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Retrospective Study of Fracture treatment of Rescued raptors in Chungnam province

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ABSTRACT

Retrospective Study of Fracture treatment of Rescued raptors in Chungnam province

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This retrospective study was conducted on 1,238 raptors that were admitted to the Chungnam Wild Animal Rescue Center from January 2014 to December 2018. The results depending on the medical treatment and the types of the analysis in accordance with the cause of distress were analyzed on the basis of the basic data concerning the rescued bird of prey. Among the rescued raptors, about 450 individuals were diagnosed with fracture and dislocation. The diagnosis was recorded on electronic medical record. The causes of the distress, fracture locations and fracture types were analyzed and the analysis of the treatment results were also carried out. The fracture and dislocation state, surgery and treatment, the union period of fracture site and treatment outcome were analyzed for 249 raptors.

Depending on the survey about the cause of the distress, the electrical wire and the collision to buildings had 453 individuals (36.6%). The analysis of diagnosis results showed 450 individuals (36.3%) with fracture and dislocation. According to the result after the treatment, 690 individuals (55.7%) among the total 1,238 individuals were able to return to nature. The rescued raptors in the Chungnam Wild Animal Rescue Center were 2 orders, 3 families, 18 species and 1,238 individuals. The species registered as a

natural monument were 14 species and 1,120 individuals (90.5%), and the endangered species were 11 species and 536 individuals (43.3%). The highest number of 344 individuals among the rescued raptors was Common kestrel (*Falco tinnunculus*), a natural monument. During the five years of the investigation, 276 raptors (22.3%) of a high order in quantity of the rescued were occupied in the year of 2015. The high order by seasons according to quantity of the rescued 503 individuals (40.7%) appeared in the summer with breeding season. The individuals rescued in Asan-si among the city and the county of Chungnam province were 224 individuals (18.1%) with the highest ratio according to the regional rescue survey.

The raptors that were diagnosed as a fracture and dislocation were 450 individuals. The Common kestrel (*Falco tinnunculus*) happened to have 99 individuals (22%) that were diagnosed with a fracture and dislocation. A highest number of Common kestrel (*Falco tinnunculus*) individuals were diagnosed with the fracture and dislocation. The 99 individuals (22%) of the Common kestrel among the 450 individuals were diagnosed with a fracture and dislocation. The collision with the building or the electrical wire was the cause of the 286 cases (69.8%) of the fracture and dislocation of the rescued raptors. Among the 701 cases on the fracture and dislocation from 450 raptors, the fracture on the wings had the highest number by 405 cases (57.8%). The 151 cases (40.8%) of the rescued raptors that had fractured and dislocated humerus were the highest rate. Depending on the results of the clinical category on the fractured raptors, the raptors that corresponded to the critical clinical category 4 occurred the most by 204 cases (45.3%). Based on the results of the rescued individuals with fracture, the number of euthanasia individuals were the 199 cases (44.2%).

There are 450 raptors that were diagnosed with fracture and dislocation. 201 raptors were unable to give a medical treatment; 73 raptors (47.1%) of the 201 raptors were unable to treat due to damaged nerves. The 249 raptors that were treated were analyzed in groups by the location, type, clinical score, and the outcome of the surgery and treatment of the fracture and dislocation. The method of Tie-in Fixator (TIF), which was used to treat the raptors with a fracture on the humerus, and the instrument of

Intramedullary (IM) pin for radius and the figure of eight bandage for curing coracoid were mostly used. The analysis of the time that was taken to remove the pins or to union the fracture after the treatment. The results of the analysis revealed that the tarsometatarsus needed the longest time by taking 25.7(±2.5) days for the union of the fractured bone. Meanwhile, the furcular was the fastest union of the fractured bone by taking 10.7(±3.2) days. The results of the fracture treatment of 249 raptors were confirmed that there were 139 raptors (55.8%) that returned to nature. However, there were 58 raptors (23.3%) that died during the treatment. There were 44 raptors (17.7%) for euthanasia and there were 8 raptors (3.2%) that became permanently disable that they could not be released to nature or their status was still continuing with the process of the treatment.

The clinical status average score according to the results of the treatment of the fracture sites were as follows; there were 2.12 score that returned to nature, 2.72 score that died during the treatment and 3.30 score for euthanasia. In other words, the lower the clinical score of the fracture condition, it was more likely that the raptors were able to return to nature. Therefore, the clinical score of fracture condition before treatment can be used as an indirect indicator to determine the prognosis of a fractured raptor.

Key words: raptor, cause of distress, collision, trauma, fracture type, clinical score

General Introduction

The Korean peninsula is composed of 70% mountainous terrain of the country, and the three sides of the Korean peninsula are surrounded by the sea. Especially, The west coast has the best conditions to have diverse ecosystem due to the existence of the large tidal mudflat. As a result, many wildlife such as 527 species of birds, 125 species of mammals, 32 species of reptiles, and 21 species of amphibians are living in the domestic natural environment. There is much interest in domestic wildlife as it is designated as to protect various species in wildlife legally such as endangered species designated by the Ministry of Environment and natural monuments registered with the Cultural Heritage Administration. Currently, the confirmed raptors including sedentary birds and migrant in Korea are 2 orders, 4 families, 46 species (23, 29). Twenty-one species (46%) were specified as a I • II classes of the endangered species. Among them, the 19 species (41%) were designated as a natural monument (23). These species attracted high national attention for protection and management because various raptors were legally designated as protected species. The raptors are top predator within the food chain and are important in maintaining the natural balance of the ecosystem (46). They are also used as an evaluation index of the contamination about the ecological environment by estimating its environmental contaminant deposition (9, 50).

Lately, urbanization and industrialization caused a diminution of a natural habitat among countries for wildlife. A lot of wild animals are usually faced with a dangerous situation because of the separation and severance of habitat due to traffic development. Certain species and individuals of wild animals which could not adapt to the environmental changes or natural ecosystem were increased. Because artificial extension of the green coverage area constructed the ecological environment on surrounding area of stream and river of the nearby city (21, 22). The injury, mortality and distress of various wild animals which inhabit directly or indirectly within the city are increased accordingly (21). The total number of the rescued raptors was 18 species and 1,238 individuals (25%) among the total rescued 4,952 wild animals during the five years in this study. This presented a large proportion of the rescued wildlife. The species registered as a natural monument are 14 species and 1,120 individuals, and it was 90.5% of total raptors. The endangered species was 43.3% of the total number of cases as 11 species and 536 individuals.

However, in Korea, there was no data on the cause and the diagnosis of the distressed raptors. There had been a survey of injuries on wildlife in Gangwon province and a data on the cause of the distressed wild birds in Daegu-Gyeongbuk region. However, in other countries, there were many researches or studies on the distress and diagnoses for raptors. There were also many related data and information. The various causes of the rescued raptors have been studied in the Wildlife Center of Virginia, University of Florida Veterinary Medical Teaching Hospital and the Iowa State University Collage of Veterinary Medicine. The collision with a vehicle and electric wire or building were the most frequent cases. As a result of the diagnosis, the trauma was the most common among the rescued raptors (9, 38). The fracture was mostly caused by the trauma (14). Following the trauma, a variety of the causes of distress were identified depending on the species and the region. The Peregrine falcons that were rescued from the Wildlife Center of Virginia were diagnosed as West Nile virus infection following trauma diagnosis (13). At the Tafira Wildlife Rehabilitation Center in Spain, the most cases were caused by the trauma and the large number of orphaned-young raptors was the second highest (32). The orphaned-young raptors that were classified by the cause of distress were focused during only the breeding season (50). Most of the cases that have been classed as an orphan were mostly rescued by human interference (27). The major cause of the raptors' distress in overseas was related to human activities (11).

In Republic of Korea as of January 2019, 15 wildlife rescue centers are ran like a hospital for wild animal are operating. The wildlife rescue centers were the instrument in returning to the nature after the rescue and treatment, and rehabilitation of the wild animals. In accordance with having special significance about the natural environment protection and public interest apropos of wild animals, the importance on the role and the position of wildlife center was increasing. Therefore, it is necessary to have basic relevant data such as rescue, treatment and rehabilitation in order that the wildlife veterinarian and the relevant workers could treat the wildlife-related duty well. However, they were inadequate so far. The fracture among the distress causes of raptor that was rescued at wildlife rescue center were commonly found (32).

In Korea, there has been a data about the 31 fractured raptors in Daegu-Gyeongbuk region, but the data about the cause of the distress only exists. The common kestrel was the most common species that had the most common sites of the reported fracture especially on the diaphysis of the humerus. The comminuted fracture was the most common type, and intramedullary pinning with bandage was the most common method of surgical treatment (24). The fractured location that occurred the highest number of the fractures was different according to the survey and research area. For example, in Australia, the collision with vehicle was the most common cause of the distress with carpometacarpus as the most common fractured sites (38). In Missouri in U. S. A, the ulna fractures were the most common site of fracture due to the collision with the vehicle as well (51). The fractures on the thoracic limb were more common than the fractures on the pelvic limb (38).

A different method of treatments and surgical methods should be used on the raptors than the mammals because they have different constructive properties and conditioned bones (2). However, the data on the fracture treatment of the domestic raptor included only a several case reports and it was difficult to gather information about the treatment on the fracture. Finally, the related data was very poor. The treatment methods of raptor fracture were the invasive methods such as; Tie-in Fixator (TIF), Intramedullary (IM) pin, cross pin, External Skleletal Fixator (ESF), wire (Cerclage wire or Figure of eight wire) and shuttle pin. The non-invasive ways included the figure of eight bandage, splint, sling. The simultaneous use of internal fixation and external fixation was safer treatment method (49). When treating fractured individuals, the appropriate treatment and surgical methods should be selected considering as mentioned to below; the size and physical condition of the individual, the site of the fracture, the location (zone) of the fracture, the condition of the fracture, the type of fracture and the over time after the fracture (13). However, even if the wild raptors were rescued after fracture due to various causes, the wildlife rescue center or wildlife related organization did not have a sufficient and essential data and information on the fractured raptors.

Consequently, an inquiry was conducted on 1.238 raptors and 18 species, admitted to Chungnam Wild Animal Rescue Center during 2014-2018. This inquiry was included the results depending on medical treatment and analyses of types in accordance with cause of distress. The medical record of 450 individuals with fracture and dislocation was recorded. Using the diagnostic record, items such as the causes of the distress, fracture location and fracture type were analyzed. The analyses of the results after the treatment were also carried out. The categories such as clinical condition score of the fracture and dislocation condition, operation and treatment, the healing time of fracture site, and treatment results were analyzed for 249 treatable raptors. The analyzed and presented data of this study will become practical to prevent the measures against the threatening factors that causes the fractured birds of prey. Concurrently, the data of the results of this study will be used to provide veterinary surgeon with the raptor clinical data which are essential for surgery and treatment of fractured raptors.

CHAPTER Ⅰ

A Retrospective Study of Morbidity and Mortality of Raptors in Chungnam province: 2014-2018

1. Introduction

The natural habitat of wildlife has been decreasing due to expansion of the city and indiscriminate development recently. In addition, the habitat was separated and disconnected due to the development of traffic. A lot of wild animals are usually faced with a dangerous situation because of the environmental pollution. For this reason, many wild animals were admitted to the Chungnam Wildlife Rescue Center after being rescued from various causes. As a result, the number of rescued wild animals has increased by 10% annually over the last five years. Wild birds were about 70% in rescued wild animals. The proportion of the raptors was about 37% of the total rescued wild bird.

The raptors are the top predator within the food chain and play an important role in maintaining ecosystem (46). They are also indicators that play an important role in assessing the environmental pollution (9, 50). Several raptors as a national protected species were vulnerable at risky environment too.

Depending on the increasing public interest in the natural environment and wild animals, the conversation about the wild animals and protection is increasing continuously. Along with the public interest, a diverse research of the treatment of the rescued wild animals are increasing as well. However, the data on the rescued raptors by the seasonal change, the cause of distress analysis on the rescued raptors and the analysis and evaluation on the treatment and rehabilitation training depending on the cause of the distress was unsatisfactory so far.

Therefore, in this study, the results depending on the medical treatment and the analysis of types in accordance with the cause of distress was compared and analyzed. These results were based on the basic data concerning accepted rapacious birds in Chungnam Wild Animal Rescue Center during the 5 years. The result of this research paper could be used as a reference to those who are concerned about giving the medical treatment and rehabilitation of the wild life in both Chungnam province and other areas. This paper could be used as the practical basic data which is necessary for the management of the Accipitrines and also the minimization of the eco-environmental threat factors for the raptors.

2. Materials and methods

1) Animal and basic data

The 1,238 individuals for rescued and accepted birds of prey in Chungnam Wild Animal Rescue Center were recorded in the electronic medical record (intowild, intoCNS) for 5 years from January 2014 to December 2018. Several items or types of data such as the accepted date, species, sex, age, the discovered place, the feature of the discovered place, conditions about its discovery at the time, the cause of distress, initial body weight, body condition score, diagnoses, medical treatment, rehabilitation and the results of the return of nature were classified and analysed.

Depending on the morphological characteristics of each species, sex was classified into male, female and undetermined sex (=Unknown), and the age was classified into nesting, juvenile, adult and unknown. The analysed cause of distress was performed based on the declarant or the rescuer elucidates the conditions about its discovery at the time and the characteristics of the discovered place.

The diagnosis for the rescued individuals through basic physical examination, blood test, radiologic examination was carried out. The additional examination such as ophthalmologic examination, chemical serum test, parasitic test and lead poisoning test were performed if necessary. The optimum intensive care was carried out depending on the diagnosis. During the treatment, if the case was impossible to provide a cure or difficult to be released back to the nature, euthanasia was performed according to experimental animal ethical standards. The data of the entire rescued individuals was input on the electronic medical chart, and the analysis and interpretation of these data were conducted.

2) Standard classification of species

The rescued Raptor in accordance with the morphological characteristics species was decided where to belong to or how to determine the correct designation was classified into various species, using A field guide to the birds of Korea and The Endangered Birds in Korea as reference.

Among the rescued raptors, the identified raptors were classified as natural monuments and endangered species. The rescued individuals were assorted by yearly and seasonally. The season was divided into spring (March, April, May), summer (June, July, August), autumn (September, October, November) and winter (December, January, February). The rescue region was classified into 8 cities, 7 counties and the administrative district besides Chungnam province was indicated as others.

3) Classification on the cause of distress

The cause of the great distress was divided into 7 categories such as collision/trauma, orphaned young, starvation or exhaustion, suspected toxicosis, entering the building, infectious disease and others.

The collision/trauma individuals were separated by 8 types such as collision with the building or power line, hit by vehicle, entangled in wires or net, unknown trauma, gunshot, falling, predation and trapped.

The case of suspected toxicosis included both agrochemical poisoning and lead poisoning, entering the building means that individuals do not come out of the building, factory or farm products warehouse after entering the inside of a building.

The infectious diseases were sorted by 3 ways, such as fungal infection, parasitic infection and protozoan infection. The section, trapped, include 2 types like leg-hold trap and sticky paper trap for mice.

The cause of distress that had not been mentioned before are the oil contamination, a natural accident that might encounter under being surrounded by the nature, case of unidentifiable specific information, and the rescued individuals that had been illegally raised on. They were classified as the other.

4) Classification according to the diagnosis

After the rescued individuals have been done additional tests and test result's estimation, definitive diagnosis were made up and reestimated. the rescued individuals reestimated were as follows; these were classified into 7 types such as trauma, orphaned young, starvation or exhaustion, suspected toxicosis, infectious disease, normal condition and unknown/undetermined.

First, after conducting a basic physical examination and radiologic examination, trauma was divided into 5 classes like fracture/dislocation, head trauma, laceration, contusion and abrasion. Supposing an individual had various trauma, the most injury of trauma was selected as one of the above 5 classes.

Second, orphaned young means that it was normal in its physical condition before leaving the nest but could not live alone in the natural ecosystem.

Third, the suspected toxicosis individuals was carried out on the agrochemical poisoning due to insecticide was identified using only the clinical manifestation. Also the suspected toxicosis individuals was carried out on the lead poisoning by confirming from a blood test, radiologic examination and using apparatus for measuring the concentration of lead (LeadCare®: Magellan Diagnostics, North Billeria, MA, USA). When blood lead concentration was more than 0.2 ppm, it was diagnosed with lead poisoning.

Fourth, the infectious disease showed no apparent trauma to the body, but the individuals with abnormal behavior and conditions were classified into mycotic infection, parasitic infection and protozoan infection. A parasitization and protozoan infection were confirmed by the analysis of microscopic examination after collecting the individual's appropriate samples from cloaca or intraoral. The mycotic infection was confirmed through radiologic examination and autopsy after death.

Lastly, the conditions of the body condition score (BCS) of the first grade among the individuals with no sign of trauma was regarded as starvation or exhaustion, and the individuals of being just simple exhaustion should be considered as starvation or exhaustion.

5) Classification after conducting diagnosis and treatment

After the rescue the results that diagnosis and treatment were performed, the individuals that were diagnosed and cured were classified under six headings like dead on arrival (DOA), captive/permanent disability, released/transfer, euthanased, died and carcass.

