and they were easily resorbed because they were made of bone tissue. Recovery time was also shorter. The study showed that bone muffs may be better than conservative treatment, however, further research is needed as real long-term results are lacking.

Key words: bone muff; causes; fracture; techniques; treatment; wild birds

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Introduction

Bone fractures in wild birds are caused due to traffic accidents, gunshot injuries, or impact with various objects and, sometimes, due to hunting outside the hunting season (DEVECİ, 2019). Most bone fractures in birds occur in the wing bones (humerus, radius, ulna, metacarpus, phalanges), and leg bone fractures (femur, tibia) are rarer than those of wings (KİBAR and BUMİN, 2006; KİZİROĞLU, 2008; ASLAN et al., 2009). Many fractures are a result of trauma, but neoplasm, infections, and metabolic diseases are also reported to cause fractures (KOTHAMDI et al., 2016). When wild bird with fractures are taken to the hospital on time, treatment is easier and the probability of their survival increases. The fact that these animals are starving and dehydrated in the wild results in infections of wing fractures, muscle over-tears and necrosis, and such occurrences decrease the probability of the recovery and survival of the animals. (KİBAR and BUMİN, 2006; ASLAN et al., 2009; ÜNSALDI and ÜNSALDI, 2012; FOWLER, 2020). The duration of the physical injury, the condition of the fracture and the health of the animal, and first aid are very important in increasing the success of treatment in the case of injuries and bone fractures of wild birds (ASLAN et al., 2009; ÜNSALDI and ÜNSALDI, 2012).

Prognosis in the case of simple fractures is favorable but unfavorable in fragmented fractures, open fractures, and worst in infected fractures that occurred more than 24 hours previously. (FOWLER, 2020). Depending on the fracture location and condition, extremity fractures in birds can be treated with several bandages, screws, intramedullary pins, external fixation, or cerclage wire techniques (KİBAR and BUMİN, 2006; HATT et al., 2007; ASLAN et al., 2009; MUNİR et al., 2015; KOTHAMDI et al. 2016; RUI et al., 2017; ÜNSALDI et al., 2019). In addition to these techniques, leg and wing fractures are treated with muffs (ÜNSALDI, 1986; ÜNSALDI, 1991; ÜNSALDI and ÜNSALDI, 2012; ÜNSALDI, 2015; NAZHVANIA et al., 2019).

Endosteal and periosteal calluses contribute to the healing process of bone fractures. In pneumatic bones, endosteal calluses contribute to the healing process more than periosteal calluses. The healing process in birds is similar to that of mammals, but the bone structures are different. The bone cortex in birds is thinner and stronger (BENNETT and KUZMA, 1992; ÖZSOY, 1996; KOTHAMDI et al., 2016) and the bones can be broken very easily. This is a result of the bone’s high calcium content. Long bones have more medullary space, and the healing process is faster, where a scar and callus may form within 7-10 days. The humerus and femur have a wide medullary canal and have a pneumatic structure (ÖZSOY, 1996). However, since a thin and soft tissue covers the bones in the distal part of the humerus, the fractures in that area will result in fragmented and open fractures (BENNETT and KUZMA, 1992; DONELEY, 2016; VERMA et al., 2018). It is stressful and disappointing that due to the thin bone cortex in wild birds, screws and plates are unsuitable for use and removal. Their usage often leads to failure (ÖZSOY, 1996; DONELEY, 2016).

The bones of wild birds are light and have thin cortexes, hence they can be easily broken. Furthermore, since half of the humerus is covered by a very thin tissue, the fractures on this part will result in scattered or open fractures (BENNET and KUZMA, 1992; DONELEY, 2016). Since bone cortexes are thin in winged animals, it is emphasized that the screws and plates are not suitable for use and removal and that it is disappointing (ÖZSOY, 1996).

In bone fractures, the time when the animals are brought to the clinic is also important. If the animals are taken to the clinic by responsible citizens, treatment is possible. If the animals are not taken to the clinic on time, treatment does not give positive results.

Turkey has rich natural resources, well-watered ranges and habitats, and it is located on wild birds’ migration routes, due to these features as well as its geographical location. Turkey is perfect for the survival of animals. 437 wild bird species have been reported in Turkey, however, it has also been reported that the number may reach up to 502 with unreported species (KİZİROĞLU, 2008; ASLAN et al., 2009).

As in many countries, wild birds are under protection by law in Turkey. In the hunting season, hunting is only allowed by the government in specific and private hunting grounds (ANONYMOUS, 2020). Hunters who do not obey these laws and injure animals outside these hunting grounds either take these animals to a clinic or leave them to die. If the animals are taken to a clinic by responsible citizens, treatment is possible. If the animals are not taken to the clinic on time, treatment does not give any positive results.

(DEVECİ, 2019). The number of official and unofficial hunters is reported to be 3,000,000. Although there are so many people with guns in the field, the official number is reported to be only 115,355. In Turkey, it is quite common to encounter many cases of wild winged animal injuries caused by shooting (DEVECİ, 2019).

It is reported that these shootings occur more during the migration seasons, such as February-April and September-November (KİBAR and BUMİN, 2006). Most of the wild birds admitted to the clinic were shot by gunfire (ÜNSALDI and ÜNSALDI, 2012).

Winged animals are absolutely necessary for the continuation of wild life. They feed on rodents and thus prevent rodents from multiplying more than necessary. This, in turn, prevents rodents from harming the farm products, and other animals including humans (KİZİROĞLU, 2008; ASLAN et al., 2009).

