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RADIOLOGICAL DIAGNOSIS AND TREATMENT OF TRAUMATIC INJURIES OF THE APPENDICULAR SKELETON IN WILD BIRDS OF PREY AND THEIR CHANCES OF REHABILITATION

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Abstract

Wild birds of prey found in Romania play a key role in maintaining biodiversity due to their position at the top of the food pyramid (Baltag, 2010). Birds are distinguished from other animals by the presence of a pneumatic skeleton with a thinner cortex, which makes them more sensitive to the dangers of the modern era (Ahmed et al., 2019; Novitskaya et al., 2017). 98 cases were documented from the Wildlife Rescue and Rehabilitation Centre of the "Visul Luanei" Foundation during 2024, of which the common kestrel (Falco tinnunculus) (33.67%), and owls (order Strigiformes) (43%) were the most encountered species. The birds underwent clinical examination, 30 were suitable for intervention with various coaptation techniques. 168 injuries were recorded, humerus (29/168) being the most affected, and the coraco-scapular humeral joint had the highest ratio of healed trauma 5/15. The study aimed to identify post-traumatic lesions of the appendicular skeleton, their presentation, the time elapsed since their occurrence, the physical condition, and the methods of treatment, providing a clear perspective on the difficulties in the rehabilitation of wild birds of prey.

Key words: *birds of prey, traum, rehabilitation, appendicular skeleton, coaptation.*

INTRODUCTION

From an ecological perspective, birds of prey are considered apex predators with a significant role in influencing prey population dynamics. Additionally, their population status and general health serve as valuable indicators of environmental changes that may affect regional biodiversity (Baltag, 2010). However, cohabitation with humans has led to a loss of biodiversity, resulting in a significant decline in species or even their extinction (Ceballos et al., 2017).

The main challenge facing predators at present is habitat loss/reduction (McClure et al., 2018), with roads playing a significant role in dividing animal populations through structural and functional fragmentation (Madadi et al., 2017). This results in the death of prey following collisions with cars, and birds of prey that attempt to consume them end up suffering the same fate (Sánchez-Ortiz et al., 2024). Other human actions that endanger the bird of prey population include poaching (Brochet et al., 2019), poisoning, electrocution (Ogada et al., 2016), and climate change (Franke, 2017). Thus, a number of considerations must be taken into account when a case is presented, given that wild animals do not have the same financial support as domestic animals (Ahmed et al., 2019).

The skeleton of birds has a different structure than that of mammals, giving them the ability to fly thanks to distinct characteristics, such as a reduced number of bones and their fusion, plus the presence of a complex respiratory system directly connected to pneumatic bones that contain a reduced amount of bone marrow and have a much thinner cortex than other terrestrial animals, which results in a lower resistance to the forces that lead to bone bending (Novitskaya et al., 2017). As such, birds are more prone to open fractures following trauma, accounting for approximately 30% to 65% of cases admitted to wildlife rehabilitation centres (Sánchez-Ortiz et al., 2024).

Unfortunately, a large number of wild birds admitted due to contusions have a poor prognosis, suffering from injuries incompatible with functional rehabilitation, resulting in the death or euthanasia of the animal (Sánchez-Ortiz et al., 2024).

The aim of this study was to analyse/ characterize post-traumatic injuries, including their presentation, the time elapsed since their occurrence, their physical condition, and the methods of treatment, in order to improve the prospects for optimal healing and facilitate a more effective rehabilitation, enabling their return to natural behaviours and thus supporting their ecological role within the food web.

MATERIALS AND METHODS

During 2024, 98 cases of wild raptors were diagnosed with traumatic injuries of the appendicular skeleton at the Wildlife Rescue and Rehabilitation Centre "Visul Luanei", situated within Bucharest Metropolitan Area, Romania. The data was managed using WRMD (Wildlife Rehabilitation MD). Age was classified according to the EURING (European Union for Bird Ringing) model as follows: hatchling – 0, nestling – 1, fledgling – 2, juvenile – 3, adult – 4. Sex was determined and recorded based on morphological characteristics, in species which present with sexual dimorphism (Collins Bird Guide).