The collected or found on the state of death at the rescue site was regarded as a carcass. The death on the way to the wild animal rescue center after the rescue, or the death before an active act of medical treatment after arriving at center, or death within 24 hours after emergency treatments were considered as DOA.

After the rescue and receipt of the wounded individuals, its condition was difficult or impossible to treat depending on the results of the diagnosis and treatment or its state was beyond natural comeback. With humanistical decision, these individuals were euthanased. The death during the treatment and rehabilitation was classified as died.

On December 31st of 2018, the individuals that were in the process of treatment were classed as captive. For the ones that were impossible to return to nature due to a disability was kept in cage for a long-term and used as an educational research. It was classified as a permanent disability. The individual that was successfully treated and rehabilitated was returned to the wild. It was classed as released. Tansferring the individual to the other institution owing to research, education and exhibition in alive condition after the treatment and rehabilitation was classed as transfer.

3. Results

1) The species of the rescued raptors

There were 8 species and 263 individuals (21.2%) of which one of raptors were usually classified by Accipitridae of Falconiformes. There were 3 species and 398 individuals (32.2%) of which the other of raptors were classified by Falconidae of Falconiformes. There were 7 species and 577 individuals (46.6%) of Strigidae of Strigiformes. The 2 orders, 3 families, 18 species and 1,238 individuals of which total rescued raptors were classified by as analyzed (Table 1.1).

There were 18 species and 1,238 individuals among the total raptors. The species registered as a natural monument were 14 species and 1,120 individuals (90.5%) of the total raptors. The endangered species was 43.3% of the total number of cases as 11 species and 536 individuals.

Table 1. 1. Raptors admitted to the Chungnam Wild Animal Rescue Center (2014-2018)

Order	Family	Species	Natural monument	Endangered species	Year (%)					Number (%)
					2014	2015	2016	2017	2018	
Falconiformes	Accipitridae	Chinese sparrowhawk (*Accipiter soloensis*)	323-2	II	7(0.6)	4(0.3)	2(0.2)	2(0.2)	0(0.0)	15(1.2)
		Cinereous vulture (*Aegypius monachus*)	243-1	II	7(0.6)	9(0.7)	6(0.5)	27(2.2)	36(2.9)	85(6.9)
		Crested honey buzzard (*Pernis ptilorhynchus*)		II	0(0.0)	1(0.1)	0(0.0)	0(0.0)	0(0.0)	1(0.1)
		Eurasian buzzard (*Buteo buteo*)			5(0.4)	16(1.3)	20(1.6)	15(1.2)	14(1.1)	70(5.7)
		Eurasian sparrowhawk (*Accipiter nisus*)	323-4	II	3(0.2)	9(0.7)	10(0.8)	10(0.8)	7(0.6)	39(3.2)
		Japanese sparrowhawk (*Accipiter gularis*)		II	1(0.1)	0(0.0)	0(0.0)	2(0.2)	1(0.1)	4(0.3)
		Northern goshawk (*Accipiter gentilis*)	323-1	II	4(0.3)	9(0.7)	12(1.0)	10(0.8)	9(0.7)	44(3.6)
		White-tailed eagle (*Haliaeetus albicila*)	243-4	I	1(0.1)	1(0.1)	1(0.1)	1(0.1)	1(0.1)	5(0.4)
	Falconidae	Common kestrel (*Falco tinnunculus*)	323-8		58(4.7)	85(6.9)	67(5.4)	70(5.7)	64(5.2)	344(27.8)
		Eurasian hobby (*Falco subbuteo*)		II	8(0.6)	10(0.8)	8(0.6)	9(0.7)	8(0.6)	43(3.5)
		Peregrine falcon (*Falco peregrinus*)	323-7	I	1(0.1)	1(0.1)	3(0.2)	3(0.2)	3(0.2)	11(0.9)
Strigiformes	Strigidae	Brown hawk owl (*Ninox scutulata*)	324-3		22(1.8)	26(2.1)	25(2.0)	21(1.7)	14(1.1)	108(8.7)
		Collared scops owl (*Otus semitorques*)	324-7		3(0.2)	7(0.6)	6(0.5)	5(0.4)	1(0.1)	22(1.8)
		Eurasian eagle owl (*Bubo bubo*)	324-2	II	46(3.7)	61(4.9)	65(5.3)	40(3.2)	47(3.8)	259(20.9)
		Long-eared owl (*Asio otus*)	324-5		3(0.2)	1(0.1)	0(0.0)	3(0.2)	0(0.0)	7(0.6)
		Oriental scops owl (*Otus sunia*)	324-6		26(2.1)	32(2.6)	22(1.8)	31(2.5)	39(3.2)	150(12.1)
		Short-eared owl (*Asio flammeus*)	324-4		0(0.0)	1(0.1)	0(0.0)	0(0.0)	0(0.0)	1(0.1)
		Tawny owl (*Strix aluco*)	324-1	II	8(0.6)	3(0.2)	10(0.8)	5(0.4)	4(0.3)	30(2.4)
Total		18	14	11	203 (16.4)	276 (22.3)	257 (20.8)	254 (20.5)	248 (20.0)	1,238 (100)

2) The causes of distress according to local

The rescued and received raptors were 1,238 individuals. 1,188 individuals (96.0%) of the 1,238 raptors were rescued at 15 cities and counties. The highest number of 224 individuals (18.1%) were rescued raptors in Asan-si (city). 50 individuals (4.0%) were rescued in the local besides in Chungnam province (Table 1.2).

Being classified as the causes of distress depending on the local, it was analysed that collision/trauma individuals showed the large part of the causes of distress followed by the lost nestling.

Table 1. 2. Regions in Chungnam where rescued raptors admitted to Chungnam Wild Animal Rescue Center (2014-2018) were found (%)

Region	Number of Cases	Collision/ Trauma	Orphaned young	Starvation or exhaustion	Suspected Toxicosis	Entering the buliding	Infectious disease	Other
Asan-si	224(18.1)	115(9.3)	47(3.8)	17(1.4)	35(2.8)	5(0.4)	0(0.0)	5(0.4)
Boryeong-si	61(4.9)	47(3.8)	11(0.9)	3(0.2)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Buyeo-gun	25(2.0)	20(1.6)	3(0.2)	1(0.1)	0(0.0)	0(0.0)	0(0.0)	1(0.1)
Cheonan-si	147(11.9)	71(5.7)	43(3.5)	7(0.6)	3(0.2)	11(0.9)	1(0.1)	11(0.9)
Cheongyang-gun	47(3.8)	22(1.8)	7(0.6)	2(0.2)	13(1.1)	2(0.2)	0(0.0)	1(0.1)
Dangjin-si	136(11.0)	79(6.4)	33(2.7)	7(0.6)	8(0.6)	3(0.2)	0(0.0)	6(0.5)
Geumsan-gun	29(2.3)	15(1.2)	11(0.9)	2(0.2)	1(0.1)	0(0.0)	0(0.0)	0(0.0)
Gyeryong-si	9(0.7)	7(0.6)	1(0.1)	1(0.1)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Hongseong-gun	76(6.1)	57(4.6)	9(0.7)	9(0.7)	1(0.1)	0(0.0)	0(0.0)	0(0.0)
Kongju-si	46(3.7)	23(1.9)	16(1.3)	4(0.3)	2(0.2)	1(0.1)	0(0.0)	0(0.0)
Nonsan-si	101(8.2)	63(5.1)	18(1.5)	9(0.7)	0(0.0)	10(0.8)	0(0.0)	1(0.1)
Seocheon-gun	48(3.9)	30(2.4)	9(0.7)	3(0.2)	1(0.1)	1(0.1)	1(0.1)	3(0.2)
Seosan-si	103(8.3)	67(5.4)	23(1.9)	6(0.5)	3(0.2)	3(0.2)	0(0.0)	1(0.1)
Taean-gun	33(2.7)	29(2.3)	2(0.2)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(0.2)
Yesan-gun	103(8.3)	54(4.4)	14(1.1)	12(1.0)	10(0.8)	5(0.4)	1(0.1)	7(0.6)
Other	50(4.1)	26(2.1)	13(1.1)	3(0.2)	1(0.1)	3(0.2)	1(0.1)	3(0.2)
Total (%)	1,238(100)	725(58.6)	260(21.0)	86(6.9)	78(6.3)	44(3.6)	4(0.3)	41(3.3)

3) The yearly and seasonal distress of the raptors

During the investigation period of five years, the 276 individuals (22.3%) was the highest quantity of the rescued in the year of the 2015. The highest order by seasons according to the rescued quantity was 503 individuals (40.7%) during summer (Table 1.3).

According to the analysis of the rescued species, the Common kestrel (*Falco tinnunculus*) were rescued the most in spring, summer and winter and the Eurasian eagle owl (*Bubo bubo*) was saved a lot especially in Autumn (Table 1.4).

Table 1. 3. Year and seasonal distribution of rescued Raptors admitted to the Chungnam Wild Animal Rescue Center (2014-2018)

Year	Season				Total Number of Cases (%)
	Spring No. of Cases (%)	Summer No. of Cases (%)	Fall No. of Cases (%)	Winter No. of Cases (%)	
2014	52 (4.2)	91 (7.4)	31 (2.5)	29 (2.3)	203 (16.4)
2015	59 (4.8)	129 (10.4)	32 (2.6)	56 (4.5)	276 (22.3)
2016	73 (5.9)	97 (7.8)	29 (2.3)	58 (4.7)	257 (20.8)
2017	55 (4.4)	94 (7.6)	31 (2.5)	74 (60.)	254 (20.5)
2018	82 (6.6)	92 (7.4)	32 (2.6)	42 (3.4)	248 (20.0)
Total (%)	321 (25.9)	503 (40.7)	155 (12.5)	259 (20.9)	1,238 (100)

Table 1. 4. Seasonal distribution of rescued Raptors admitted to the Chungnam Wild Animal Rescue Center (2014-2018)

Order	Family	Species	Season (%)				Total Number of cases (%)
			Spring No. of cases (%)	Summer No. of cases (%)	Fall No. of cases (%)	Winter No. of cases (%)	
Falconiformes	Accipitridae	Chinese sparrowhawk (*Accipiter soloensis*)	1(0.1)	13(1.1)	1(0.1)	0(0.0)	15(1.2)
		Cinereous vulture (*Aegypius monachus*)	34(2.7)	1(0.1)	2(0.2)	48(3.9)	85(6.9)
		Crested honey buzzard (*Pernis ptilorhynchus*)	0(0.0)	0(0.0)	1(0.1)	0(0.0)	1(0.1)
		Eurasian buzzard (*Buteo buteo*)	10(0.8)	0(0.0)	10(0.8)	50(4.0)	70(5.7)
		Eurasian sparrowhawk (*Accipiter nisus*)	4(0.3)	2(0.2)	5(0.4)	28(2.3)	39(3.2)
		Japanese sparrowhawk (*Accipiter gularis*)	1(0.1)	0(0.0)	3(0.2)	0(0.0)	4(0.3)
		Northern goshawk (*Accipiter gentilis*)	4(0.3)	4(0.3)	8(0.6)	28(2.3)	44(3.6)
		White-tailed eagle (H*aliaeetus albicila*)	1(0.1)	0(0.0)	0(0.0)	4(0.3)	5(0.4)
	Falconidae	Common kestrel (*Falco tinnunculus*)	84(6.8)	186(15.0)	21(1.7)	53(4.3)	344(27.8)
		Eurasian hobby (*Falco subbuteo*)	9(0.7)	29(2.3)	5(0.4)	0(0.0)	43(3.5)
		Peregrine falcon (*Falco peregrinus*)	0(0.0)	1(0.1)	4(0.3)	6(0.5)	11(0.9)
Strigiformes	Strigidae	Brown hawk owl (*Ninox scutulata*)	42(3.4)	52(4.2)	14(1.1)	0(0.0)	108(8.7)
		Collared scops owl (*Otus semitorques*)	6(0.5)	0(0.0)	4(0.3)	12(1.0)	22(1.8)
		Eurasian eagle owl (*Bubo bubo*)	74(6.0)	112(9.0)	51(4.1)	22(1.8)	259(20.9)
		Long-eared owl (*Asio otus*)	3(0.2)	0(0.0)	0(0.0)	4(0.3)	7(0.6)
		Oriental scops owl (*Otus sunia*)	32(2.6)	96(7.8)	22(1.8)	0(0.0)	150(12.1)
		Short-eared owl (*Asio flammeus*)	0(0.0)	0(0.0)	0(0.0)	1(0.1)	1(0.1)
		Tawny owl (*Strix aluco*)	16(1.3	7(0.6)	4(0.3)	3(0.2)	30(2.4)
	Total	18	321(25.9)	503(40.6)	155(12.5)	259(20.9)	1,238 (100)

4) The causes of distress

The causes of distress which had the highest percentage were 725 cases (58.6%) such as a collision and trauma. It was analysed that the lost nestling without a mother was 260 cases (21.0%). The opportunistic infections from the distress were the lowest by 4 cases (0.3%). It was analyzed that the natural accidents or immersed body in oil contamination, the unknown causes of distress and unknown individuals were 41 cases (3.3%) (Table 1.5).

In detail, 725 cases according to the collision and trauma were classified. Accident by electric wire/building collision had the most cases by 453 cases (62.5%) (table 1.6).

Table 1. 5. Causes and frequency of the raptors distress by season

Causes of distress	Spring No. of cases (%)	Summer No. of cases (%)	Fall No. of cases (%)	Winter No. of cases (%)	Total Number of Cases (%)
Collision/Trauma	163 (13.2)	259 (20.9)	117 (9.5)	186 (15.0)	725 (58.6)
Orphaned young	86 (6.9)	173 (14.0)	0 (0.0)	1 (0.1)	260 (21.0)
Starvation or exhaustion	13 (1.1)	38 (3.1)	17 (1.4)	18 (1.5)	86 (6.9)
Suspected Toxicosis	36 (2.9)	1 (0.1)	2 (0.2)	39 (3.2)	78 (6.3)
Entering the buliding	10 (0.8)	12 (1.0)	14 (1.1)	8 (0.6)	44 (3.6)
Infectious disease	0 (0.0)	3 (0.2)	0 (0.0)	1 (0.1)	4 (0.3)
Other	13 (1.1)	17 (1.4)	5 (0.4)	6 (0.5)	41 (3.3)
Total (%)	321 (25.9)	503 (40.7)	155 (12.5)	259 (20.9)	1,238 (100)

Table 1. 6. Causes of collision and trauma in 725 raptors admitted to the Chungnam Wild Animal Rescue Center by season. (2014-2018)

Causes of collision and trauma	Spring No. of cases (%)	Summer No. of cases (%)	Fall No. of cases (%)	Winter No. of cases (%)	Total Number of Cases(%)
Collided with Building or power line	106 (14.6)	149 (20.6)	75 (10.3)	123 (17.0)	453 (62.5)
Hit by vehicle	21 (2.9)	42 (5.8)	28 (3.9)	30 (4.1)	121 (16.7)
Entangled in wires or net	8 (1.1)	24 (3.3)	12 (1.7)	16 (2.2)	60 (8.3)
Unknown trauma	6 (0.8)	10 (1.4)	0 (0.0)	6 (0.8)	22 (3.0)
Gunshot	2 (0.3)	3 (0.4)	2 (0.3)	7 (1.0)	14 (1.9)
Falling	10 (1.4)	4 (0.5))	0 (0.0)	0 (0.0)	14 (1.9)
Predation	2 (0.3)	8 (1.1)	0 (0.0)	0 (0.0)	10 (1.4)
Trapped[a]	8 (1.1)	19 (2.6)	0 (0.0)	4 (0.6)	31 (4.3)
Total(%)	163 (22.5)	259 (35.7)	117 (16.1)	186 (25.7)	725 (100)

[a]Trapped includes a Leg-hold trap and a Sticky paper trap

5) The result of the medical treatment

The results of the primary diagnosis were obtained through appropriate first aid and treatment during these five years from January 2014 to 31 December 2018. The results of diagnosis were shown that the most part of trauma was 450 individuals (36.3%) as a fracture and dislocation (table 1.7).

Among the lost nestling without a mother, there were no external signs of injury. However, it was verified that the cases which could not live by itself once it is released to nature were 228 individuals (18.4%).

Among 76 individuals of the suspected toxicosis, 75 individuals were in a state of second pesticide poisoning by clinical manifestation and medical checkup was identified and cured. The other individual was identified as a lead poisoning by radiologic examination and measurement of blood lead concentrations. Then, it was diagnosed and treated.

In infectious diseases, Trichomonas sp. was verified carrying out microscopic examination in oral samples about one individual of Eurasian eagle owl (*Bubo bubo*). Capillaria sp. was checked out in oral samples respectively from each individual Eurasian eagle owl (*Bubo bubo*) and Common kestrel (*Falco tinnunculus*). After Aspergillosis was diagnosed and cured about one individual of Cinereous vulture (*Aegypius monachus*), it was dead. Therefore, Aspergillus sp. was also verified after conducting autopsy.

After the treatment and rehabilitation was successfully completed, the cases that individuals were returned to nature were 687 individuals (55.5%). Two individuals like White-tailed eagle and Tawny owl were impossible to return to nature due to permanent disability.