Birds and mammals have different bone structures. The bones of wild birds are thin and can be broken easily because of their bones contain high amount of calcium. Humerus and femur has a wide medullary canal and are of pneumatic structure (ÖZSOY, 1996). But healing process in birds and mammals are similar. In case of comminuted fractures, fragments break apart more easily. Long bones has more medullary space and healing process of them are faster, scar and callus can occur within 7-10 days. (ÖZSOY, 1996; RUI et al., 2017).

Wild birds either die since they do not want to be fed, or survive if they allow to be fed after operation (ALKAN et al., 1992). Wild birds in the polyclinics with humerus fractures, both radius and ulna fractures or femur fractures either did not want to be fed or even if fed, they vomited the food out and died after a few days. In the case of wing fractures, independent feeding and drinking was less probable compared to cases of leg fractures, because in the case of wing fractures, their psychology worsened. When either the ulna or radius was broken, and when treatment was performed using a bone muff, the animals began to feed on their own after anesthesia (ÜNSALDI and ÜNSALDI, 2012).

Studies have shown that wild birds with bone muffs did not need bandages because the bone muff was light and did not produce a heavy burden. So these birds were not under any psychological stress and recovery times were shortened (ÜNSALDI and ÜNSALDI, 2012; ÜNSALDI, 2015).

The aim of this study was to evaluate the advantage of bone muffs in comparison to other routine fracture treatment methods, retrospectively. In this study, we prepared bone muffs from bird and cattle bones to use them in the treatment of 14 bird wing and extremity fractures. In the study, we evaluated the repair process, absorption of the bone muffs, and the ability to fly of 14 wild birds using clinical and radiographic examinations.

Materials and methods

This retrospective study consisted of 14 wild birds of different species and ages, with wing and extremity fractures due to traffic accidents, gunshot injuries or impact with various objects, that were admitted to the Clinical and Animal Hospital of the F.Ü. Veterinary Faculty, between 1986 and 2011. The wild birds used in this study were patients who were found injured in the wild and brought to our clinic by the Nature Conservation Directorate or citizens and needed urgent surgical intervention. This was not an experimental study. This retrospective study was not subject to ethics committee approval since the clinical diagnosis and treatment were in accordance with Article 8, subparagraph k1 of the AELEC (Animal Experiments Local Ethics Committee) Regulation in Turkey.

Of the birds brought to the clinic, those with lower extremity and small bone fractures were bandaged, and then either returned to their owners or released to the wild after they healed. In the case of extremity fractures (humerus, radius, ulna, femur, os cruris), depending on the location of the fracture and condition, bandages, intramedullary pins or cerclage were applied for the treatment. Apart from those, 14 winged animals were treated with cattle or winged animal muffs (humerus, radius, ulna, femur, os cruris),

Bone muffs were applied to bone fractures of 14 birds, that is, two Long-eared owls *(Asio otus),* two Eagle owls *(Bubo bubo),* four Golden eagles *(Aquila chrysaetos),* two Booted eagles *(Hieraaetuss pennatus),* one Hawk *(Buteo buteo),* one Ruddy shelduck *(Tadorna ferruginea),* one Bonelli's eagle *(Aquila fasciatus)*, and one unidentified bird.

X-rays of animals were taken with Toshiba (Japan) and Varian (USA) brand X-ray instruments and then, depending on the location, structure, and the formation of the fracture, treatment was performed using one of the above-mentioned methods. For X-rays no sedative was applied, and the animals were controlled with appropriate measures against their beaks and claws.

Before the operation, the birds were fed through their mouths by hand for two days, and supplemented with subcutaneous serum injections. Animals whose general condition became suitable for the operation were taken into surgery. Bone muffs (Fig. 1) prepared from cattle or birds in appropriate sizes were boiled for 30-45 minutes in distilled water to remove the proteins and salts before the operation.

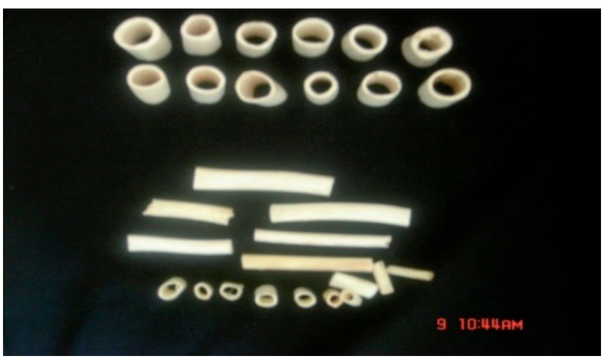

Fig. 1. Several bone muffs with different diameters and lengths.

For osteosynthesis, Pentobarbital (Nembutal sodium 50 mg/cc, ABBOTT) or ketamine (Ketalar 50 mg/ml PARKE-DAVİS) was used for anesthesia of the birds (ÜNSALDI and CANPOLAT, 2002; ÜNSALDI, 2011; ÜNSALDI and ÜNSALDI, 2012). 50 mg/ml of pentobarbital sodium (Nembutal) was dissolved in 8 ml of double distilled water, and 0.2 ml/35 g was injected into the chest muscle (m. pectoralis), and 30-40 min. anesthesia was achieved. When ketamine (Ketalar 50 mg/ml) was applied at a ratio of 30-50 mg/kg, anesthesia for 20-30 min or more was achieved. During the anesthesia, depending on the location and the condition of the bone fracture, the animal's feathers in that part were removed, the part was disinfected, muscles and the skin were incised to reveal the fragments (Fig. 2). One of the appropriately sized bone muffs (Fig. 1) was fixated firmly onto the upper fragment of the fracture, and the lower fragment was placed in the muff by the elbow method (Fig. 3). When placing the fixation on the fragmented parts, great care was exercised. In the case of longitudinal fractures, the sharp parts of the bone fragments were cut slightly in order to place the fractured bones into the muffs. 500.000 IU Penicillin G Potassium (İ.E. ULAGAY) was poured into the wound and then muscles and skin were closed by suture. Since muffs can detect the bone fractures and support the bone, if either radius or ulna was broken, there was no need for bandaging. Animals that were bandaged were observed to be uneasy, nervous and psychologically unstable. After the operation, repeat X-rays of the animals were taken.