All birds were clinically evaluated, and radiographic examination was performed with a GIERTH TR 90/20 Battery device, applying specific incidences (Tudor and Vlăgioiu, 2015). The patients were anesthetized with ketamine (Narkamon Bio 100 mg/ml, 10-40 mg/kg i.v.) and diazepam (Diazepam 10 mg/ml, 1-1.5 mg/kg i.v., i.m.) diluted and administered intramuscularly, then switched to gas anaesthesia with isoflurane, using 2% to maintain anaesthesia during surgery. Meloxicam (Meloxidolor 5 mg/ml, 0.5-2 mg/kg i.m.) was administered preoperatively and postoperatively at 12-24-hour intervals, subcutaneously or intraosseous for a maximum of 4 days.

To prevent aspergillosis during the indoor housing period, itraconazole (Itrafungol; 10 mg/ml, 10 mg/kg p.o., q24h) was administered prophylactically to species considered highly susceptible to captivity-related stress, particularly those of the genus *Accipiter*. All treatment protocols and dosage regimens followed the recommendations of Carpenter and Marion (2018).

The coaptation techniques utilized were both non-surgical and surgical. Non-surgical methods included the use of figure-of-eight bandages, wing-to-body wraps, and splints. Surgical repairs were performed using an intramedullary (IM) pin-external skeletal fixator (ESF) tie-in. This involved placing IM pins via normograde or retrograde techniques with a manual mandrel, which were then connected to a mono- or biplanar ESF frame using an epoxy polymer (Orosz E. Susan et al., 2023).

Postoperatively, amoxicillin trihydrate (Amoxykel 150 mg/ml, 150 mg/kg i.m. q24h, 5 days) was administered to prevent infection, and meloxicam (Meloxidolor 5 mg/ml, 0.5-2 mg kg i.m. q24h, 3-4 days) or buprenorphine (Buprecare 0.3 mg/ml, 0.01-0.2 mg/kg i.m. q12h, 3-7 days) was administered for pain relief (Carpenter and Marion, 2018).

Statistical analysis was performed using Fisher's exact test together with the Monte Carlo simulation method with n = 10.000 simulations, using R software version 4.5.0 with the RStudio development environment.

RESULTS AND DISCUSSIONS

The most frequently admitted birds were of the order *Strigiformes* (43%), followed by *Falconiformes* (36%) and *Accipitriformes* (21%).

The most commonly identified species was the common kestrel (*Falco tinnunculus*) (33.67%; 33/98), with females being more numerous, as can be seen in Table 1. In terms of age, category 4 represented 60.20% (59/98) of the studied population, followed by category 3-29.59% (29/98), category 2-4.08% (4/98), and categories 1 and 0 both recorded one case each.

Of the 98 recorded cases, the total number of patients that were successfully rehabilitated was 14, resulting in a rehabilitation rate of 14.28%. Moreover, the 98 patients in the study presented with a total of 168 distinct injuries, as 38 individuals (38.8%) had sustained multiple traumatic lesions.

Table 1. Distribution of cases by species

Species	Number of cases	Sex		
		M	F	Un
Falco tinnunculus	33	9	9	14
Athene noctua	19	5	3	12
Accipiter nisus	12	2	10	0
Asio otus	11	3	6	2
Otus scops	4	3	1	0
Strix alu	4	2	2	0
Accipiter brevipes	3	0	1	2
Accipiter gentilis	3	1	1	1
Buteo buteo	2	1	0	1
Falco subbuteo	2	0	0	2
Strix uralensis	2	1	1	0
Circus aeruginosus	1	1	0	0
Falco cherrug	1	0	1	0
Tyto alba	1	1	0	0
Total	98	29	35	34

Table 2. Distribution of lesions according to the affected region

Bone/Joint	Number of lesions	Percentage
Humeral bone	29	17.26%
Radial bone	26	15.48%
Ulnar bone	23	13.69%
Carpometacarpal bone	15	8.93%
Coraco-scapulo-humeral joint	15	8.93%
Tibiotarsal bone	11	6.55%
Humero-radio-ulnar joint	9	5.36%
Tarsometatarsal bone	8	4.76%
Coracoid bone	7	4.17%
Femoral bone	7	4.17%
Radio-ulno-carpometacarpal joint	7	4.17%
Clavicle bone	4	2.38%
Femuro-tibiotarsal joint	2	1.19%
Coxofemural bone	1	0.60%
Phalangeal bone	1	0.60%
Pelvic bone	1	0.60%
Scapular bone	1	0.60%
Tibio-tarsometatarsal joint	1	0.60%
Total	168	100%