Table 1. 7. Summary of primary clinical diagnoses and Results for raptors treated at Chungnam Wild Animal Rescue Center during (2014-2018)

Condition		Number of Cases (%)	DOA (%)	Captive/ Permanent disability (%)	Released/ Transfer (%)	Euthanased (%)	Died (%)	Carcass (%)
Trauma	Fracture/Dislocation	450(36.3)	34(2.7)	8(0.6)	139(11.2)	199(16.1)	58(4.7)	12(1.0)
	Head trauma	149(12.1)	10(0.8)	0(0.0)	99(8.0)	17(1.4)	17(1.4)	6(0.5)
	Laceration	49(4.0)	4(0.3)	2(0.2)	15(1.2)	20(1.6)	8(0.6)	0(0.0)
	Contusion	47(3.8)	7(0.6)	0(0.0)	24(1.9)	6(0.5)	8(0.6)	2(0.2)
	Abrasion	24(1.9)	0(0.0)	2(0.2)	21(1.7)	0(0.0)	1(0.1)	0(0.0)
Orphaned young		228(18.4)	8(0.6)	3(0.2)	206(16.6)	2(0.2)	9(0.7)	0(0.0)
Starvation or exhaustion		145(11.7)	33(2.7)	3(0.2)	69(5.6)	5(0.4)	28(2.3)	7(0.6)
Suspected Toxicosis		76(6.1)	1(0.1)	0(0.0)	65(5.3)	2(0.2)	3(0.2)	5(0.4)
Infectious disease		4(0.3)	2(0.2)	0(0.0)	0(0.0)	0(0.0)	2(0.2)	0(0.0)
Normal		38(3.1)	0(0.0)	0(0.0)	36(2.9)	0(0.0)	2(0.2)	0(0.0)
Unknown/ undetermined		28(2.3)	2(0.2)	0(0.0)	16(1.3)	3(0.2)	0(0.0)	7(0.6)
Total		1,238(100.0)	101(8.2)	18(1.5)	690(55.7)	254(20.5)	136(11.0)	39(3.1)

4. Discussion

The most frequently occurred collision/trauma among the causes of distress for the rapacious birds were 58.6%, and the collision with building or electric wire were 62.5% from the collision/trauma of the cause of distress. In regional analysis the number of the rescued individuals was in order by 224 individuals (18.1%) in Asan-si (city) and 147 individuals (11.9%) in Cheonan-si (city). Compared to any other region in Chungnam province, there are lots of cases on the individuals that were rescued from relatively densely populated city centre and urban fringe in Asan-si and Cheonan-si. The assessment of the trauma was occurred frequently caused by the collision with building or electric wire. It was regarded as one of the greatest causes.

The reason the raptors collided with the manmade structure such as windows of the building, electrical wire, high-tension electricity pylon and baffle wall was the increasing population of the raptors that were invaded by the city centre and urban fringe (36). When the birds of prey fly around the city, the frequent collision with the building occur due to the reflection of the projected landscape on the window or the transparency of the window (27, 32). It was an unavoidable fact that the city is developing. Due to the developing city, the number of the rescued individuals are increasing. The research on the prevention of the raptor's collision are needed.

The orphaned young were 260 cases (21.0%) among 1,238 cases. There was 173 cases (14.0%) in summer. In general, the breeding season of the birds was in late spring and summer (14). Among the 260 individuals of the rescued orphaned young, the sedentary birds were 172 individuals (66.2%), the summer birds were 84 individuals (32.2%) and the winter birds were 4 individuals (1.5%). The sedentary birds had the greater percentages among the rescued as an orphan. The common kestrel (*Falco tinnunculus*) of the sedentary birds was 119 individuals (34.6%) among 344 rescued individuals that were all orphaned young.

The Common kestrel (*Falco tinnunculus*) nestle in a cliff, and the building in cities resemble the ecological feature of a cliff (36). Therefore, the Common kestrel found in cities will nestle in the apartment close to the green space like an artificial park. The Common kestrel was widely seen accidentally by the people and reported when nestling around the city center. During the breeding season, many orphaned Common kestrel are rescued. The orphaned Common kestrel due to the removal of their nest and illegally picked by human had much more numbers compared to the number of injured, diseased, and motherless. Educating humans is important to decrease the number of the orphaned raptors.

The suspected toxicosis was 78 cases (6.3%). It was analyzed that Cinereous vulture (*Aegypius monachus*) that migrates in winter had 51 cases (4.1%) and Eurasian buzzard (*Buteo buteo*) had 21 cases (1.7%). Many individuals were rescued in Asan-si (35 individuals) and Cheongyang-gun (13 individuals). The rescued Cinereous vulture from pesticide poisoning has increased from 10 individuals in 2017 to 16 individuals in 2018. Cinereous vulture diets on the dead animals. The Cinereous vulture that was suspected toxicosis was caused by eating the dead wild duck which had been killed by eating the seed of rice contaminated by the agricultural chemicals. To prevent the secondary poisoning of the Cinereous vulture, all the carcasses have to be collected and disposed. If the agricultural poisoning was suspected, individuals were treated on organophorus pesticide or carbamate pesticides poisoning on the basic set of circumstances and clinical manifestation, for example, diarrhea, vomiting, salivation, and lacrimation might be seen. Generalized neurologic signs such as depression, tremors, or seizures may be observed. To exact diagnosis of the insecticide poisoning, the clinical manifestation, blood concentration or toxic substance within cellular tissue should be verified. The decreased acetylcholinestrase should be tested, and then finally must be diagnosed (50).

The lead was poisoned as individuals eat normally the lead bullet included in the food or carcass, or owing to swallowing pieces of lead bullet or fishing sinkers (18). The radiography and the examination on the lead levels on blood were carried out.

If the lead levels on blood were greater than 0.2 ppm (20 ug/dl), it is verified and treated as a lead poisoning (43, 50). The presence of lead in the stomach of the rescued vultures was verified on the radiograph. The lead concentrations of the rescued vulture was 43.8 ug/dl. The 0.5 cm size of a piece of lead bullet was washed out by performing gastrolavage. Then, the lead level decresed to 7.9 ug/dl as a result of cure and management. After a treatment of 65 individuals among 71 individuals rescued by the secondary poisoning due to the agricultural chemicals, many of those were returned to nature. The lead poisoning of the individual was also returned to nature. In the case of the secondary poisoning due to the agricultural chemicals and lead poisoning, the prognosis would be good the faster the proper treatment is completed.

Trauma had 719 individuals (58.1%). Among the trauma, the facture and dislocation had 450 individuals (36.3%). Head trauma had 149 individuals (12.1%). In general, the raptors in normal condition would not be observed, but the raptors with a sever wound, disease, or the severe malnutrition could be caught and observed (38). Most of the rescued raptors suffer from severe trauma due to bone fracture. The number of 298 individuals (41.4%) among 719 rescued individuals due to trauma were returned to nature. The number 242 individuals (33.7%) of euthanasia appeared. The number of 139 individuals (30.9%) among 450 individuals that were rescued with the fracture and dislocation were able to return to nature. The euthanasia was effectively performed under controlled conditions on the 199 individuals that could not be treated. The number of 687 individuals (55.5%) among the total rescued individuals were returned to nature. It was thought that 206 (95.2%) out of 228 individuals diagnosed as orphaned young had a great influence on the rate of released increase.

The depression, hemorrhage in the oral or the cornea, and neurological sign and symptom as well as eye damage within head trauma in the individuals were verified. The symptom of hyphema and corneal lacerations along with the concussion appeared in both diurnal raptors by 5 individuals and nocturnal raptors by 22 individuals. As a result of the symptoms, losing the sight on one or both eyes and suffer from also the severe enophthalmos. The disappearance of the badly damaged eyeball or neurological sign symptom was impossible to treat. As an aftereffect of concussion, it was impossible to return to the nature. Then, euthanasia was effectively performed. The fact that the proportion of the eye of the nocturnal rapacious birds were relatively larger than the diurnal birds of prey, the eyeballs of the nocturnal birds were more damaged than expected. If the data was gathered while treating these raptors, it is expected to be handy.

The sex of a certain species was morphologically distinguishable, but it was mostly impossible to determine. The sex could be distinguished by using its weight and the size depending on the species. However, it was not 100 percent accurate. In most cases, the sex could be determined by autopsy. Although sex could be identified using the molecular method, it was not used in this research. The age was also not used in this research because its vague and the standard of the nesting, juvenile, adult are different depending on species. In the future, if both the morphological classification and the molecular biological classification were carried out, more accurate data should be presented.

The studies of the causes of distress were generally found in the areas of human activity such as around buildings and roads. The cautious consideration should be given to the fact that the cause of the distress was sometimes overestimated (9, 11). Figuring out the exact reasons of the rescued individuals could be difficult because they were mostly exposed to various situations. Therefore, listening to the history about the rescued raptors from the rescuer is essential when giving exact diagnosis and treatment.

Normally, the virus infection could be identified by using commercially available veterinary diagnostic testing kits or molecular biology method (9). The wild birds with various pathogenic bacteria and viruses were communicable to humans (36). The birds that fly a long distance or migrating to several countries had a high possibility of having a variety of pathogenic micro-organisms. The typical infectious virus which could spread to person are Avian influenza (AI), West Nile Virus, and

Paramyxovirus-1 (PMV-1) (13, 50). The migratory raptors also had various internal and external parasites and pathogenic microbes because they could be a vector to spread the disease. The thorough examination and diagnosis, diagnosis of autopsy, and ongoing monitoring during the rescue period were carried out. It would be a great assistance to diagnose birds of prey that were rescued and to prevent the infectious disease in the future.

The purpose of the rescue center is to release the cured raptors. In order to successfully return to the nature, the injured raptors should receive fast treatment and management along with thorough rehabilitation. The selection of appropriate place and an ongoing monitoring were needed before releasing the raptors (22). During the treatment and rehabilitation, the raptors could have respiratory illness, bumble-foot, a parasitic infection, and damage on feather. The careful management should be maintained by both the veterinarians and the rehabilitators before the returning the raptors to the nature.

The natural monument and endangered species are the regional monuments, indigenous species, and contain local character traits. Also, they should be preserved because they have academic, cultural, environmental and scientific values (36). Since, the secondary poisoning and illegal hunting with gun and trap still exist (37), the preventive measure, the systematic management should be need. The ongoing monitoring and management by cooperating with the local government and civil society were carried out and needed to strengthen the regulatory burden.

The trauma, distress and the dead were increasing due to the human activities rather than naturally occurring infectious disease in the overlapping areas between urban periphery and wildlife habitat. It is necessary to improve and develop the surrounding environment for the sake of the wild animals to live along with humans.

5. Conclusion

The raptors that were rescued in the Chungnam Wild Animal Rescue Center were 2 orders, 3 families, 18 species and 1,238 individuals.

1. The registered species as a natural monument were 14 species and 1,120 individuals (90.5%). The endangered species were 11 species and 536 individuals (43.3%).

2. During the period of five years, the high order by seasons according to the quantity of the rescued 503 raptors (40.7%) were shown in the summer.

3. Individuals that rescued in Asan-si (city) among the cities and the counties of Chungnam province were 224 individuals (18.1%). It was the highest ratio according to the regional rescue survey.

4. Depending on survey about the cause of the distress, the collision with electrical wire and buildings, it had 453 individuals (36.6%) as the highest proportion. It was analysed by the diagnosis results that the fractured and the dislocated individuals had 450 individuals (36.3%).

5. According to result after a treatment, the fact that the 690 individuals (55.7%) of the total 1,238 individuals had returned to nature.

The collision with bulidings and electrical wire constituted the most proportion of the causes of distress. The results of diagnosis showed the highest percentage of the fractures and dislocation.

CHAPTER Ⅱ

A Retrospective Study of Fracture and Dislocation of Raptors in Chungnam province: 2014-2018

1. Introduction

Over the past few decades, relatively many wild animal's habitat was decreasing while the city is expanding. As a result, there were more exposure to factors that threatened the safety and the activities of a lot of wild animals (19). The cause of distress were associated with various human activities such as crash and collision with man-made structure. As a result, the fractures and the trauma were frequently observed in most rescued bird of prey (27, 32).

The fractured raptors on the wings or legs still move actively because they are unware of the pain. The fracture site and fragment like a sharp edges tear easily on a soft tissue. As a result, the most open fracture or the compound fracture was confirmed (31, 48). Therefore, there were a lot of the cases of raptors that filed on wildlife center due to fracture and trauma with having a serious injury.

However, so far the elemental data of the fracture and the dislocation of wild raptor rescued in distress in South Korea were not enough and inadequate. Consequently, this study was conducted on 450 raptors diagnosed with fracture and dislocation at Chungnam Wild Animal Rescue Center for five years from January 2014 to December 2018. As using fundamental information of the diagnosed results about 450 individuals with fracture and dislocation, the causes of the distress, fracture location and fracture type were analysed. The analysis of results after treatment were also carried out.

As the analysed and presented results in this study were used, they would become a practical data to provide specific prevention measures for threat factors causing fracture of birds of prey. Concurrently, they would provide as a veterinary basic material for diagnose and treatment of raptor's fracture and dislocation.

2. Materials and methods

1) Animal and basic data

The basic examinations such as physical exams, blood test and radiography about 1,238 individuals of raptors were filed at Chungnam Wild Animal Rescue Center from January 2014 to December 2018. The 450 individuals diagnosed as a fracture and dislocation were classified and analyzed using the results of basic examination on an electronic medical record (intowild, intoCNS). It is based on the basic information of the medical records such a discovered place, characteristics of the place it was found and its conditions at the time it was found. With the gathered information, the causes of the distress per raptor were figured out, recorded, and analyzed. As the fracture and dislocation were identified through the basic check-up in detail, the sites of the fracture through the outer observation, radiogram and palpation was rechecked. Then, the fractured region, existence of the open fracture and the type of fracture were recorded as a data.

In the case of the diagnosis of the fractured individuals, the most appropriate care depending on the state of each individuals were performed. With the individual that was not able to treat or impossible to return to the nature after the treatment, it was decided to be euthanized in a humane way. The results of the treatment and rescue for each individual were also recorded as a data.

2) The causes of fracture and dislocation

The causes of fracture were classed as 6 types such as collision/trauma, orphaned young like the lost nestling without a mother, starvation or exhaustion, suspected toxicosis, entering the building which means the trespassing on another's premises or buildings, and other that means all the rest of it. The cases of collision/trauma among the causes of fracture were divided into 9 types such as collided with building or power line, hit by vehicle, entangled in wires or net, unknown trauma, gunshot, falling, predation, sticky paper trap and leg-hold trap.

3) The anatomical position depending on the fracture and dislocation

The classification about the fracture and dislocation of raptors was carried out with reference to the book of Anatomical and Clinical Radiology of Birds of Prey (40). The region of the fracture and dislocation were roughly classed as thoracic limb, thoracic girdle, pelvic limb and cranium/vertebra. The thoracic limb was departmentalized into 10 parts, the thoracic girdle was departmentalized into 6 parts, the pelvic limb was departmentalized into 7 parts, and the cranium/vertebra was also departmentalized into 7 parts. Then, the fractured and dislocated sites were recorded.

The thoracic limb was classed as humerus, ulna, radius, carpometacarpus and phalanx (the small bones like phalanx, alula, phalanx major and phalanx minor among the phalanx are included). The joints were divided into shoulder joint, elbow joint, carpal joint, metacarpophalangeal joint and interphalangeal joint (Fig. 2.1).

The thoracic girdle was classed as clavicle (furcula), coracoid, scapula, sternum and ribs. The only one joint was classified on its own as sternocoracoidal joint (Fig. 2.2). The pelvic limb was classed as femur, tibiotarsus, tarsometatarsus and digit. The joints were divided into coxofemoral joint, stifle joint, tarsal joint and metatarsophalangeal joint (Fig. 2.3).

The 4 toes that belong to the related bird's toe were classed as 26 parts. However, it is not possible to emphasize the characteristics of the fracture and dislocation, therefore, it will be classified as digit on the record. The cranium was classed as upper beak, lower beak and cranium among the parts of cranium/vertebra. The vertebra was classed as cervical vertebra, thoracic vertebra, synsacrum and caudal vertebrae. With these classifications, the fractured sites were recorded (Fig. 2.4). The bones that were not mentioned above were excluded from the classification.