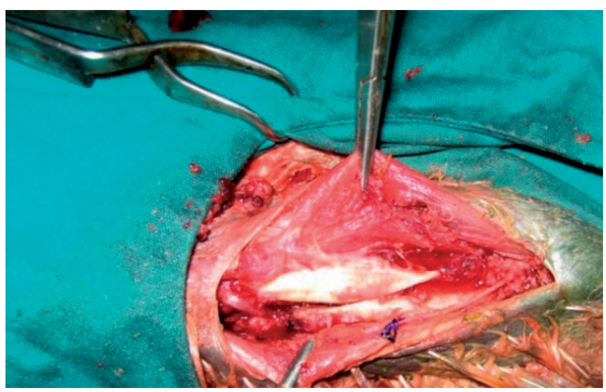

Fig. 2. Open bones, fracture treated surgically.

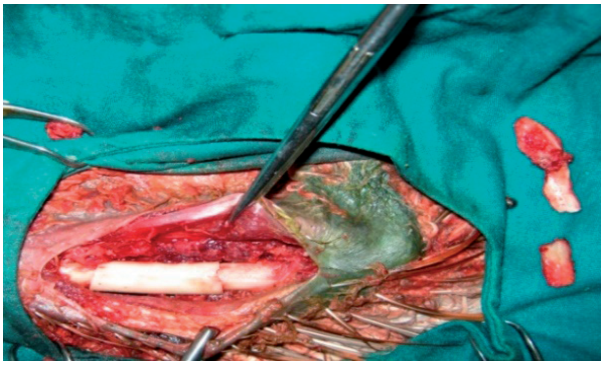

Fig. 3. Fragments, bullet fragments were removed from the fractures, and a muff was surgically applied.

In the post-operative period, the animals were given parenteral antibiotics for 5 days, serum supplements (sc) and vitamin supplements were mixed in their food. Analgesics were given for 3 days. None of them developed infection. Animals that could not self-feed were fed by hand until the animals' general condition improved. When we observed by X-ray that the fracture healing was complete, the animals was encouraged to fly. The animals that could not fly well were trained by several exercises until they could fly off (Fig. 24) (The flight was screened by a media channel). No other obvious complications developed.

The cases and species, fracture situation, general condition, osteosynthesis methods and results are shown in Table 1.

Table 1. The fracture situation, general condition and treatment results of 14 wild birds treated with bone muffs

	Case and Species	General Condition	Fractured bone	Osteosynthesis applied	Result
1	Long eared owl (first one) (asio otus)	Normal	Left humerus Right metetarsus	Cattle muff Intramedullary pin	It did not feed and hence died after 5 days
2	Long eared owl (second one)	Good	Right radius, ulna	Bird muff	Bones were fractured taking a blow, it was euthanized
3	Eagle owl (first one) (Bubo bubo)	Good	Left humerus	Bird muff	It was returned to its owner, no feedback
4	Baby eagle owl (Bubo bubo)	Very bad	Right Radius, ulna	Bird muff	It did not feed and died after two days
5	Golden eagle (first one) (Aquila Chrysaetos)	Normal	Left humerus	Catlle bone muff	It was returned to its owner, no feedback
6	Golden eagle (second one) (Aquila Chrysaetos)	Very bad	Right humerus	Cattle bone muff	It did not feed and hence died after two days
7	Golden eagle (third one) (Aquila Chrysaetos)	Normal	Right radius	Bird bone muff	40 days after radiog. was taken, callus was good it healed and was released to the wild
8	Golden eagle (fourth one) (Aquila Chrysaetos)	Good	Right humerus Left wing received electric shock	Cattle bone muff Left wing came off after 10 days	Callus formation was quite regular, but when the left wing came off, animal could not balance itself and died after two months. Histopatology results showed that the callus formation was regular.

Table 1. The fracture situation, general condition and treatment results of 14 wild birds treated with bone muffs (continued)

	Case and Species	General Condition	Fractured bone	Osteosynthesis applied	Result
9	Booted eagle (first one) (Hieraaetus Pennatus)	Normal	Right humerus	Bird muff	Since it did not feed, it died after three days
10	Booted eagle (second one (Hieraaetus Pennatus)	Good	Left ulna	Bird muff	It was returned to its owner, and it healed.
11	Hawk (Buteo Buteo)	Very bad	Left femur	Cattle muff	It was fed by hand, but it vomitted back, died after one week.
12	Ruddy shelduck (Tadorna Ferruginea)	Good	Right radius	Bird muff	It healed.
13	Unidentified bird	Normal	Right tibia	Cattle muff	It was returned to its owner, no feedback
14	Bonelli's eagle (Aquila Fasciatus)	Good	Right ulna	Bird muff	Owner was persuaded to take the animal into clinic so that it could be monitored for 14 months. It healed and by media, it was released into the wild.