79.17% (133/168) were fractures, 17.86% (20/168) were dislocations, and 2.98% (5/168) were sprains. Most of the injuries (80.95%; 136/168) were located in the upper limb (Figure 1, Figure 2) and a smaller proportion (19.05%; 32/168) in the lower limb.

The most frequently affected bone was the humerus, and among the joints, the coraco-scapulo-humeral joint (Table 2).

Fisher's exact test was applied to assess whether there was a correlation between the joint and the type of lesion, and the result (p=0.659) did not indicate a correlation, the observed difference being attributed to random deviation.

Figure 1. Radiographic image of a Eurasian sparrowhawk (*Accipiter nisus*), diagnosed with a fracture of humerus and ulna

Figure 2. Radiographic image of a Eurasian sparrowhawk (*Accipiter nisus*), diagnosed with a dislocation of the humerus and fracture of coracoid

The most frequently recorded traumas were assessed as chronic and open, as can be seen in Table 3, and following statistical calculation (p=0.085), no direct correlation was found between the chances of healing and the type of injury.

Table 3. Distribution of presentation mode and time elapsed since injury

Type of lesion	Healed	Unhealed	Total
Chronic	1	27	28
Acute	2	6	8
Opened	24	1	25
Closed	17	5	22
Total	44	39	83

Table 4. Distribution of coaptation techniques

Techniques utilized	Number of applied treatments
Dorsal wing-tip taping	16
Rod with uniplanar external fixator	11
Figure 8 bandage	4
Splint	1
Rod with biplanar external fixator	1
Total	33

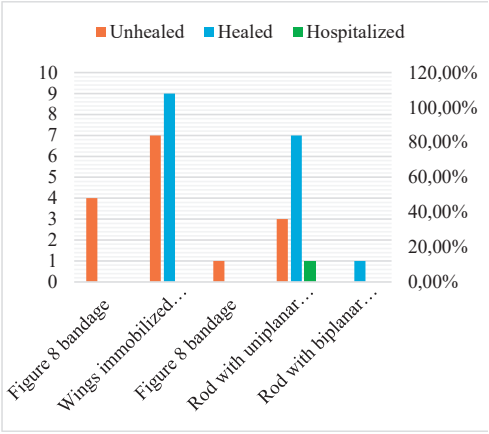

Figure 3. Distribution of cured and uncured cases according to the curing method used

The most frequently used method of coaptation was immobilization by dorsal wing-tip taping, as can be seen in Table 4, a technique which also recorded the highest number of healed cases (Figure 3). Of the total number of cases, 69 (70.41%) died or were euthanized before treatment, 14 (14.29%) died during treatment, 14 (14.29%) were successfully rehabilitated, and 1 (1.02%) was still hospitalized at the end of the study.

Coraco-scapulo-humeral joint injuries had the highest chances of healing; these being represented by dislocations and sprains (Table 5).

All traumas were statistically evaluated, but the result (p=0.239) did not indicate a correlation between the chances of healing and the region involved.

Table 5. Distribution of healed and unhealed lesions by region

Bone/Joint	Healed	Unhealed
Coraco-scapulo-humeral joint	5	10
Tibiotarsal bone	3	8
Humeral bone	2	27
Femural bone	2	5
Radial bone	1	25
Ulnar bone	1	22
Carpometacapal bone	1	14
Humero-radio-ulnar joint	1	8
Tarsometatarsal bone	1	7
Coracoid bone	1	6
Clavicle bone	1	3
Radio-ulno-carpometacarpal joint	0	7
Femuro-tibiotarsal joint	0	2
Scapular bone	0	1
Pelvic bone	0	1
Phalangeal bone	0	1
Coxofemural joint	0	1
Tibio-tarsometatarsal joint	0	1
Total	19	149

Analysing the evaluated cases and their distribution, a trend can be observed indicating that patients in good physical condition had a higher chance of rehabilitation, as can be seen in Table 6. There is no correlation between this and the chances of functional rehabilitation, with the Fisher exact test result (p=0.135) being negative, this can be caused by the asymmetrical distribution of data.