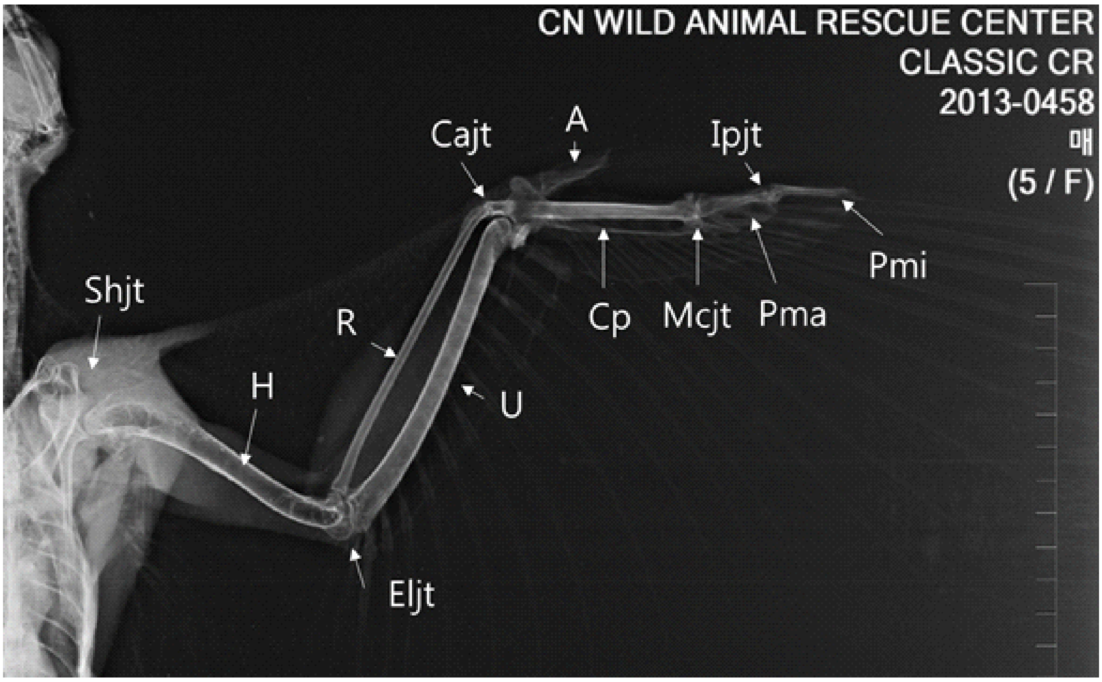

Fig. 2. 1. Ventrodorsal view of the left thoracic limb of the Peregrine falcon (*Falco peregrinus*), 2013-0458. Humerus (H), ulna (U), radius (R), carpometacarpus (Cp), alula (A), phalanx major (Pma), phalanx minor (Pmi), shoulder joint (Shjt), elbow joint (Eljt), carpal joint (Cajt), metacarpophalangeal joint (Mcjt), interphalangeal joint (Ipjt).

Fig. 2. 2. Ventrodorsal view of thoracic girdle of the Peregrine falcon (*Falco peregrinus*), 2013-0458. Coracoid (Cc), furcular (Fu), sternocoracoidal joint (Scjt). scapular (Sc), sternum (St), ribs (Ri).

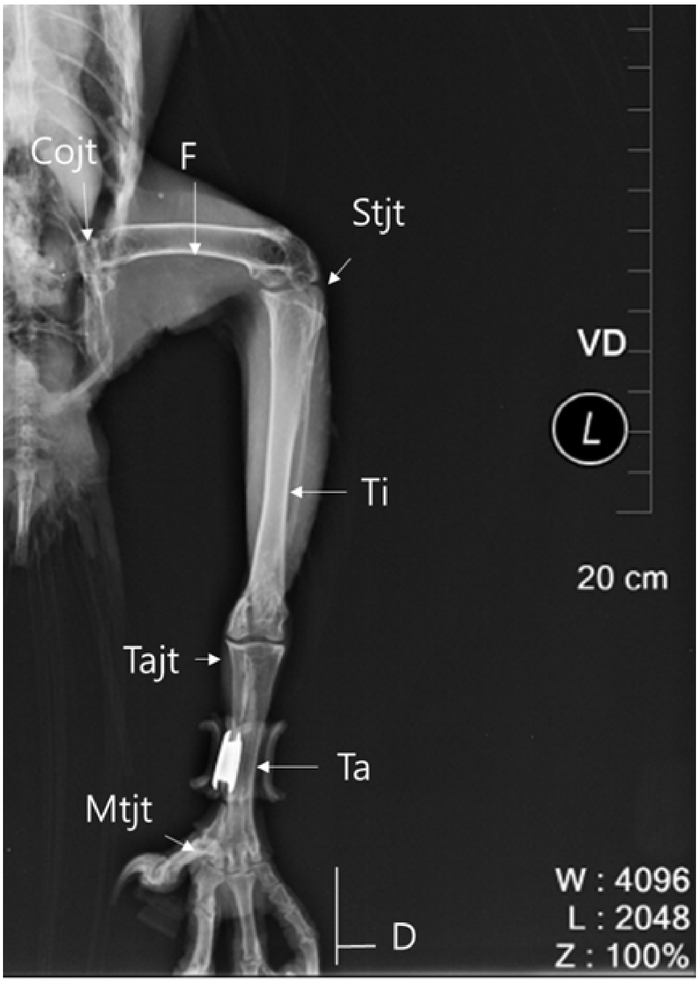

Fig. 2. 3. Ventrodorsal view of pelvic limb of the Peregrine falcon (*Falco peregrinus*), 2013-0458. Femur (F), tibiotarsus (Ti), tarsometatarsus (Ta), digit (D), coxofemoral joint (Cojt), stifle joint (Stjt), tarsal joint (Tajt), metatarsophalangeal joint (Mtjt).

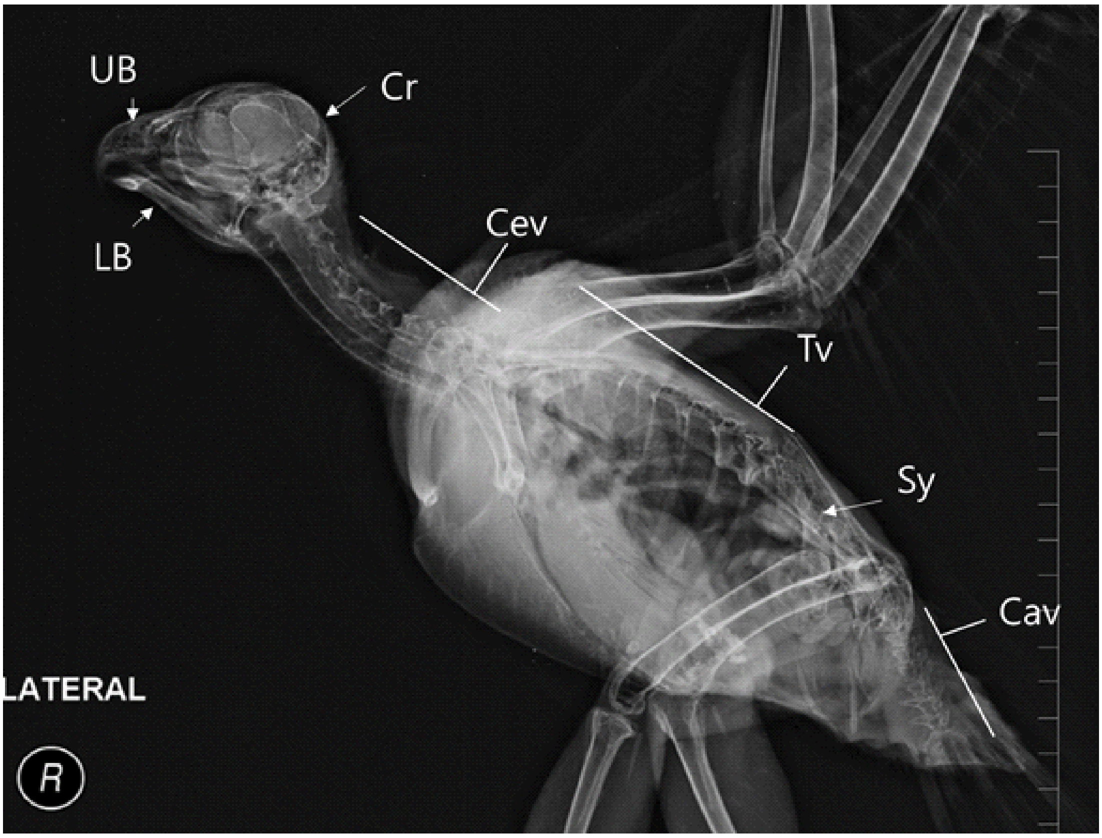

Fig. 2. 4. Lateral right view of the body of the Peregrine falcon (*Falco peregrinus*), 2013-0458. Upper beak (UB), lower beak (LB), cranium (Cr), cervical vertebra (Cev), thoracic vertebra (Tv), synsacrum (Sy), caudal vertebrae (Cav).

4) Classification according to fracture types

The classification according to fracture types, the analysis was carried out with the 7 long bones. The fractured region was divided into thoracic limb and pelvic limb. The thoracic limb was departmentalized as humerus, ulna, radius and carpometacarpus. The pelvic limb was departmentalized as femur, tibiotarsus and tarsometatarsus. They were classed as an open fracture and a closed fracture depending the accompanied with open or closed wound. Each of the 7 long bones were divided into 5 equal parts according to the fracture location of bones. The 1/5 of the bone is the proximal zone, the 5/5 of the bone is the distal zone, and 2/5 till 4/5 of the bone is the diaphysis zone.

The simple fracture is the case with two pieces that were verified by one fracture line. The comminuted fracture is the case with three or more pieces that were verified by the fracture line of two or more. The linear fracture is the case with the cracked bone without any fragments. The segmental fracture is a type of the comminuted fracture. The segmental fracture is a fracture composed of at least two fracture lines that together isolate a segment of bone. The fragments that were less than 1mm was exempt. Therefore, it was classified as a simple fracture. Depending on the fracture plane, it was also classified as transverse, oblique/spiral and longitudinal fractures (Fig 2.5-9).

Fig 2. 5. Ventrodorsal view of the body of the Eurasian buzzard (*Buteo buteo*) 2016-0080. This Eurasian buzzard was admitted with an open, comminuted fracture of the diaphyseal of the right humerus.

Fig 2. 6. Ventrodorsal view of the body of the Northern goshawk (*Accipiter gentilis*) 2015-0869. This Northern goshawk was admitted with a closed, transverse fracture of the diaphyseal of the right radius and ulna.

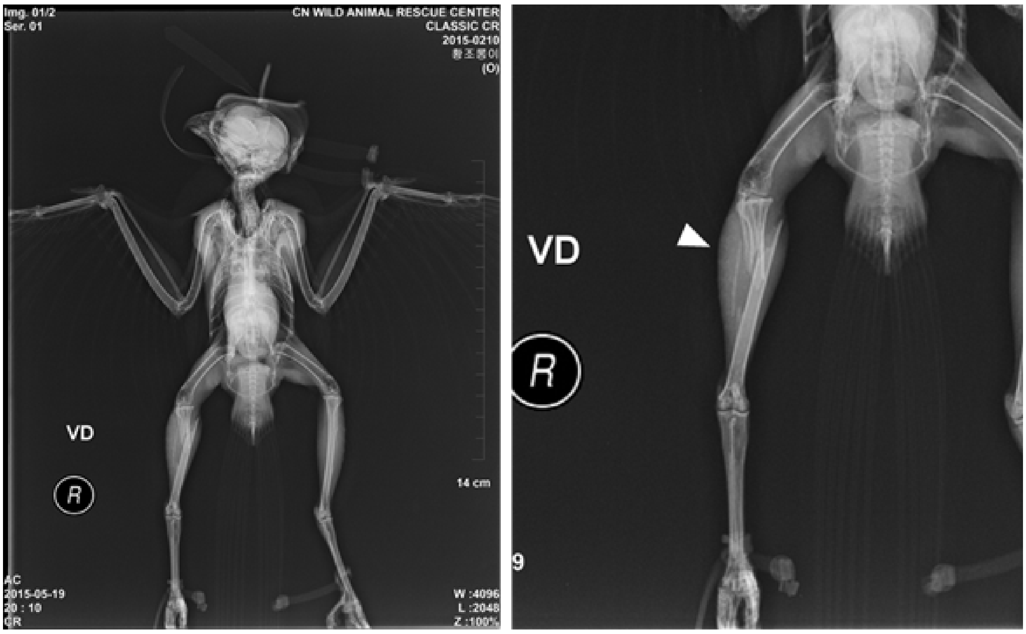

Fig 2. 7. Ventrodorsal view of the body of the Common kestrel (*Falco tinnunculus*) 2015-0210. This Common kestrel was admitted with a closed, oblique/spiral fracture of the proximal of the right tibiotarsus.

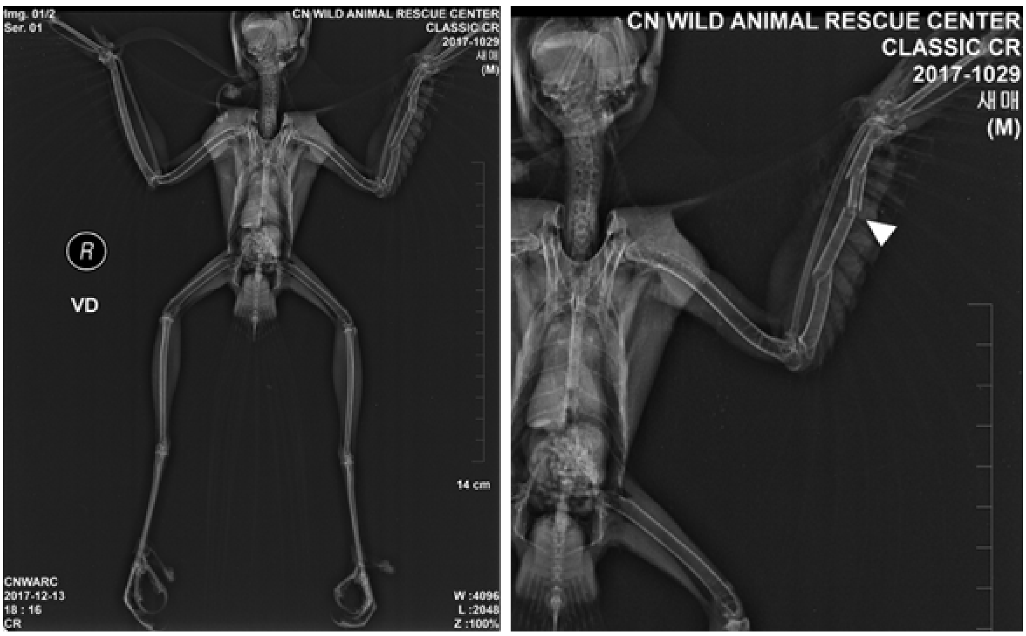

Fig 2. 8. Ventrodorsal view of the body of the Eurasian Sparrow hawk (*Accipiter Nisus*) 2017-1029. This Eurasian Sparrow hawk was admitted with a closed, segmental fracture of the left ulna.

Fig 2. 9. Ventrodorsal view of the body of the Cinereous vulture (*Aegypius Monachus*) 2018-0045. This Cinereous vulture was admitted with a closed, linear fracture of the right ulna.

5) Classification of a clinical category

After the clinical category about 450 individuals rescued as a fracture was classed into 5 steps; category 1 to category 5 with reference to the electronic medical record (intowild, intoCNS). It was classified that the clinical category 2 includes the minor injuries and closed fracture without weight degradation or spiritual oppression. The clinical category 3 included clinical category 2 as well as the infection of fracture sites, certain weight loss and neurological sign and symptom owing to head injury due to open fracture or openness fraction as time passed after closed fracture. The clinical category 4 includes clinical category 3 as well as the respiratory disturbance, extreme starvation (BCS1), loss of nervous reactions due to fracture, or loss on splinters of a bone due to open fracture as time passed after open fracture. The normally diagnosed was categorized in to the clinical category 1. The carcass was categorized as the clinical category 5.

6) Classification of the diagnose and treatment results

The result of the fractured and dislocated raptors that were rescued and treated was classed into 6 items; DOA, Pending for birds and permanent disability, the release of rescued birds/transfer of notification, euthanased, dead, carcass. The carcass was the collected and detected cases in a state of dead in the rescue scene. The DOA was classified as the dead during transfer after rescue, or the dead before active act of medical treatment after arrival at the rescue center, or the dead within a day after basic emergency treatment. The euthanased was euthanasia that was carried out by using medications in a humane way for the ones that were unable to treat or the state that could not be released. Depending on the results of the examination after the arrival and admission at the rescue center, it was classed as the dead indicates the death during the course of treatment and rehabilitation. By December 31st of 2018, there were the still pending birds or classed as permanently disabled. Some of them are transferred to the other institution for the research, education and exhibition purpose on alive condition through the course of treatment and rehabilitation.

3. Results

1) The causes of fracture and dislocation occurrence on raptor species

The physical tests and radiographic inspection were conducted after the admission at wild Animal rescue center. The results of classification about 450 individuals included within 2 orders, 3 families and 18 species (Table 2.1).

The results of analyses in ratio depending on the causes of the fracture occurrence were showed as mentioned below. The fracture individuals are 410 cases (91.1%) due to the causes of collision/trauma.

The collision/trauma which occupied the highest percentage among the causes of the fracture occurrence were classed into 9 types. The cases collided with building or power line occupied the highest percentage by 286 individuals (63.6%), followed by the cases that hit by vehicle were 74 individuals (16.4%) (Table 2.2).