In this study, there was no need for a statistical study since the method was comparative and information was given on a case-by-case basis.

Results

Most of the birds that were taken to the clinic had humerus, radius, ulna, metacarpus, and phalanx fractures, and several of them had femur, tibia, and metatarsus fractures (Table 1). Some of them had a cattle bone muff applied and the others a bird bone muff (Fig. 1). The first Long-eared owl *(Asio otus)* had left-wing (humerus) and right leg (metatarsus) fractures. A cattle muff was applied to the humerus and a metal intramedullary pin was applied to the metatarsus. The second had a right-wing (radius and ulna) fracture (Fig. 4). After the bird bone muff was applied (Fig. 5), callus formation was observed to be regular by X-ray after one and half months (Fig. 6). Two months later, since the wing was broken by a blow (Fig. 7), the animal had to be euthanized. The first Eagle-owl *(Bubo bubo*) had a left-wing (humerus) fracture (Fig. 8). A bird bone muff was applied (Fig. 9). The second one, a juvenile Eagle-owl, had a right radius and ulna fracture (Fig. 10), bone muffs were applied to both fragments (homograft) (Fig. 11). The First Golden eagle *(Aquila chrysaetos)* had a left humerus fracture (Fig. 12) and, a cattle muff was applied (heterograft) (Fig. 13). The second one had a right humerus fracture and, a cattle muff was applied (heterograft). The third one had a radius fracture and, a bird bone muff (homograft) was applied (Fig. 14). Callus formation was normal and regular after 40 days (Fig. 15). The fourth one had a right humerus fracture and, a cattle bone muff was applied (heterograft). The first Booted eagle (*Hieraaetus pennatus)* had a right humerus fracture and a bird bone muff was applied. The second one had a left ulna fracture. A bird bone muff was applied. The Hawk *(Buteo buteo)* had a left femur fracture and a cattle bone muff was applied. The Ruddy shelduck *(Tadorna ferruginea*) had a right radius fracture. A bird bone muff was applied, callus formation occurred without any problem. The unknown bird had a right tibia fracture. A cattle bone muff was applied (Fig. 16). The Bonelli's eagle *(Aquila fasciatus*) had a right wing (ulna) fracture and bullets were seen on radiography (Fig. 17). Since the fracture was longitudinal and its edges were quite sharp, the fracture was cut at a length of 0.5 mm from both ends and a bird bone muff was applied by removing a bullet piece. When the radiography was taken, fixation was observed to be complete (Fig. 18). A 15-day radiography (Fig. 19) showed that the outer callus moved towards the muff, while 1.5-month radiography (Fig. 20) showed that the outer and inner calluses took shape quickly. In the 3rd month, the outer callus covered the surface of the muff, and the inner callus filled the broken ends (Fig. 21). In the 5th month, endosteal callus had formed successfully and resorption increased at the bottom of the muff (Fig. 22). In the 6th and 7th months, the bone began to display a compact shape, including the bottom fragments, and resorption of the muff increased. In the 8th and 9th months, the bone structure strengthened, the muff residues decreased considerably and at the bottom an intramedullary space formed (Fig. 23). In the 10th and 11th months, the intramedullary space in the lower fragments increased and moved up, the muff was resorbed, and very little muff residue remained. In the 12th month, the bone muff was completely resorbed (Fig. 24). The animal flew 14 months later.

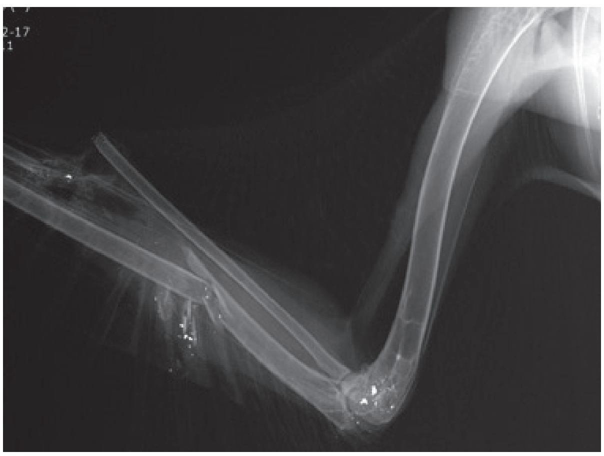

Fig. 4. Second Long eared owl, X-ray of fragmented radius and ulna.

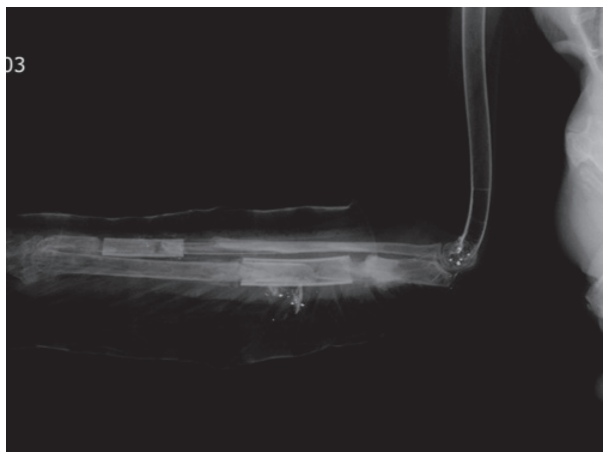

Fig. 6. Long eared owl, callus formation after 1.5 months.

Fig. 5. Second Long eared owl, a bone muff was applied to both fragments.