Table 6. Distribution of patients according to body condition score

Body condition score	Rehabilitated	Nonrehabilitated	Total
Emaciated	0	17	17
Thin	4	37	41
Reasonable	9	27	36
Good	2	2	4
Total	15	83	98

In the current study, the most frequently identified species were the common kestrel

(*Falco tinnunculus*), the little owl (*Athene noctua*), and the sparrowhawk (*Accipiter nisus*), with the order Strigiformes being more predominant and adult females being more numerous. Similar to our results, Ahmed et al. (2019) found that the common kestrel (*Falco tinnunculus*) was the most frequently affected, followed by the northern boobook (*Ninox japonica*) and the Eurasian sparrowhawk (*Accipiter nisus*), and the most common order was *Falconiformes*.

Similarly, Bueno et al. (2015) found that males were more numerous than females, and adult birds were more numerous than other age categories. These observations may be due to the geographical distribution of different species of birds of prey, habitats, and food sources.

Kayikci et al. (2019) found that the radius and ulna, followed by the tibiotarsus, were the most affected bone rays, and Titze (2017) highlighted that the coraco-scapulo-humeral joint was more frequently involved in pathological processes. The current study recorded similar results to previous studies, with the humerus and radius being the most frequently affected bones, and the coraco-scapulo-humeral joint being the most frequently affected joint. The variance in observed injuries is likely attributable to a combination of species-specific factors, such as flight mechanics and hunting methods. For example, the active-pursuit hunting characteristic of *A. nisus*, probably exposes it to different mechanical risks than species with passive hunting strategies. The ultimate nature and severity of an injury are further modulated by key ecological variables, such as habitat complexity, migratory status, and prey selection.

The results of a study conducted in South Korea (Jang, 2019) showed that the bones with the highest chances of rehabilitation were the scapula, ulna, and clavicle. Our study showed that the clavicle, femur, and tibiotarsal bones have a higher rehabilitation rate (Table 5). This discrepancy may be due to the significantly different distribution of cases included in the respective studies.

Compared to the results obtained by Bueno et al. (2015) and Vigneault et al. (2021) regarding the presentation and time elapsed since their occurrence, in which closed and chronic injuries were most frequently recorded, in this study, open and chronic injuries were more frequent, assuming that this observation may be due to the different causes that led to the occurrence of the respective pathologies. Additionally, the differences observed may be due to regional variations in public education about wildlife, the availability of local rehabilitation centres, and the relevant national legislation, all of which can impact the time elapsed between an injury's occurrence and the patient's admission.

Studies by Jang (2019) and Kayikci et al. (2019) showed a tendency to use non-invasive coaptation techniques, which were used more than invasive ones. This choice may be motivated by the fact that a non-invasive approach is easier to apply, involves lower costs, reduces the risk of iatrogenic infections, and leads to less stress on the bird's body, favouring more effective functional rehabilitation, with a fracture healing period of two weeks. No studies focusing on the chances of healing and rehabilitation of birds that have benefited from these procedures have been identified.

A study conducted in Spain (Molina-López et al., 2015) found a clear and direct correlation between body condition score and patient prognosis, similar to the findings of the present study. Thus, birds with poor body condition had a much lower chance of survival, as the body is much weaker after enduring the injury, especially for a long period of time.

The absence of correlations in the statistical results may be due to the limited number of cases. If a sample with a higher number of patients had been used, the data calculations could have indicated direct correlations that would have helped establish a more accurate prognosis.

CONCLUSIONS

Following the analysis of the results of this study, it can be said that acute and closed injuries had a more favourable prognosis compared to open and chronic ones. In addition, dorsal wing-tip taping and the surgical repair of fractures using intramedullary rods with uniplanar external fixators were the most commonly used methods of fixation.

The body condition score correlates positively with the chances of functional rehabilitation.

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