Table 2. 1. Classification of the fracture and dislocation related to the species of raptors admitted to the Chungnam Wild Animal Rescue Center (2014-2018)

Order	Family	Species	Number of Cases	Percentage of Cases
Falconiformes	Accipitridae	Chinese Sparrow hawk (*Accipiter soloensis*)	3	0.7
		Cinereous vulture (*Aegypius monachus*)	21	4.7
		Crested honey buzzard (*Pernis ptilorhynchus*)	1	0.2
		Eurasian buzzard (*Buteo buteo*)	28	6.2
		Eurasian Sparrow hawk (*Accipiter nisus*)	23	5.1
		Japanese Sparrow hawk (*Accipiter gularis*)	4	0.9
		Northern goshawk (*Accipiter gentilis*)	23	5.1
		White-tailed eagle (*Haliaeetus albicila*)	2	0.4
	Falconidae	Common kestrel (*Falco tinnunculus*)	99	22.0
		Eurasian hobby (*Falco subbuteo*)	29	6.4
		Peregrine falcon (*Falco peregrinus*)	6	1.3
Strigiformes	Strigidae	Brown hawk owl (*Ninox scutulata*)	56	12.4
		Collared scops owl (*Otus semitorques*)	5	1.1
		Eurasian eagle owl (*Bubo bubo*)	83	18.4
		Long-eared owl (*Asio otus*)	6	1.3
		Oriental scops owl (*Otus sunia*)	55	12.2
		Short-eared owl (*Asio flammeus*)	1	0.2
		Tawny owl (*Strix aluco*)	5	1.1
Total			450	100.0

Table 2. 2. Causes of the fracture and luxation of rescued raptors admitted to the Chungnam Wild Animal Rescue Center (2014-2018)

Condition		Number of Cases	Percentage of Cases
Collision/ Trauma	Collided with Building or power line	286	63.6
	Hit by vehicle	74	16.4
	Entangled in wires or net	12	2.7
	Gunshot	12	2.7
	Unknown trauma	10	2.2
	Leg-hold trap	8	1.8
	Falling	4	0.9
	Predation	3	0.7
	Sticky paper trap	1	0.2
Total		410	91.1
Orphaned young		20	4.4
Starvation or exhaustion		5	1.1
Entering the buliding		5	1.1
Suspected Toxicosis		2	0.4
Other		8	1.8
Total		450	100.0

2) The result of the anatomical position depending on the fracture and dislocation

After diagnosing 450 individuals that were fractured and dislocated, there were the total of 701 cases. The 636 cases (90.7%) were identified as the fracture and 65 cases (9.3%) were identified as the dislocation. The fracture on the thoracic limb had the highest number of 370 cases (52.8%) in total as shown in the table 2.3.

The fractured humerus was comprised high percentage of the cases as 151 cases (40.8%) among 370 cases of fracture of thoracic limb. The fractured ulna was 95 cases (25.7%) as shown in the table 2.4. The fractured tibiotarsus was comprised high percentage of the individuals as 34 cases (39.1%) among the 87 cases of the fractured pelvic limb. The fractured femur was 21 cases (24.1%) as shown in the table 2.5. The fractured coracoid was comprised high percentage of 50 cases (36.0%) among the 139 cases of the fractured thoracic girdle. The fractured clavicle was 46 cases (33.1%) as shown in the table 2.6.

The fractured thoracic vertebra was 20 cases (50.0%) among the 40 cases of the fractured cranium/vertebra. The fractured synsacrum was 6 cases (15%) as shown in the table 2.7.

The sternocoracoidal joint dislocation was 19 cases among the 65 cases of the verified dislocation. The elbow joint dislocation was 17 cases (26.2%). The carpal joint dislocation was 8 cases (12.3%) as shown in the table 2.8.

Table 2. 3. Distribution of fractures and dislocations by location

Trauma Location	Condition		Number of Cases (%)
	Fracture (%)	Luxation (%)	
Thoracic Limb	370 (52.8)	35 (5.0)	405 (57.8)
Thoracic Girdle	139 (19.8)	19 (2.7)	158 (22.5)
Pelvic Limb	87 (12.4)	11 (1.6)	98 (14.0)
Cranium/Vertebra	40 (5.7)	0 (0.0)	40 (5.7)
Total	636 (90.7)	65 (9.3)	701 (100.0)

Table 2. 4. Distribution of thoracic limb fractures

Fracture		Falconiformes (%)	Strigiformes (%)	Number of cases	Percentage of Cases
Thoracic Limb	Humerus	70 (18.9)	81 (21.9)	151	40.8
	Radius	45 (12.2)	37 (10.0)	82	22.2
	Ulna	52 (14.1)	43 (11.6)	95	25.7
	Carpometacarpus	28 (7.6)	12 (3.2)	40	10.8
	Phalanx	0 (0.0)	2 (0.5)	2	0.5
Total		195 (52.7)	175 (47.3)	370	100.0

Table 2. 5. Distribution of pelvic limb fractures

Fracture		Falconiformes (%)	Strigiformes (%)	Number of cases	Percentage of Cases
Pelvic Limb	Femur	12 (13.8)	9 (10.3)	21	24.1
	Tibiotarsus	10 (11.5)	24 (27.6)	34	39.1
	Tarsometatarsus	9 (10.3)	12 (13.8)	21	24.1
	digit	0 (0.0)	11 (12.6)	11	12.6
Total		31 (35.6)	56 (64.4)	87	100.0

Table 2. 6. Distribution of thoracic girdle fractures

Fracture		Falconiformes (%)	Strigiformes (%)	Number of cases	Percentage of Cases
Thoracic Girdle	Furcula	29 (20.9)	17 (12.2)	46	33.1
	Coracoid	30 (21.6)	20 (14.4)	50	36.0
	Scapula	7 (5.0)	13 (9.4)	20	14.4
	Sternum	9 (6.5)	3 (2.2)	12	8.6
	Ribs	2 (1.4)	9 (6.5)	11	7.9
Total		77 (55.4)	62 (44.6)	139	100.0

Table 2. 7. Distribution of cranium and vertebra fractures

Fracture		Falconiformes (%)	Strigiformes (%)	Number of cases	Percentage of Cases
Cranium/ Vertebra	Upper Beak	3 (7.5)	2 (5.0)	5	12.5
	Lower Beak	2 (5.0)	2 (5.0)	4	10.0
	Cranium	0 (0.0)	3 (7.5)	3	7.5
	Cervical Vert[a]	1 (2.5)	0 (0.0)	1	2.5
	Thoracic Vert	10 (25.0)	10 (25.5)	20	50.0
	Synsacrum	1 (2.5)	5 (12.5)	6	15.0
	Caudal Vert	1 (2.5)	0 (0.0)	1	2.5
Total		18 (45.0)	22 (55.0)	40	100.0

[a]Vert : Vertebra

Table 2. 8. Distribution of dislocations by location

Dislocation		Falconiformes (%)	Strigiformes (%)	Number of cases	Percentage of Cases
Thoracic Limb	Shoulder jt[a]	3 (4.6)	1 (1.5)	4	6.2
	Elbow jt	9 (13.8)	8 (12.3)	17	26.2
	Carpal jt	5 (7.7)	3 (4.6)	8	12.3
	Metacarpophalangeal jt	2 (3.1)	3 (4.6)	5	7.7
	Interphalangeal jt	1 (1.5)	0 (0.0)	1	1.5
Thoracic Girdle	Sternocoracoidal jt	9 (13.8)	10 (15.4)	19	29.2
Pelvic Limb	Coxofemoral jt	1 (1.5)	0 (0.0)	1	1.5
	Stifle jt	2 (3.1)	5 (7.7)	7	10.8
	Tarsal jt	1 (1.5)	1 (1.5)	2	3.1
	Metatarsophalangeal jt	0 (0.0)	1 (1.5)	1	1.5
Total		33 (50.8)	32 (49.2)	65	100.0

[a]jt : Joint

3) The fracture types for the raptors

Depending on the fracture types for the raptors, about 7 relatively long-bones were classified. The thoracic limb was classed as humerus, ulna, radius and carpometacarpus. The pelvic limb was classed as femur, tibiotarsus and tarsometatarsus. The 444 cases of the fracture on the 7 long bones were classified and analyzed.

The open fracture was 207 cases (46.6%) depending on open and closed wound. It was comprised of the cases that were relatively less than the closed fracture with 237 cases (53.4%). On the other hand, the humerus had the highest number of cases on open fracture by 94 cases (21.2%) and 57 cases (12.8%) were closed fracture (Table 2.9).

The fracture location of the fractured bone was divided into; the proximal zone with 127 cases (28.6%), the diaphysis zone with 243 cases (54.7%), and distal zone with 74 cases (16.7%). However, the fracture zone of fractured carpometacarpus has the highest proximal zone with 15 cases (3.4%) (Table 2.10).

According to the results of the analysis depending on the number of splinters of a bone of fracture location, the simple fracture was 266 cases (59.9%) and the comminuted fracture was 154 cases (34.7%) (table 2.11).

Table 2. 9. Distribution of open or closed fracture by location

Fracture site	Numer of Fracture Condition		Number of Cases (%)
	Open Fracture (%)	Closed Fracture (%)	
Humerus	94 (21.2)	57 (12.8)	151 (34.0)
Radius	37 (8.3)	45 (10.1)	82 (18.5)
Ulna	35 (7.9)	60 (13.5)	95 (21.4)
Carpometacarpus	22 (5.0)	18 (4.1)	40 (9.0)
Femur	2 (0.5)	19 (4.3)	21 (4.7)
Tibiotarsus	4 (0.9)	30 (6.8)	34 (7.7)
Tarsometatarsus	13 (2.9)	8 (1.8)	21 (4.7)
Total	207 (46.6)	237 (53.4)	444 (100.0)

Table 2. 10. Distribution according to fracture zone of fractured bones

Fracture site	Number of Fracture Zone (%)			Number of Cases (%)
	Proximal	Diaphysis	Distal	
Humerus	35 (7.9)	82 (18.5)	34 (7.7)	151 (34.0)
Radius	35 (7.9)	41 (9.2)	6 (1.4)	82 (18.5)
Ulna	26 (5.9)	60 (13.5)	9 (2.0)	95 (21.4)
Carpometacarpus	15 (3.4)	13 (2.9)	12 (2.7)	40 (9.0)
Femur	6 (1.4)	10 (2.3)	5 (1.1)	21 (4.7)
Tibiotarsus	8 (1.8)	21 (4.7)	5 (1.1)	34 (7.7)
Tarsometatarsus	2 (0.5)	16 (3.6)	3 (0.7)	21 (4.7)
Total	127 (28.6)	243 (54.7)	74 (16.7)	444 (100.0)

Table 2. 11. Distribution of seven long-bone fracture type

Fracture Site	Fracture Type (%)					Number of Cases (%)
	Simple Fracture		Comminuted Fracture	Linear Fracture	Segmental Fracture	
	Transverse Fracture	Oblique/ Spiral Fracture				
Humerus	44 (9.9)	37 (8.3)	63 (14.2)	0 (0.0)	7 (1.6)	151 (34.0)
Radius	51 (11.5)	5 (1.1)	24 (5.4)	0 (0.0)	2 (0.5)	82 (18.5)
Ulna	26 (5.9)	22 (4.9)	33 (7.4)	1 (0.2)	13 (2.9)	95 (21.4)
Carpometacarpus	14 (3.1)	11 (2.5)	15 (3.4)	0 (0.0)	0 (0.0)	40 (9.0)
Femur	13 (2.9)	4 (0.9)	4 (0.9)	0 (0.0)	0 (0.0)	21 (4.7)
Tibiotarsus	20 (4.5)	6 (1.4)	7 (1.6)	1 (0.2)	0 (0.0)	34 (7.7)
Tarsometatarsus	10 (2.3)	3 (0.7)	8 (1.8)	0 (0.0)	0 (0.0)	21 (4.7)
Total	178 (40.1)	88 (19.8)	154 (34.7)	2 (0.5)	22 (5.0)	444 (100.0)

4) The clinical category types of raptors

The clinical category types about 450 individuals of the fracture to be diagnosed were classed roughly into 5 types as arranged in the table 2.12. As a result, the clinical category 4 was the highest by 204 cases (45.3%).

Table 2. 12. Distribution of clinical category

Clinical Category	Number of Cases	Percentage of Cases
1	0	0.0
2	140	31.1
3	94	20.9
4	204	45.3
5	12	2.7
Total	450	100.0

5) The results of the medical treatment on the fracture and dislocation

The results of treatment that were obtained through the surgery and treated after the diagnosis of fracture and dislocation were classified and summarized on December 31st 2018 (table 2.13).

The euthanasia was performed to those that was impossible to be treated or was not able to return to the nature after the medical treatment. It was the highest percentage by 199 individuals (44.2%). The release/transfer of notification was 139 individuals (30.9%).

Table 2. 13. Results of fractures and dislocated raptors treated at Chungnam Wild Animal Rescue Center during 2014-2018

Results	Number of Cases	Percentage of Cases
Euthanased	199	44.2
Released/ Transfer	139	30.9
Died	58	12.9
DOA[a]	34	7.5
Carcass	12	2.7
Captive/ Permanent disability	8	1.8
Total	450	100.0

[a]DOA: Dead on Arrival

4. Discussion

According to the analyzed results in this study done in Chungnam Wild Animal Rescue Center, the collision of the buildings/electric wire was the main cause of the fractured raptors. The second most cause of the fractured raptors as the collision with vehicle. In other similar papers, the case on the collision with the vehicle among the causes of fracture occurrence for the raptors had shown a large quantity (14, 38). The gunshot wound, wounded by a trap, bitten by a dog as had the different causes of fracture occurrence (51). The poaching like the gunshot wound and being caught in a trap among the causes of the fracture occurrence for the raptors was also included in this study. The cause of the fractured raptors could have a difference compared to other studies, this study was mainly caused by human activities either directly or indirectly (27).

It was necessary to run a basic physical test and image examination in order to diagnose fracture. Also much stress due to other trauma in the case rescued raptors, the fracture assessment must be carried out after a long resting the rescued individuals (7, 19). The radiography was conducted after the visual inspection on the state of the wings or legs in general. If any unusual image was seen in the radiograph, the visual inspection and palpation must be checked again.

While conducting x-ray, keeping both the wings and legs symmetrical is the most important step. The radiograph had to be taken at two directions, VD (Ventrodorsal view) and LAT (Lateral view), in order to get more detailed and accurate diagnosis (3). Palpating from proximal to distal direction, the fracture or dislocation, or the damaged soft tissue were needed to be verified.

Carrying out first aid was crucial before medical treatment. However, finding and selecting the suitable treatment for depending the state of the individuals was important as well. The rescued raptors that received a lot of mental stress and serious trauma had to be in a stable state. To prevent the infection in the trauma of the fractured region, it was necessary to clean the wound carefully. In the case of the open fracture, the bone fragments that were sticking out of the skin should be tucked back into the skin after cleaning the wound and also temporary suture should be done to prevent being infected (17). To alleviate pain of the fractured and trauma, analgesic should be administered by injection. To prevent bacterial infection and prophylaxis, the injection of the antibiotics was recommended. The figure-of-eight bandage should be implemented and maintained before the surgery to prevent the damage on the soft-tissue around the fracture and severely dislocated.

The 450 individuals were diagnosed as fracture and dislocation, but the number of fractured and dislocated of 701 cases was verified. The fact that the fracture occurred much more by 636 cases (90.7%) than the dislocation that occurred by 65 cases (9.3%) was confirmed. The estimation of performing the fracture and dislocation occurred more than one site due to various causes. In the evaluation of the other research, the fractured wings of the 542 wild birds was 81.5% (3). The results of this study had 405 cases (57.8%) on fractured and dislocated wing.

Among the case of the fractured wild birds in Healesville Sanctuary, there was 10% of the fractured coracoid (17). In this study, the fractured coracoid occurred commonly by 7.1% of the total 701 cases. The fractured coracoid occurred as the thorax collided with the solid object such as the walls, windows, and vehicle (8, 31, 44). The dislocation of the sternocoracoidal joint was the most common by 19 cases (29.2%) among the total dislocation of 65 cases. The dislocation of elbow joint was analyzed to be the second most by 17 cases (26.2%). Within the elbow joint, the fractured radius had 8 cases, which is 47.1% of the total dislocation of the elbow joint. Although the dislocation of the elbow joint did not occur often, the prognosis was not good after medical treatment (1, 7). The elbow joint is covered with a thin and mitis joint membrane and it is surrounded by very small amount of muscle (7). There is one of the joints that plays an important role when spreading the wings during a flight because it surrounds the end of the humerus, radius, and ulna. It is common for ulna to have the dislocation on the back of the elbow joint (31). Even if returning and attaching the dislocation region, the prognosis is often not satisfactory due to the ankylosis. The causes of the fracture or dislocation were mostly collision and trauma. Generally, the fractured and dislocated wings and the chest was relatively common due to the impact of in-flight collision.

According to the classification of the fractured region of 31 individuals in other research on the fractured raptors, the fracture on the humerus was analyzed to be more frequent and than radius and ulna (45). In another research, the fractured long bone of the 28 raptors was analyzed the fracture on the ulna was more frequent than the humerus and radius (51). However, in this study, the most frequent dislocation and fracture occurred on the humerus followed by ulna and radius in order. There were 82 cases of the fractured radius, 95 cases of the fractured ulna, and 43 cases (about 50%) on the fractured radius and ulna at the same time. To sum up the results and information from the researches, the differences were the number of individuals, flight characteristics of diverse species, and the relative ration of man-made artificial structures of the rescued region.