Fig. 7. Long eared owl, fractured bones after suffering a blow.

Fig. 8. First Eagle owl, broken humerus and bullet scatters.

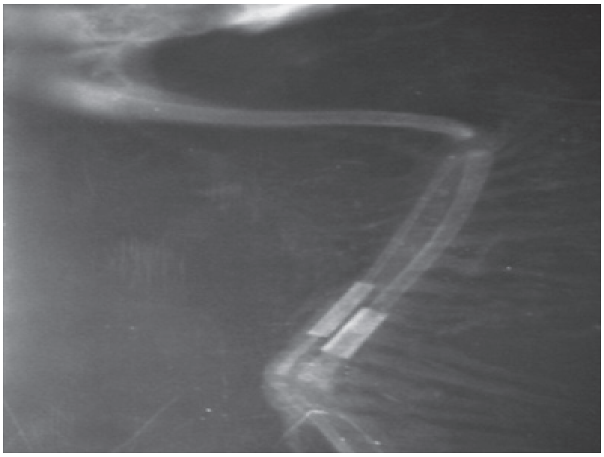

Fig. 11. Eagle owl, the second one is a baby. A bird muff was applied.

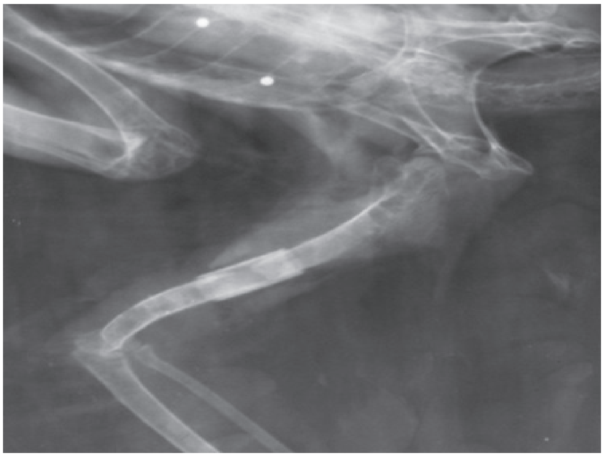

Fig. 9. First Eagle owl, a bird muff was applied to the humerus.

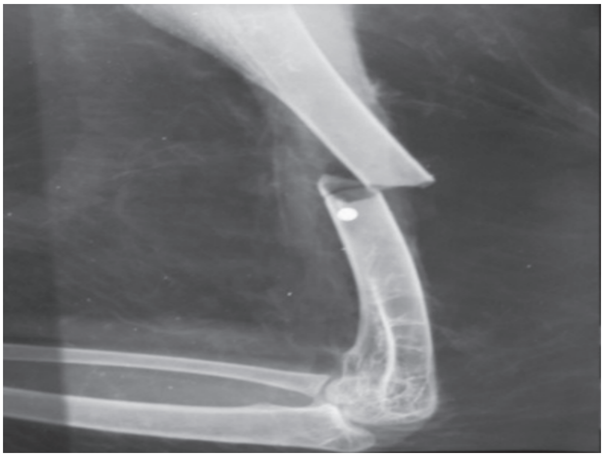

Fig. 12. First Golden eagle, humerus fracture.

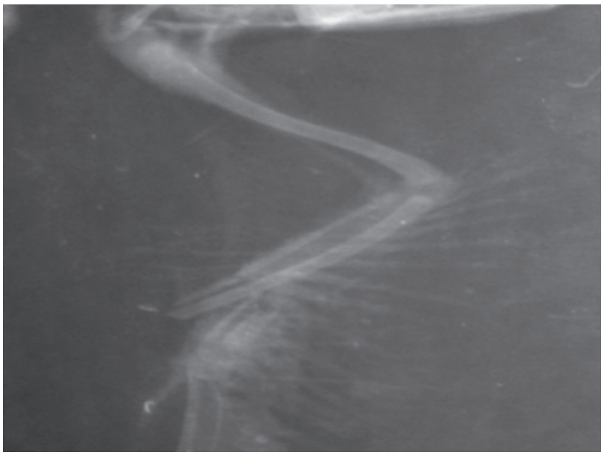

Fig. 10. Eagle owl, the second one is a baby. Radius and ulna fractures.

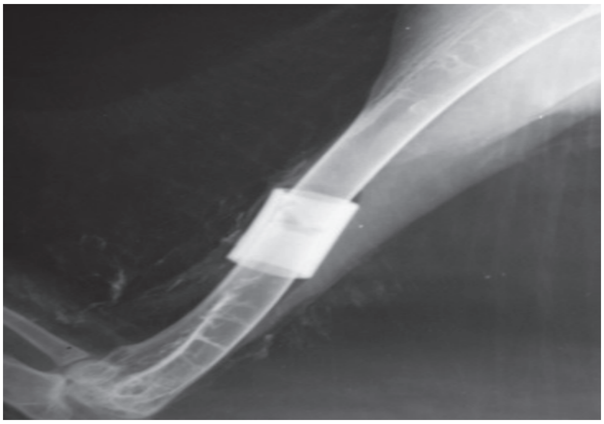

Fig. 13. Bullet fragments were removed from the first Golden eagle. A cattle muff was applied to the humerus.