Typically, the fractured humerus of the raptors occurred often. The fracture on 2/3 distal part of the humerus occurred often because the soft tissue is relatively lacking (7, 45). In this study, depending on the results of the diagnose on the fracture, the fractured humerus mostly occurred at the diaphysis. The fracture ratio of the proximal and distal was almost similar. Because of the influence of deep pectoral muscles and pectoral muscles attached to pectoral crest that existed to proximal in case of humerus fracture, the proximal of fracture was turned medially and the distal of fracture was laterally pulled upward by the effects of the biceps muscle (19, 26, 31). As a result, the open fracture commonly occurred below the middle parts where the soft-tissue of humerus was relatively lacking. The open fracture of the proximal humerus mostly occurs dorsally. On the other hand, the open fracture of the distal humerus mostly occurs ventrally on the relatively thin skin (3, 45). Owing to passing from the sides of the abdomen of medianoulnar nerve (the middle of Ulnar nerve), and diagonally over the edge of the back of humerus of radial nerve. In case of the fractured humerus, neurotmesis or neurological damage due to open fracture (3). As a result, a lot of cases had relatively bad prognosis when compared to the fracture on the other site.

Both of the open and comminuted fractures were frequently observed as the fracture of the wild birds (2). However, according to the results of the analyses of the open or closed fracture on humerus, radius, ulna, carpometacarpus, femur, tibiotarsus and tarsometatarsus, the closed fractures relatively occurred more than the open fracture on the bones except humerus. While the open fracture relatively occurred more than the closed fracture in humerus.

For the raptors that were not able to stand even though the fractured pelvic limb could not be found could be due to the fractured spine or neurological damage by the head trauma (concussion) causing paralysis. It was difficult to identify the fracture accurately just by radiograph in the case fracture on the spine or the synsacrum (48). Therefore, if the spinal fractures were not exactly identified on the radiograph, it was necessary to treat as a concussion. In this study, the fractures of the thoracic vertebrae were identified the most as a 20 cases (50.0%) among the 40 cases of the fracture of the head and the spine. Falconiformes has notarium where a part of the thoracic vertebrae was conglutinated. In between notarium and synsacrum, there is two intervertebral joints (3). As a result, the existence of fractured thoracic spine on the rescued individuals were verified in the vertebrae in between notarium and synsacrum.

The clinical assessment with accurate damage estimation was carried out on the injured individual before proceeding treatments and surgeries after conducting the basic examination for each of the rescued raptors with broken bones. And the individuals that seemed possible to conduct the surgery and the treatment almost included mostly in clinical category 2 or 3. Therefore, it was important to treat accordingly. Selecting the appropriate materials for medical treatment is important when conducting the surgery (28). For the individuals that were not able to be treated, they were euthanized because they were not able to be released or recover.

The 204 individuals (45.3%) among the individuals diagnosed as a fracture were classed most as a clinical category 4. Most of the individuals that fall into this category were because of the state of severe starvation along with the open fracture, or because a long time had passed after the open fracture causing the skin tissue necrosis, or many individuals that could not take the surgery due to the fracture causing neurotmesis and damaged nerve. Typically, raptors could live quite a long time by a few weeks or months at a state of trauma like the broken wings (45). Therefore, the most cases of the treatment on the fractured individuals that were discovered and rescued after a long time could not be treated.

The dead during the surgical procedure or after the surgery because of the other severe trauma or an internal injury except the fractured site occurred frequently. In addition, the case that diaclasia occurred due to the accidents in the rehabilitation space of the rescue center in spite of succeeding the surgery. The rate of the release of the captive raptors that were diagnosed as a fracture was 139 individuals (30.9%).

Accurate diagnosis must be completed for the treatment and performing surgery. The course of treatment was also very important for wounded individuals to return to the nature completely. During the treatment, any faults in the region of the fractures or formation of the callus should be observed by conducting radiographic inspection. The physical therapy at the proper time must be carried out during the customized rehabilitation to the state when the raptors could be released back to the nature. Also if the physical therapy or rehabilitation training was not carried out in time, the raptors could be delayed or could not be released back to the nature.

The 450 individuals (36.3%) of the 1,238 individuals were admitted as a severe trauma like fracture at wild Animals Rescue Center for 5 years from 2014 to 2018. The distress was mostly caused by human activity such as collision with the building/electrical wire or vehicle. As the result of this study, there was an opportunity to consider again about the causes of the fractured raptors. Having the opportunity to establish to protect and reduce the number of the fractured raptors. It would be helpful to make a coexisting environment between the raptors and humans.

Based on the medical record of the fractured and dislocated raptors, the results related to the various fracture such as the site, type, and ratio of the fractured and dislocated raptor would be used as an excellent basic data for the treatment.

5. Conclusion

The treatment results and the classification of the fracture types, sites, and conditions of 450 individuals were analyzed.

1. A Common Kestrel (*Falco tinnunculus*) had the highest number of the individuals that were diagnosed as a fracture. The individuals had 99 cases that indicated the 22.0% of the 450 individuals.

2. The collision with the building/the electrical wire was the main cause of the fracture and dislocation by 286 cases (63.6%).

3. Within the total 701 cases of the fracture and dislocation, the fracture and dislocation on the wings was by 405 cases (57.8%). Within the fracture and dislocation on the wings, the fractured humerus was the highest rate by 151 cases (40.8%).

4. Based on the results of the rescued fractured individuals, the number of euthanasia individuals were the highest by 199 cases (44.2%). The release of the successful treatment were 139 cases (30.9%).

The fracture and the dislocation occurred most common in the thoracic limb. The humerus of the thoracic limb had the highest number of the fractures.

CHAPTER Ⅲ

A Retrospective Study of Medical and Surgical treatment of Raptors in Chungnam province: 2014-2018

1. Introduction

Over the last few decades, wildlife habitat has been declining relatively as human activity increased due to rapid urbanization. As a result, most wildlife activity space was exposed to threats (19, 24). It was common to see the fact that many raptors were rescued with broken bones. Many raptors were distressed by collision with artificial manmade structures such as vehicles, building windows, electric wires and soundproof walls (26, 51).

Unlike mammals, birds have both pneumatic bone and fusion bone that are light and strong. Birds also have a unique skeletal system suitable for flight (3, 24, 48). In addition, it is easily broken by impact because cortex is thin and calcium content density is relatively high. And so iatrogenic fracture is more likely to occur during orthopedic surgery (24). For this reason, it is positively necessary to seek the treatment method different from general mammals (49).

There were various treatments for the fractured birds of prey as mentioned below. For the treatment of fracture, there are surgical methods such as Tie-in Fixator (TIF), Intramedully (IM) pin, cross pin, wire and intramedullary shuttle pin. In addition, there are non-invasive methods of treatment using the figure of eight bandage or splint (15, 20, 31). When treating the fractured individuals, the appropriate treatment and surgical methods should be selected by considering; the size and physical condition of the individual, the site of the fracture, the location (zone) of the fracture, the condition of the fracture, the type of fracture and the time after the fracture (7). However, even if the wild raptors were rescued after the fracture due to various causes, the wildlife rescue center or wildlife related organization did not have sufficient data and appropriate information on the case. The data of the fracture treatment or orthopedic surgery for the domestic inhabiting raptors was limited as well.

Therefore, in this study, basic physical examinations were conducted for 2 orders, 3 families, 18 species and 1,238 individuals admitted to Chungnam Wild Animal Rescue Center for 5 years from January 2014 to December 2018. And the clinical records based on the basic information of 450 individuals diagnosed with fracture and dislocation were analyzed. And the causes of euthanasia were also analyzed for 155 individuals among the 201 individuals that could not be treated. The state of the fracture and dislocation, the surgery treatment, the union period of the fracture site and the outcome of the treatment were analyzed for 249 individuals. The results of this study would be used as a basic data to provide the veterinary clinical data necessary for surgery and treatment for raptor fractures.

2. Materials and methods

1) Animal and basic data

Performing the basic physical examination about 1,238 individuals for birds of prey admitted in Chungnam Wild Animal Rescue Center for 5 years from January 2014 to December 2018, the medical records of 450 individuals diagnosed as the fracture and dislocations among 1,238 individuals were analyzed. The 201 individuals who could not be medically treated were classified as euthanasia, DOA and carcass. Euthanasia was performed in accordance with experimental animal ethical standards in cases of euthanasia. And the reason of euthanasia were classified and summarized.

Using the basic information of the medical records of 249 individuals with the treatable fracture, a variety of things such as the fracture, fracture site, presence of open fracture, fracture type, presence of dislocation and BCS were recorded and the data of those were made. Based on the records of medical data, the clinical state of the fracture site was scored.

Depending on the physical condition of each individual, appropriate surgical procedures or methods of treatment were selected at the most appropriate time. The ET tube used in first-aids or respiratory anesthesia, the type and size of the pins used in the medical operation, the surgery technique and treatment methods used for the medical operation, the duration of the union and the treatment results were recorded in detail and documented. All of them listed as data.

2) Classification of individuals diagnosed with treatable fracture and dislocation

In order to evaluate the possibility of the treatment for the 450 individuals diagnosed with fracture and dislocation, the state of soft tissue of fracture region, the time after fracture, types of fracture through radiography, loss of bone fragment, palpation and pain response were accurately checked. If it was also impossible to return to nature even though it was possible to treat it, euthanasia was performed in accordance with experimental animal ethical standards. And the reasons of euthanasia were classified and listed as a data. In the cases of the dead during the course of treatment or rehabilitation are classified as dead, individuals in the process of treatment or permanent disability were classified as captive based on the criteria of December 31st 2018.

3) Classification according to the anatomical location of fracture and dislocation

The fractured parts were classified into four parts as thoracic limb, pelvic limb, thoracic girdle and other sites. In the case of individuals diagnosed with fracture, there were often more than one fracture, because of this, thoracic limb, pelvic limb, thoracic girdle and other sites were classified in order of importance avoiding duplication count. The thoracic limb portion was divided into six parts such as the humerus, the humerus with other sites, the radius, the radius with other sites, the ulna with other sites and the carpometacarpus with other sites. The pelvic limb portion was divided into two parts; the femur with other sites and the tibiotarsus with other sites. The thoracic girdle region was divided into three categories, that is, the coracoid with other sites, the furcula with other sites and the scapular with other sites. The other sites were classified as those that contained beak, sternum, ribs and vertebrae except for the duplication as was stated above. Dislocations were summarized regardless of location.

4) Clinical condition score of fracture state

The clinical condition of the fractures and dislocations about 249 individuals diagnosed with the fracture and luxation were scored as follows; each individual was given by 1 score respectively after classing as those that contained items such as the number of dislocations and fractures, open fracture, comminuted or segmental fracture, fracture of proximal or distal, over time after fracture, and body condition score.

After the site of the fracture was divided into 5 parts, the 1/5 part was defined as the proximal part and the 5/5 part was defined as the distal part. Depending on 7 fracture regions such as humerus, radius, ulna, carpometacarpus, femur, tibiotarsus and tarsometatarsus, the locations of fracture were decided. The other fractures except mentioned above were excluded because they could not be accurately identified. The clinical condition scores were used to score the state for the fracture and dislocation. The other diseases except the fracture and dislocation, intoxication and concussion were excluded from the clinical condition score of the fracture site.

Depending on the number of the fractures and dislocation, an additional 1 score was added in the clinical score. If there were 2 fractured sites in a raptor, the score was designated as 2 scores. If there were 2 fractured sites and 1 dislocation in a raptor, the score was designated as 3 scores.

One score was added in the clinical score if the fracture status was an open fracture, and any scores were not added in the clinical score if it was confirmed to be a closed fracture.

If the type of fracture was the comminuted fracture or segmental fracture, an additional 1 score was added in the clinical score depending on the number of the fractures. If there was 1 simple fracture and 1 comminuted fracture in a raptor, an additional score was added in the clinical score.

One score was added in the clinical score to the distal and proximal parts according to the fractured zone. However, no score was added for fractured diaphysis. The scoring was performed on the 7 long bones where the fracture site could be identified. An additional score was added in the clinical score depending on the number of fractures after the fracture occurred.

An additional score was added in the clinical score depending on the number of fractures in case over time after the fracture occurred. If two fractures were found in a raptor, 2 scores were added in the clinical score in case the over time after the fracture occurred. The criterion for determining the over time was determined by discoloration of the protruding bone and discoloration of the skin tissue around the fracture site in the case of open fracture. Euthanasia excluded because it was impossible to treat the bone tissue necrosis or skin necrosis around the fracture site in process of a long time after the open fracture.

If the BCS were 1, 1 score was added in the clinical score. The BCS was an indirect measure of an individual's health status and the BCS was an important indicator during the surgery. The BCS was divided into five stages and the BCS 1 meant the condition of a severe starvation.

Table 3. 1. Classification of clinical condition scoring for fracture site

Classification	Standard	Point
Site	fracture, dislocation	add the number of fracture and dislocation
Condition	open fracture, open dislocation	add the number of fracture and dislocation
Type	comminuted fracture, segmental fracture	add the number of comminuted and segmental fracture
Zone	proximal zone, distal zone	add the number of proximal and distal zone
BCS	BCS1	add 1 point
Time	over time after fracture	add the number of fracture and dislocation

5) Classification of treatment according to fracture site

In the 249 individuals diagnosed with the fracture and dislocation, there were about 192 raptors including the fractured site where surgical treatment was possible. Based on the medical records of 187 individuals among the 192 individuals except 5 individuals that were died before treatment or surgery, the surgical operation and treatment were divided into 8 sections. The 8 sections of fracture site were as follows; humerus, radius, ulna, carpometacarpus, femur, tibiotarsus, tarsometatarsus and coracoid.

The surgery was performed at the appropriate time according to the physical condition of the individual. The surgical procedure was carried out by selecting the best right way according to the physical features of the individual and the condition of the fracture site. The surgical procedures were classified into surgery method such as TIF, TIF with wire, IM pin, IM pin with wire, Type1, Type1 with wire, Type2, cross pin, cross pin with External Skeletal Fixator (ESF), wire (Cerclage wire or Figure of eight wire) and shuttle pin. The non-invasive methods were categorized, including the use of the figure of eight bandage or splint. In all of the treatments of the thoracic region, the figure of eight bandage was used. The treatment was performed using only bands that is called the figure of eight bandage and it was categorized as the type of figure of eight bandage.

6) Classification depending on union period of fracture site

The union period was analyzed about 147 individuals that had been confirmed the union of the fracture site after the fracture surgery or treatment. In the case of the surgically treated individual, radiographs were taken at regular intervals after the medical operation. Then, the degree of union of the fracture site was read and the pin was removed.

In the case of individuals performed treatments with figure of eight bandage or splint, the bandage or the splint was removed after confirming that there was no any movability during radiography reading and palpation. Since the beginning of surgery or treatment, the period of removal of the pin or bandage was summarized by means of the mean and the standard deviation using Excel (Microsoft Excle, USA). The union of the fractured sites were divided into 10 bones such as humerus, radius, ulna, carpometacarpus, femoris, tibiotarsus, tarsometatarsus, coracoid, furcula and scapula.

7) Classification of the results of treatments

The results of the fracture and dislocation treated 249 individuals were classed into four items like released, died, euthanased and captive/permanent disability.

To return to the nature after the rehabilitation process after rescue and admission of wounded individuals was called released. The dead that died at the wild Animal Rescue Center during treatment and rehabilitation process was called died. It was difficult or impossible to perform treatment in view of its condition depending on the results of the diagnosis and treatment, or their state are beyond natural come back, or, the case that it was impossible to return to nature due to having a problem in flight or action during rehabilitation process was regarded as euthanased, administering euthanasia under humanitarian.

Individuals in the process of treatment as of December 31^{st} 2018 were classed as captive. The cases that was impossible to return of the nature due to the disability and continuously stay in bird cage during the long-term period with a view to research and educational object were classed as permanent disability.

3. Results

1) Classification of diagnosis results of fracture and dislocation for raptors

Among 450 raptors diagnosed with fractures by basic physical examination, 249 individuals (55.3%) that were considered to be treatable were identified. The 201 individuals (44.7%) that were considered not able to treat and impossible to treat (table 3.1).

Euthanasia was assessed carefully after reconfirmation of the state of individual in case of euthanasia of the object. Euthanasia was then performed in humanitarian way. The causes occurred in euthanasia of the object were classified into nerve, bone, joint and soft tissues. The most common cause of occurrence on euthanasia was nerve damage of 73 individuals (47.1%) (Table 3.2).

It was generally impossible to know the exact reason of the occurred DOA within 24 hours of its arrival at the wildlife rescue center and the carcass confirmed in the field. In these cases, it was excluded from the study.

Table 3. 2. Classification of 450 individuals diagnosed with fracture and luxation

Order	Family	Species	Treatment (%)	Euthanased (%)	DOA (%)	Carcass (%)	Total (%)
Falconiformes	Accipitridae	Chinese Sparrow hawk (*Accipiter soloensis*)	1(0.2)	1(0.2)	0(0.0)	1(0.2)	3(0.7)
		Cinereous vulture (*Aegypius monachus*)	11(2.4)	10(2.2)	0(0.0)	0(0.0)	21(4.7)
		Crested honey buzzard (*Pernis ptilorhynchus*)	1(0.2)	0(0.0)	0(0.0)	0(0.0)	1(0.2)
		Eurasian buzzard (*Buteo buteo*)	13(2.9)	13(2.9)	1(0.2)	1(0.2)	28(6.2)
		Eurasian Sparrow hawk (*Accipiter nisus*)	15(3.3)	2(0.4)	4(0.9)	2(0.4)	23(5.1)
		Japanese Sparrow hawk (*Accipiter gularis*)	3(0.7)	1(0.2)	0(0.0)	0(0.0)	4(0.9)
		Northern goshawk (*Accipiter gentilis*)	17(3.8)	5(1.1)	1(0.2)	0(0.0)	23(5.1)
		White-tailed eagle (*Haliaeetus albicila*)	2(0.4)	0(0.0)	0(0.0)	0(0.0)	2(0.4)
	Falconidae	Common kestrel (*Falco tinnunculus*)	61(13.6)	29(6.4)	7(1.6)	2(0.4)	99(22.0)
		Eurasian hobby (*Falco subbuteo*)	16(3.6)	11(2.4)	2(0.4)	0(0.0)	29(6.4)
		Peregrine falcon (*Falco peregrinus*)	3(0.7)	2(0.4)	1(0.2)	0(0.0)	6(1.3)
Strigiformes	Strigidae	Brown hawk owl (*Ninox scutulata*)	32(7.1)	17(3.8)	7(1.6)	0(0.0)	56(12.4)
		Collared scops owl (*Otus semitorques*)	5(1.1)	0(0.0)	0(0.0)	0(0.0)	5(1.1)
		Eurasian eagle owl (*Bubo bubo*)	36(8.0)	36(8.0)	7(1.6)	4(0.9)	83(18.4)
		Long-eared owl (*Asio otus*)	1(0.2)	3(0.7)	2(0.4)	0(0.0)	6(1.3)
		Oriental scops owl (*Otus sunia*)	29(6.4)	23(5.1)	1(0.2)	2(0.4)	55(12.2)
		Short-eared owl (*Asio flammeus*)	1(0.2)	0(0.0)	0(0.0)	0(0.0)	1(0.2)
		Tawny owl (*Strix aluco*)	2(0.4)	2(0.4)	1(0.2)	0(0.0)	5(1.1)
	Total	18	249(55.3)	155(34.4)	34(7.6)	12(2.7)	450(100.0)

Table 3. 3. Classification of the reason of euthanasia before treatment

Euthanasia reason		Number of Cases	Percentage of Cases
Nerve	Neurological damage	73	47.1
Bone	Over time after fracture	20	12.9
	Loss of fractured bone	16	10.3
	Fracture near joint	8	5.1
	Severe comminuted fracture	6	3.9
Joint	Joint damage	15	9.7
Soft-tissue	Soft-tissue necrosis	15	9.7
	Extensive laceration	2	1.3
Total		155	100.0

2) Treatment results according to fracture region.

The treatment results were analyzed based on the medical record about 249 raptors with treatment, excluding 201 raptors which could not be medically treated among the 450 raptors of the fracture diagnosis. The data on individuals that related to 11 types such as body weight, BCS, fracture site, fracture location (zone), fracture condition, fracture type, clinical category, the treatment method, interval to union or removal fixator after performing treatment, hospitalization period, and the treatment outcome were arranged and analyzed.

(1) Humerus fracture

The data for 41 raptors that occurred only fracture of humerus was tabulated. (Table 3.4).

The fracture location (zone) of the humerus was that there were 13 cases (31.7%) in the proximal part, 22 cases (53.7%) in the diaphysis part and 6 cases (14.6%) in the distal part. Out of these, the most common part of the fractured location (zone) was 22 cases (53.7%) in diaphysis. The fracture condition was classed as 20 cases in closed fractures (48.8%) and 21 cases in open fractures (51.2%). The fracture type was classified into 13 cases (31.7%) in the comminuted fracture, 14 cases (34.1%) in transverse fracture of simple fracture, 12 cases (29.3%) in oblique/spiral fracture of simple fracture and 2 cases (4.9%) in segmental fracture. Within the 40 raptors that medically treated for only fracture of humerus, the results of those were classed as follows; 15 raptors (37.5%) in case of using TIF, 6 raptors (15.0%) in case of using TIF with wire, followed by 5 raptors (12.5%) in case of using IM pin and 4 raptors (10.0%) in case of using IM pin with wire (Fig 3.1). Out of these, TIF was used most frequently.

Table 3. 4. Classification of fractured humerus site on 41 individual

Registration Number	Species Name	Physical condition		Description of fracture				Clinical category	Treatment method[d]	Interval to union or removal of fixator(day)	period	Outcome (Identification metal ring)[e]
		Weight (g)	BCS	Fracture Site	Fracture Zone[a]	Fracture Condition[b]	Fracture Type[c]					
2014-0011	Collared scops owl (*Otus semitorques*)	210	3	Lt. Humerus	(H)Pr	(H)Cl	(H)Tr	2	(Lt)H:IM 1.4mm	(Lt)H:11	181	Re (080-05434)
2014-0134	Oriental scops owl (*Otus sunia)*	78	2	Lt. Humerus	(H)Pr	(H)Cl	(H)Tr	2	(Lt)H:IM 1.0mm	(Lt)H:15	33	Re (060-09528)
2014-0281	Eurasian eagle owl (*Bubo bubo*)	1780	3	Rt. Humerus	(H)Mi	(H)Op	(H)OS	2	(Rt)H:IM 2.2mm Cerclage Wire 0.5mm		10	Eu/Nonunion
2014-0423	Eurasian eagle owl (*Bubo bubo*)	1800	2	Lt. Humerus	(H)Mi	(H)Op	(H)Se	3	(Lt)H:(TIF) IM 2.2mm ESF 1.6mm Wire 0.5mm		57	Eu/Nonunion
2014-0543	Oriental scops owl (*Otus sunia*)	66	3	Lt. Humerus	(H)Pr	(H)Cl	(H)Tr	2	(Lt)H:8 Bandage		6	De/Unknown
2014-0558	Eurasian eagle owl (*Bubo bubo*)	1584	2	Rt. Humerus	(H)Di	(H)Op	(H)Co	4	(Rt)H:(TIF) IM 1.8mm ESF 1.6mm (2)		6	De/Accident in cage
2014-0572	Brown hawk owl (*Ninox scutulata*)	182	3	Lt. Humerus	(H)Mi	(H)Op	(H)OS	2	(Lt)H:(TIF) IM 1.2mm ESF 0.9mm (2)		50	De/Accident in cage
2014-0642	Common kestrel (*Falco tinnunculus*)	210	2	Rt. Humerus	(H)Mi	(H)Cl	(H)Tr	1	(Rt)H:(TIF) IM 1.2mm ESF 1.2mm (2)	(Rt)H:13	44	Eu/Flight Disorder
2014-0688	Eurasian eagle owl (*Bubo bubo*)	1460	2	Lt. Humerus	(H)Pr	(H)Op	(H)OS	3	(Lt)H:(TIF) IM 1.8mm ESF 1.6mm (2)		12	Eu/Necrosis
2015-0044	Common kestrel (*Falco tinnunculus*)	216	2	Rt. Humerus	(H)Mi	(H)Op	(H)Se	3	(Rt)H:(TIF) IM 1.3mm ESF 0.9mm/1.1mm		56	Eu/Nonunion
2015-0056	Peregrine falcon (*Falco peregrinus*)	612	2	Rt. Humerus	(H)Mi	(H)Op/+	(H)Co	4	(Rt)H:(TIF) IM 1.8mm ESF 1.6mm (2)		74	Eu/Nonunion
2015-0134	Oriental scops owl (*Otus sunia*)	66	2	Rt. Humerus	(H)Mi	(H)Cl	(H)Co	2	(Rt)H: Cross pin (26GX90mm.0.45mm)	(Rt)H:19	260	Eu/Flight Disorder
2015-0182	Eurasian eagle owl (*Bubo bubo*)	2512	3	Lt. Humerus	(H)Di	(H)Op	(H)Co	4	(Lt)H:(TIF) IM 2.0mm ESF 2.0mm (2)		38	Eu/Ankylosis
2015-0345	Common kestrel (*Falco tinnunculus*)	192	2	Rt. Humerus	(H)Mi	(H)Cl	(H)OS	1	(Rt)H:8 Bandage	(Rt)H:7	50	Re (080-06805)
2015-0460	Eurasian eagle owl (*Bubo bubo*)	2506	2	Lt. Humerus	(H)Pr	(H)Cl	(H)Co	3	(Lt)H:(TIF) IM 2.4mm ESF 2.0mm (2)	(Lt)H:24	93	Re (140-01386)
2015-0487	Common kestrel (*Falco tinnunculus*)	192	2	Rt. Humerus	(H)Pr	(H)Cl	(H)Co	3	(Rt)H:8 Bandage	(Rt)H:16	551	Eu/Flight Disorder
2015-0568	Brown hawk owl (Ninox scutulata)	162	2	Rt. Humerus	(H)Mi	(H)Op	(H)OS	2	(Rt)H:IM 1.5mm		44	Eu/Nonunion

2015-0657	Oriental scops owl (*Otus sunia*)	78	3	Rt. Humerus	(H)Pr	(H)Op	(H)OS	3	(Rt)H:IM 1.0mm		3	De/Unknown
2015-0833	Eurasian buzzard (*Buteo buteo*)	746	3	Lt. Humerus	(H)Pr	(H)Cl	(H)Tr	2	(Lt)H:8 Bandage	(Lt)H:15	66	Re
2015-0878	Eurasian buzzard (*Buteo buteo*)	520	1	Lt. Humerus	(H)Mi	(H)Cl	(H)Tr	2	(Lt)H:(TIF) IM 2.0mm ESF Pr1.6mm Di1.1mm	(Lt)H:23	74	Re
2016-0045	Common kestrel (*Falco tinnunculus*)	232	2	Rt. Humerus	(H)Mi	(H)Op	(H)Co	3	(Rt)H:IM 1.2mm Cerclage wire 0.2mm	(Rt)H:10	137	Eu/Accident in cage/Refracture
2016-0053	White-tailed eagle (*Haliaeetus albicila*)	3940	2	Rt. Humerus	(H)Mi	(H)Op	(H)Co	3	(Rt)H:(TIF) IM 2.8mm ESF 2.0mm (2)		1029	Pe/Necrosis/Amputation
2016-0080	Eurasian buzzard (*Buteo buteo*)	724	2	Rt. Humerus	(H)Mi	(H)Op	(H)Co	3	(Rt)H:(TIF) IM 2.0mm ESF Pr1.6mm Di1.1mm Cerclage wire 0.35mm	(Rt)H:16	60	Re
2016-0277	Brown hawk owl (*Ninox scutulata*)	172	3	Rt. Humerus	(H)Mi	(H)Op	(H)Tr	2	(Rt)H:(TIF) IM 1.0mm ESF 1.0mm (2)		14	Eu/Self-injury
2016-0463	Common kestrel (*Falco tinnunculus*)	144	2	Lt. Humerus	(H)Di	(H)Cl	(H)Tr	2	(Lt)H:8 Bandage	(Lt)H:13	37	Re (080-06896)
2016-0524	Brown hawk owl (*Ninox scutulata*)	140	2	Rt. Humerus	(H)Mi	(H)Cl	(H)Co	2	(Rt)H:IM 1.1mm Cerclage wire 0.2mm	(Rt)H:25	85	Eu/Accident in cage/Refracture
2016-0613	Common kestrel (*Falco tinnunculus*)	158	2	Lt. Humerus	(H)Pr	(H)Cl	(H)OS	2	(Lt)H:(TIF) IM 1.1mm ESF 1mm (2) Cerclage wire: 0.3mm	(Lt)H:14	79	Re (080-09467)
2016-0772	Common kestrel (*Falco tinnunculus*)	174	2	Rt. Humerus	(H)Pr	(H)Cl	(H)OS	2	(Rt)H:(TIF) IM 1.1mm ESF 1mm (2) 8 Shaped wire 0.3mm	(Rt)H:14	60	Re (080-09475)
2016-0799	Peregrine falcon (*Falco peregrinus*)	950	3	Rt. Humerus	(H)Di	(H)Op	(H)Co	4	(Rt)H: Cross pin 0.6mm ESF 1.6mm/1.1mm		31	Eu/Nonunion
2017-0392	Eurasian eagle owl (*Bubo bubo*)	2430	3	Lt. Humerus	(H)Mi	(H)Op	(H)Tr	2	(Lt)H: Type 1 ESF 2.0mm (3) Cerclage wire 0.5mm		3	De/Unknown
2017-0764	Oriental scops owl (*Otus sunia*)	64	2	Lt. Humerus	(H)Mi	(H)Op	(H)Co	3				De/Death before operation
2017-0777	Oriental scops owl (*Otus sunia*)	68	3	Rt. Humerus	(H)Di	(H)Op	(H)OS	3	(Rt)H:IM 1.2mm Wire 0.2mm	(Rt)H:10	285	Re (060-08303)
2017-0867	Brown hawk owl (*Ninox scutulata*)	184	4	Lt. Humerus	(H)Pr	(H)Cl	(H)Tr	2	(Lt)H:8 Bandage	(Lt)H:28	396	Re (080-09539)
2017-0914	Common kestrel (*Falco tinnunculus*)	160	2	Rt. Humerus	(H)Mi	(H)Cl	(H)OS	1	(Rt)H:(TIF) IM 1.0mm ESF 0.9mm (2) 8 Shaped wire 0.3mm	(Rt)H:15	48	Re (080-09516)

2017-1022	Eurasian buzzard (*Buteo buteo*)	1092	3	Lt. Humerus	(H)Mi	(H)Op	(H)OS	2	(Lt)H:(TIF) IM 1.8mm ESF 1.6mm/1.4mm		38	Eu/Necrosis
2018-0353	Brown hawk owl (*Ninox scutulata*)	178	2	Lt. Humerus	(H)Mi	(H)Cl	(H)Co	2	(Lt)H:(TIF) IM 1.2mm ESF 0.9mm (2) Cerclage wire 0.2mm		12	De/Unknown
2018-0639	Eurasian Sparrow hawk (*Accipiter nisus*)	230	2	Lt. Humerus	(H)Mi	(H)Cl	(H)Tr	1	(Lt)H:(TIF) IM 1.2mm ESF 0.9mm (2)	(Lt)H:15	59	De Accident in cage
2018-0952	Eurasian hobby (*Falco subbuteo*)	172	2	Rt. Humerus	(H)Di	(H)Op	(H)Tr	3	(Rt)H:(TIF) IM 1.2mm/0.7mmESF 0.9mm(1)	(Rt)H:18	105	Ca
2018-0979	Common kestrel (*Falco tinnunculus*)	190	2	Rt. Humerus	(H)Mi	(H)Op/+	(H)Tr	3	(Rt)H:(TIF) IM 1.1mm ESF 1.1mm (2)	(Rt)H:17	36	Eu/Flight Disorder
2018-1050	Oriental scops owl (*Otus sunia*)	56	2	Rt. Humerus	(H)Pr	(H)Cl	(H)OS	2	(Rt)H:IM 1.0mm		3	De/Death in operation
2018-1058	Common kestrel (*Falco tinnunculus*)	176	3	Rt. Humerus	(H)Pr	(H)Cl	(H)Tr	2	(Rt)H:8 Bandage	(Rt)H:14	43	Re (080-09540)
Total	41											

[a]Pr=Proximal Third of the Bone; Mi=Middle Third of the Bone; Di=Distal Third of the Bone; (H)=Humerus
[b]Cl=Closed Fracture; Op=Open Fracture; +=Over time after fracture
[c]Tr=Transverse Fracture; OS=Oblique/Spiral Fracture; Co=Comminuted Fracture; Li=Linear Fracture; Se=Segmental Fracture; Si=Simple Fracture
[d]IM=Intramedully Pin; TIF=Tie-in Fixator; ESF=External Skeletal Fixator; (Rt)=Right; (Lt)=Left; H=Humerus
[e]Re=Released; Eu=Euthanased; Di=Died; Ca=Captive; Pe=Permenent disability

Fig 3. 1. Radiographs show a closed, oblique/spiral fracture of the proximal of the right humerus in Common kestrel (*Falco tinnunculus*) 2016-0772 (A). Radiographs were taken several times in order to confirm to be fixed TIF and 8 shaped wire properly and accurately during operation (B), post-operation figure (C), POD 5th (D), after pin removal on POD 14th (E), and POD 60th before the release (F).

(2) Humerus fracture including other fractured sites

The data for 18 raptors that occurred fracture of humerus and other site was tabulated (Table 3.5).

The fractured parts together with the humerus fracture were identified in various parts of bone. There were 18 individuals that confirmed humerus fractures. However, one raptor showed both sides of humerus fractures then 19 cases of humerus fractures were verified.