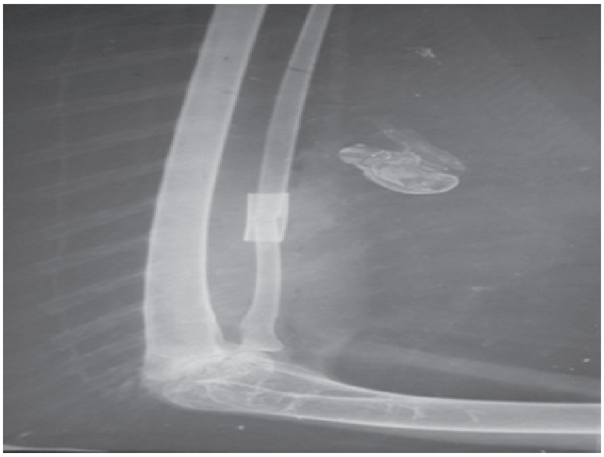

Fig. 14. Third Golden eagle, radius is broken. A bird muff was applied.

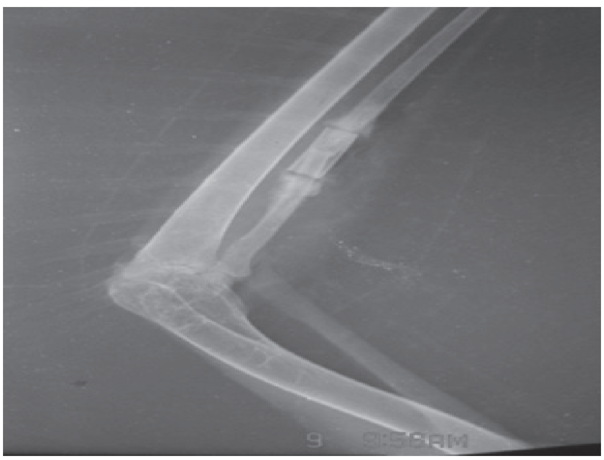

Fig. 15. Third Golden eagle, 40 days after the muff was applied.

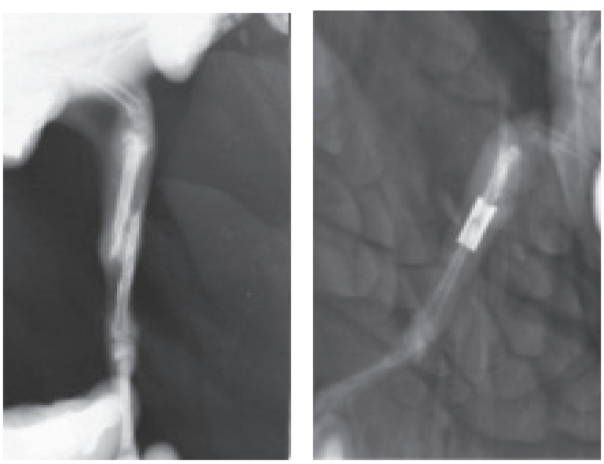

Fig. 16. Unknown bird; right tibia is broken. A cattle muff was applied.

Fig. 17. Bonelli's eagle, right ulna fracture.

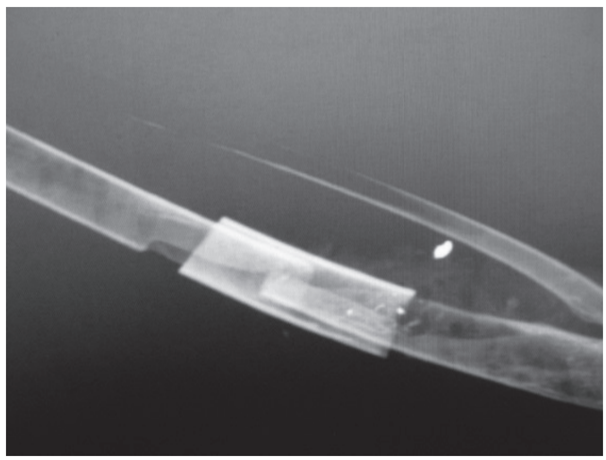

Fig. 18. Bonelli's eagle, A bird muff was applied to the ulna.

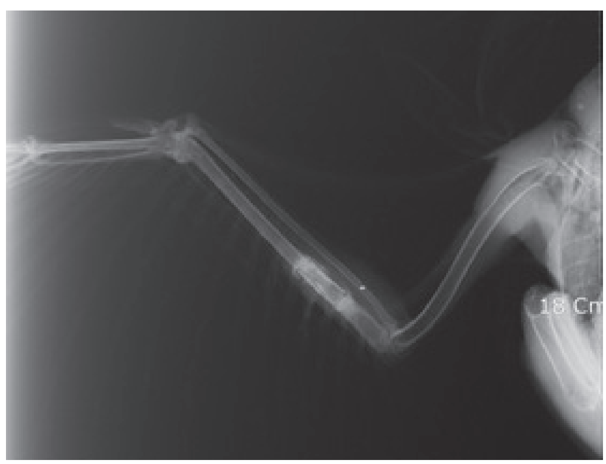

Fig. 19. 15-day radiography of the Bonelli's eagle after surgery.

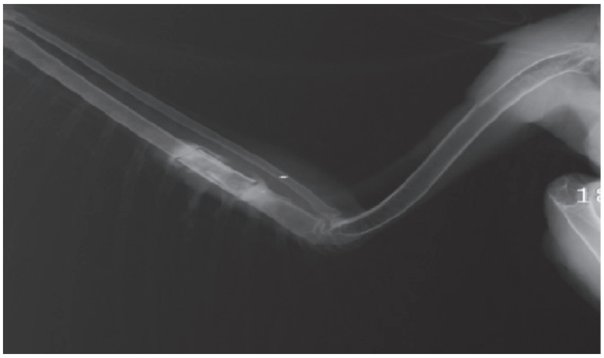

Fig. 20. 1.5-month radiography of the Bonelli's eagle after surgery.

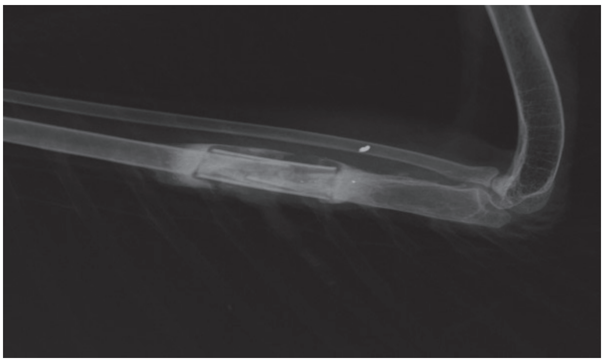

Fig. 21. 3 month radiography of the Bonelli's eagle after surgery.

Fig. 22. 5 month radiography of the Bonelli's eagle after surgery.

Fig. 23. 9 month radiography of the Bonell's eagle after surgery.

Fig. 24. Flying Bonelli's eagle after exercise.

The animal was encouraged to fly after 12 months; however, since it was always indoors for 12 months, it could not fly well and after flying a short distance, it landed. The animal was trained for 2 months using various exercises. In the 14th month it could fly without any problem and hence it was released into the wild.

The results of the bone muff treatment applied to fourteen wild bird fractures are shown in Table 1.

As a result, we found that bone muffs provided several advantages over other routine applications such as bandages, cerclage and intramedullary pins, as they did not cause psychological stress to the animals because they were light and did not require bandages, and they were easily resorbed because they were made of bone tissue. Recovery time was also shorter.

The study showed that bone muffs may be better than conservative treatment, however, further research is needed as long-term real results are lacking.

Discussion

Wild birds are absolutely essential to the survival of wildlife. Flight is an important activity in birds, and any disruption or inability to fly endangers the bird's life (NAZHVANIA et al., 2019). Fractures in birds are reported mostly in the wings and rarely in the legs (KİBAR and BUMİN, 2006; Aslan et al., 2009; ÜNSALDI and ÜNSALDI, 2012). Of the fractures of the limbs, 52% occurred in the wings, 40% in the pelvic limb, and 8% fractures were elsewhere than limbs. 28% of the fractures in the wings were observed in th humerus, 50% in the radius-ulna and 22% in the metacarpal bones. Of the radius-ulna fractures, 56% were found to be on both of the bones, 28% on the ulna and 16% on the radius bone. It was determined that 24% of the fractures in the pelvic extremity were found in the femur, 51% in the tibiotarsal bones and 25% in the metatarsal bones. Clinical improvement was observed in 45 of 75 cases (KAYIKCI et al., 2019).

The prognosis for simple fractures is reported to be good, for partial fractures it is reported to be bad, and for fractures that are not treated within 24 hours, the prognosis is reported to be quite bad. Humerus fractures are the most common and the prognosis is 1.3% success. On the other hand, for radius fractures, the success rate with bandages is 20% and if only one of the bones is broken, the prognosis is good. If both bones (radius and ulna) are broken, a surgical operation is necessary, and it results in a poor prognosis. If two major bones, such as the humerus and femur, are broken, the animal can not maintain its balance, and therefore needs to be euthanized (FOWLER, 2020). In our study, wild, winged animals had similar fractures and prognosis.

Depending on the location and features of the fractures in birds, metal intramedullary pins, polydioxanone and bone plates, external fixation, cerclage, and several bandages can be applied for the healing process. (BUSH, 1977; ÜNSALDI, 1986; ALKAN et al., 1992; HOLLAMBY et al., 2004; KILIÇ and TIMURKAAN, 2004; KİBAR and BUMİN, 2006; HATT et al., 2007; SANCHEZ et al., 2007; MANJUKLAR et al., 2008; ASLAN et al., 2009; MUNİR et al., 2015; RUI et al., 2017; NAZHVANIA et al., 2019; ÜNSALDI et al., 2019). Agreeing with the reports of other researchers, we used most of these techniques in our clinic depending on the fracture formation.

It is not appropriate to use bandages on larger bones since the bandage increases the bone weight and hence disrupts the balance of the birds (HATT et al., 2007; MANJUKLAR et al., 2008). Although an intramedullary metal pin is a good fixation technique, it is reported that it increases the burden and that it necessitates some support from outside (BUSH, 1977; MANJUKLAR et al., 2008; RUI et al., 2017). In the case of intramedullary pin applications, if stabilization is not enough and the joint capsule is damaged, joint ankylosis can occur due to cicatrix. Thus, the endosteal blood flow may be adversely affected, the probability of osteomyelitis increases in open fractures, and ankylosis can occur in the articulatio humeri and cubiti (ÖZSOY, 1996). In our study we obtained similar findings.

When bone muffs covered two bone fractures and successfully completed the fixation, the complications mentioned above did not occur (ÜNSALDI and ÜNSALDI, 2012; NAZHVANIA et al., 2019).

It is reported that bone pins are lighter than metal pins and that they are absorbed by the body hence they do not necessitate removal, and they act as a source of calcium during the callus formation (ALKAN et al., 1992; SCHLICKEWEI et al., 2019). To achieve enhanced osteogenesis, osteoconductive scaffolds can be used in combination with osteoinductive agents. Such agents were first described in the 1960s, when URIST (1965) showed that an acellular, devitalized and decalcified bone matrix could induce bone formation in ectopic tissue.

It is also reported that bone plates can be applied. Bone plates are suitable for winged animals that are unable to fly, and they are also suitable for bone fractures of larger winged animals, but they require specially designed thin screws. Polydioxanone can also be used since it is absorbed by the body (KILIÇ and TİMURKAAN, 2004). We observed that birds treated with bone muffs were more comfortable and peaceful after the osteosynthesis, compared to other methods of osteosynthesis. Since the bone muff is light and does not produce a heavy load, it supports the bone by wrapping around the bone, so that no bandages are required.

In the case of complicated fractures, since the animals cannot feed on their own in the wild, hypoglicemia and shock may occur. Osteosynthesis is required for winged animals whose health is critical after the temporary stabilization of fractures (ASLAN et al., 2009; ÜNSALDI and ÜNSALDI, 2012). If either the radius or the ulna is broken, and the other one is healthy, there is no need for a bandage; however, if both the radius and ulna are broken and the humerus is broken, a light bandage is required after bone muff treatment (ÜNSALDI, 1986; ÜNSALDI and ÜNSALDI, 2012). If the radius or ulna is fractured, animals will feed or allow themselves to be fed after the muff is applied. After being fed by hand, they are willing to feed on their own (ÜNSALDI and ÜNSALDI, 2012). In this study, the animals taken to our clinic underwent osteosynthesis following anesthesia after their general health condition was stabilized. However, those with poor health died. Those that could be fed lived if the bone reformed in a short time, and no excessive infection or necrosis occurred; however, those that did not feed died within 2-7 days. Since flying is very important to wild birds, they leave themselves to die by refusing to eat if they cannot fly or realize that they cannot fly. Bone fractures mostly occurred in birds in the humerus, radius, ulna, and, partially, in the femur. In the case of humerus fractures, both radius and ulna fractures or femur fractures, animals were not willing to feed, and their psychological condition was quite poor. In such cases, they did not allow us to feed them by hand, or even if they were fed by hand, they vomited back the food within 5-10 minutes.

In 1986 and 1991, muffs of goat, cattle, sheep bones were applied to dogs, and showed resorption within 6 months (ÜNSALDI, 1986; ÜNSALDI, 1991), while winged animal muffs were resorbed within 10-11 months (ÜNSALDI and ÜNSALDI, 2012). In this study, in the case of ulna and radius fractures, some animals were under control and all the healing processes were observed by radiography, and the results proved to be successful. In the case of humerus fractures, since the animals were taken back by their owners, healing processes were not observed regularly. Nevertheless, the 4th golden eagle mentioned above had a humerus fracture and it lived 2 months after the muff application. During this period, callus formation was normal. Histopathology showed that callus began to reform. The study showed that bone muffs may be better than conservative treatment, however, further research is needed as long-term real results are lacking.

Conclusions

In conclusion, the bone muff supports the bone, it does not necessitate bandaging, it is resorbed, and does not need to be removed, it is quite light and, most importantly, it does not inflict any injury on the joints and does not obstruct flying. In the study, it was concluded that bone muffs may be better than conservative treatment but the long-term effects should be investigated.

Conflicts of interest

The authors have no conflict of interest.

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SAŽETAK

U ortopediji ptica primjenjuju se različite tehnike fiksacije prijeloma. Svaka od njih ima svoje prednosti i nedostatke, a najbolji se rezultati dobivaju odabirom tehnike ovisno o mjestu, obliku i vrsti prijeloma. Osim toga za pozitivan ishod liječenja važna je i poslijeoperacijska skrb, posebno kad je riječ o divljim vrstama. Cilj je ovog retrospektivnog istraživanja bio procijeniti prednosti upotrebe koštanih umetaka (engl. muff) u odnosu na druge rutinske oblike liječenja prijeloma kao što su primjena zavoja, intramedularne igle i serklaža. Veći broj divljih ptica s prijelomima nogu i krila primljeno je u Kliničku bolnicu za životinje F. Ü. Veterinarskog fakulteta u razdoblju od 1986. do 2011. godine, a liječene su zavojima, serklažom i tehnikom intramedularne igle. Od toga je u 14 ptica primijenjen koštani umetak. Životinje su u svrhu ostesinteze za anesteziju dobile Pentobarbital (Nembutal sodium 50 mg/cc, Abbott) ili ketamin (ketalar 50 mg/mL Parke-Davis). Koštani umeci odgovarajuće veličine dobiveni od goveda i ptica čvrsto su fiksirani na kosti s prijelomom te je praćen oporavak životinja za vrijeme poslijeoperacjske skrbi. Ptice s umecima nisu trebale zavoje, bile su mirnije i oporavile su se za kratko vrijeme. Histopatološki je u ptica koje su liječene koštanim umecima zapaženo uredno stvaranje koštanog kalusa na tretiranom mjestu. Životinje koje su liječene drugim, rutinskim tehnikama kojima se liječe prijelomi kostiju bile su agresivne i pod stresom. One su imale dulje vrijeme oporavka te su odbijale hranu i na kraju uginule. Zbog postavljenih zavoja nisu mogle održavati ravnotežu uz pomoć jednog krila što je uzrokovalo uznemirenost, odbijanje hrane i uginuće.

Ključne riječi: koštani umetak; uzroci; prijelom; tehnike liječenja; divlje ptice