The fracture location (zone) of the humerus was occupied as mentioned below; there were 7 cases (36.8%) in the proximal part, 9 cases (47.4%) in the diaphysis part and 3 cases (15.8%) in the distal part. Out of these, the most common part of fracture was diaphysis. The fracture condition was classed as 11 cases in closed fractures (57.9%) and 8 cases in open fractures (42.1%). The fracture type was classified into 5 cases (26.3%) in comminuted fracture, 8 cases (42.1%) in transverse fracture of simple fracture and 6 cases (31.6%) in oblique/spiral fracture of simple fracture. Within the 17 raptors that medically treated for the fracture of humerus, the results of those were classed as follows; 7 raptors (38.9%) in case of using TIF, 3 raptors (16.7%) in case of using TIF with wire, and followed by 6 raptors (33.3%) in case of using IM pin and 2 raptors (11.1%) in case of using IM pin with wire (Fig 3.2).

Out of these, TIF was used most frequently. The mean union time that was measured for 8 individuals was 22.5(±4.0) days after the initiation of humeral fracture surgery or the bandage treatment. It took time until the removal of the pin or taking off bandage.

Table 3. 5. Classification of fractured humerus with other sites on 18 individuals

Registration Number	Species Name	Physical condition		Description of fracture				Clinical category	Treatment method[d]	Interval to union or removal of fixator(day)	period	Outcome (Identification metal ring)[e]
		Weight (g)	BCS	Fracture Site	Fracture Zone[a]	Fracture Condition[b]	Fracture Type[c]					
2015-0011	Collared scops owl (*Otus semitorques*)	176	2	Rt. Humerus, Rt. Tibiotarsus, Lt. Tarsometatarsus	(H)Mi/ (Ti)Di/ (Ta)Pr	(H)Op/ (Ti)Cl/ (Ta)Cl	(H)Tr/ (Ti)Co/ (Ta)Co	8	(Rt)H:IM 1.2mm (Rt)Ti:IM 1.3mm (Lt)Ta:Splint		8	Eu/ Nonunion
2015-0879	Northern goshawk (*Accipiter gentilis*)	478	1	Lt. Humerus, Lt. Furcula, Lt. Sternocoracoidal jt	(H)Mi	(H)Op /(Scjt)Lu	(H)OS/ (Fu)Tr	5	(Lt)H:(IM) 2.0mm (Lt)Scjt:reduction/8 Shaped and body wrap Bandage	(Lt)H/Scjt:21	52	Re (100-09744)
2016-0057	Collared scops owl (*Otus semitorques*)	128	3	Rt. Humerus, Rt. Femur	(H)Pr/ (F)MI	(H)Cl/ (F)Cl	(H)Co/ (F)OS	4	Death before operation		4	De/ Unknown
2016-0117	Common kestrel (*Falco tinnunculus*)	196	3	Rt. Humerus, Lt. Furcula	(H)Mi	(H)Op/ (Fu)Cl	(H)OS/ (Fu)Tr	3	(Rt)H:(TIF) IM 1.0mm ESF 0.8mm (2)	(Rt)H:20	35	Re (080-06856)
2016-0618	Eurasian hobby (*Falco subbuteo*)	148	2	Lt. Humerus, Lt. Furcula	(H)Pr	(H)Cl/ (Fu)Cl	(H)Co/ (Fu)Tr	4	(Lt)H:(TIF) IM 1.1mm ESF 1.0mm (2)	(Lt)H:20	78	Eu/ Flight Disorder
2016-0671	Common kestrel (*Falco tinnunculus*)	168	2	Rt. Humerus, Rt. Ulna	(H)Di/ (U)Pr	(H)Op+/ (U)Cl	(H)OS/ (U)Tr	6	(Rt)H:IM 1.1mmCerclage wire 0.2mm/0.4mm		20	Eu/Necrosis
2016-0809	Brown hawk owl (*Ninox scutulata*)	172	3	Rt. Humerus, Rt. Radius, Rt. Ulna	(H)Pr/ (R)Mi/ (U)Mi	(H)Cl/ (R)Op+/ (U)Op+	(H)OS/ (R)Tr/ (U)Tr	8	(Rt)H:(TIF)IM 1.1mm ESF 0.9mm (2) (Rt)R:IM 0.9mm		3	De/Unknown
2016-0949	Common kestrel (*Falco tinnunculus*)	178	3	Lt. Humerus, Sternum	(H)Pr	(H)Cl	(H)Tr/ (St)Si	3	(Lt)H:IM 1.8mm	(Lt)H:19	100	Re (080-09405)
2017-0031	Common kestrel (*Falco tinnunculus*)	192	2	Rt. Humerus, Rt. Radius	(H)Mi/ (R)Pr	(H)Op+/ (U)Cl	(H)Co/ (R)Tr	6	(Rt)H:(TIF)IM 1.1mm ESF 1.1mm (2)		47	Eu/Malunion
2018-0068	Common kestrel (*Falco tinnunculus*)	210	3	Rt. Humerus, Rt. Radius	(H)Mi/ (R)Pr	(H)Op/ (U)Cl	(H)Tr/ (R)Tr	4	(Rt)H:(TIF)IM 1.0mm ESF 0.9mm (2)	(Rt)H:30	43	Eu/Necrosis of Mouth
2018-0173	Eurasian Sparrow hawk (*Accipiter nisus*)	158	2	Rt. Humerus, Sternum	(H)Di	(H)Op	(H)Tr	4	(Rt)H:(TIF)IM 1.1mm ESF 1.1mm (2) Cerclage wire		4	De/ Unknown

									0.2mm			
2018-0356	Eurasian hobby (*Falco subbuteo*)	166	2	Lt. Humerus, Lt. Radius	(H)Mi/ (R)Pr	(H)Cl+/ (U)Cl+	(H)OS/ (R)Tr	5	(Lt)H:(TIF)IM 1.0mm ESF 0.9mm (2) Cerclage wire 0.3mm		10	Eu/ Necrosis
2018-0662	Common kestrel (*Falco tinnunculus*)	186	3	Lt. Humerus, Rt. Tarsometatarsus	(H)Di/ (Ta)Mi	(H)Cl/ (Ta)Op+	(H)OS/ (Ta)Tr	5	(Lt)H:(TIF)IM 1.0mm ESF 0.8mm Cerclage wire 0.2mm (Rt)Ta:Splint	(Lt)H:23 (Rt)Ta:23	47	Re (080-09530)
2018-0899	Oriental scops owl (*Otus sunia*)	72	3	Rt. Humerus, Lt. Coracoid	(H)Pr	(H)Cl/ (Cc)Cl	(H)Tr/ (Cc)Tr	3	(Rt)H:IM 1.8mm (Lt)Cc:IM (24G)	(Rt)H:27	56	Eu/ Ankylosis
2018-0910	Brown hawk owl (*Ninox scutulata*)	108	3	Rt. Humerus, Lt. Ulna, Lt. Humerus	(RtH)Mi/ (LtH)Mi/ (U)Mi	(RtH)Cl/ (LtH)Cl/ (U)Op+	(RtH)Tr/ (LtH)Co/ (U)OS	6	(Rt)H:IM 1.0mm Cerclage wire 0.2mm (Lt)H:IM 1.0mm (Lt)U:IM 0.8mm		6	De/ Unknown
2018-1040	Eurasian eagle owl (*Bubo bubo*)	1330	1	Rt. Humerus, Lt. Tarsometatarsus	(H)Mi/ (Ta)Mi	(H)Op/ (Ta)Cl	(H)Co/ (Ta)Co	6	(Rt)H:(TIF)IM 2.0mm ESF 2.0mm (4) Ta:Splint		35	Eu/ Necrosis
2018-1048	Oriental scops owl (*Otus sunia*)	74	3	Lt. Humerus, Lt. Radius, Lt. Ulna	(H)Pr/ (R)Mi/ (U)Mi	(H)Cl/ (R)Cl/ (U)Cl	(H)Tr/ (R)Tr/ (U)Tr	4	(Lt)H:(IM)1.4mm (Lt)R:(IM)0.6mm	(Lt)H/R:20	57	Ca
2018-1218	Eurasian buzzard (*Buteo buteo*)	680	2	Rt. Humerus, Thoracic vert	(H)Pr	(H)Cl	(H)Tr/ (Tv)?	3	(Rt)H:(TIF)IM 1.6mm ESF 1.2mm (2) Tv:Restrict movement/ Sling		2	Eu/Behavior disorder
Total	18											

[a]Pr=Proximal Third of the Bone; Mi=Middle Third of the Bone; Di=Distal Third of the Bone; (H)=Humerus; (U)=Ulna; (R)=Radius; (Fu)=Furcula; (Cc)=Coracoid; (F)=Femor; (Ti)=Tibiotarsus; (Ta)=Tarsometatarsus; (Tv)=Thoracic vert
[b]Cl=Closed Fracture; Op=Open Fracture; +=Over time after fracture
[c]Tr=Transverse Fracture; OS=Oblique/Spiral Fracture; Co=Comminuted Fracture; Li=Linear Fracture; Se=Segmental Fracture; Si=Simple Fracture
[d]IM=Intramedully Pin; TIF=Tie-in Fixator; ESF=External Skeletal Fixator; (Rt)=Right; (Lt)=Left
[e]Re=Released; Eu=Euthanased; Di=Died; Ca=Captive; Pe=Permenent disability

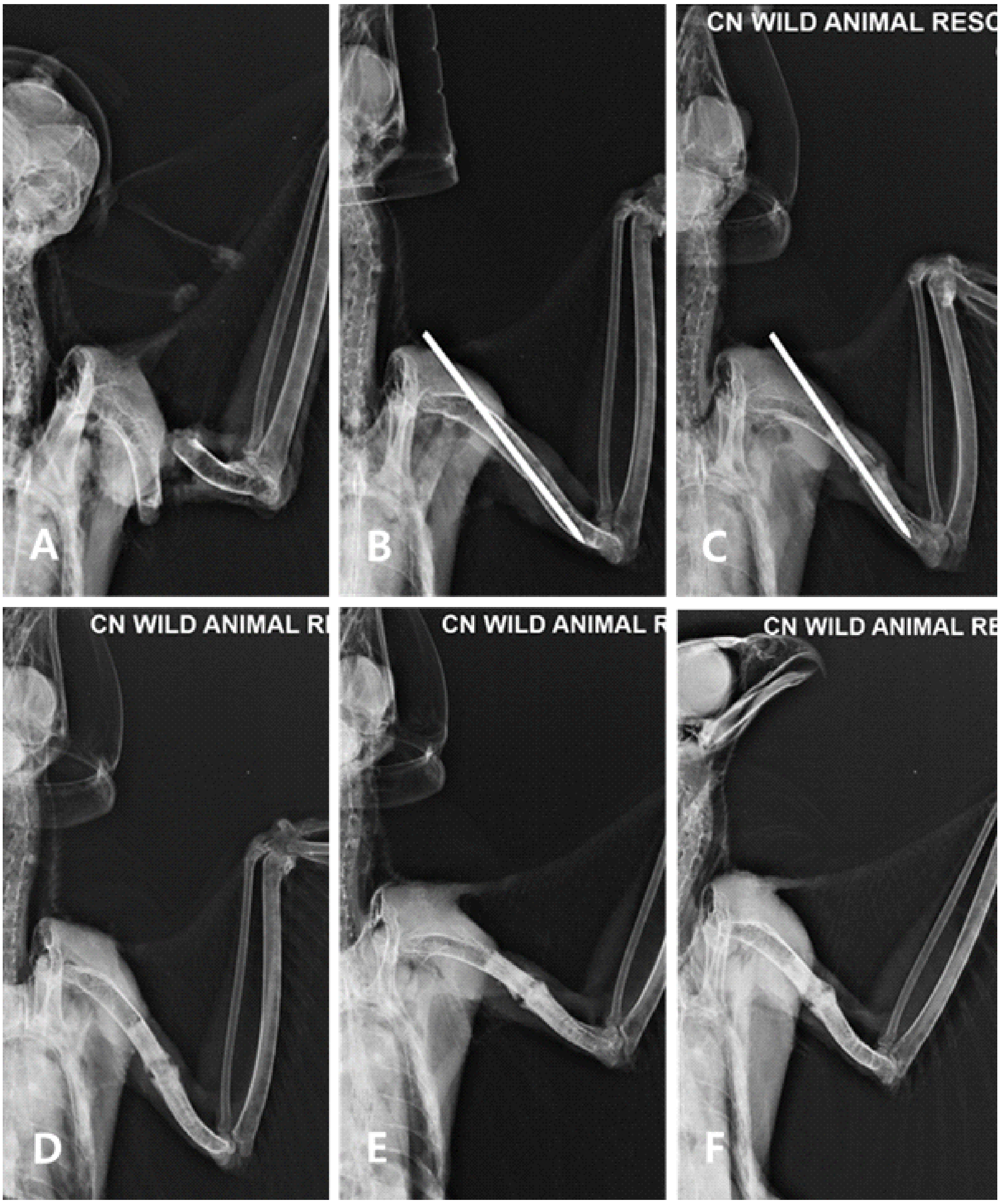

Fig 3. 2. Radiographs show an open, oblique/spiral fracture of the diaphyseal of the left humeral and left Sternocoracoidal joint luxation in Northern goshawk (*Accipiter gentilis*) 2015-0879 (A). Radiographs were taken to confirm to be fixed intramedully pin properly and accurately after operative 7th day (B), POD 14th (C), after pin removal on POD 21th (D), POD 29th (E), and POD 35th (F).

(3) Radius fracture

The data for 8 raptors that were occurred only the fracture of radius was tabulated (Table 3.6).

The fracture location (zone) of the radius was occupied as mentioned bellow; there were 5 cases (62.5%) in the proximal part and 3 cases (37.5%) in the diaphysis part. The fractured condition was classed as total 8 cases (48.8%) in closed fractures. Within the 8 raptors that medically treated for only fracture of radius, the results of those were classed as follows; there were 6 raptors (75.0%) in case of using figure of eight bandage, 1 raptor (12.5%) in case of using IM pin and 1 raptor (12.5%) in case of using shuttle pin (Fig 3.3).

The mean union time that measured for 8 individuals was 22.2(±6.4) days after the initiation of radius fracture surgery or bandage treatment. It took time until pin removal or taking off bandage.

Table 3. 6. Classification of fractured radius site on 8 individuals

Registration Number	Species Name	Physical condition		Description of fracture				Clinical category	Treatment method[d]	Interval to union or removal of fixator(day)	period	Outcome (Identification metal ring)[e]
		Weight (g)	BCS	Fracture Site	Fracture Zone[a]	Fracture Condition[b]	Fracture Type[c]					
2015-0059	Cinereous vulture (*Aegypius monachus*)	7620	2	Rt. Radius	(U)Mi	(U)Cl	(U)Tr	1	(Rt)R:(shuttle pinning) Cerclage wire 0.4mm Shuttle pin (1ml syringe)	(Rt)R:14	250	Re(150-00712,03(G/B))
2015-0076	Northern goshawk (*Accipiter gentilis*)	628	3	Lt Radius	(U)Mi	(U)Cl	(U)Tr	1	(Lt)R:8 Shaped Bandage	(Lt)R:23	40	Re(100-04798)
2015-0750	Eurasian eagle owl (*Bubo bubo*)	1466	1	Lt Radius	(U)Pr	(U)Cl	(U)Tr	3	(Lt)R:8 Shaped Bandage	(Lt)R:32	61	Re(140-01388)
2015-0556	Eurasian eagle owl (*Bubo bubo*)	2134	2	Lt Radius	(U)Mi	(U)Cl	(U)Co	2	(Lt)R:8 Shaped Bandage	(Lt)R:17	460	De/Accident in cage
2016-0475	Oriental scops owl (*Otus sunia*)	96	3	Rt. Radius	(U)Pr	(U)Cl+	(U)Co	4	(Rt)R:8 Shaped Bandage		8	De/Unknown
2017-0155	Brown hawk owl (*Ninox scutulata*)	212	3	Lt Radius	(U)Mi	(U)Cl	(U)Tr	1	(Lt)R:IM 0.9mm	(Lt)R:26	25	Re(080-09414)
2017-0779	Oriental scops owl (*Otus sunia*)	56	2	Rt. Radius	(U)Pr	(U)Cl	(U)Tr	2	(Rt)R:8 Shaped Bandage		3	De/Unknown
2017-0815	Eurasian eagle owl (*Bubo bubo*)	1974	2	Lt Radius	(U)Pr	(U)Cl	(U)Tr	2	(Lt)R:8 Shaped Bandage	(Lt)R:21	36	Re(140-01887)
Total	8											

[a]Pr=Proximal Third of the Bone; Mi=Middle Third of the Bone; Di=Distal Third of the Bone; (R)=Radius
[b]Cl=Closed Fracture; Op=Open Fracture; +=Over time after fracture
[c]Tr=Transverse Fracture; OS=Oblique/Spiral Fracture; Co=Comminuted Fracture; Li=Linear Fracture; Se=Segmental Fracture; Si=Simple Fracture
[d]IM=Intramedully Pin; TIF=Tie-in Fixator; ESF=External Skeletal Fixator; (Rt)=Right; (Lt)=Left; R=Radius
[e]Re=Released; Eu=Euthanased; Di=Died; Ca=Captive; Pe=Permenent disability

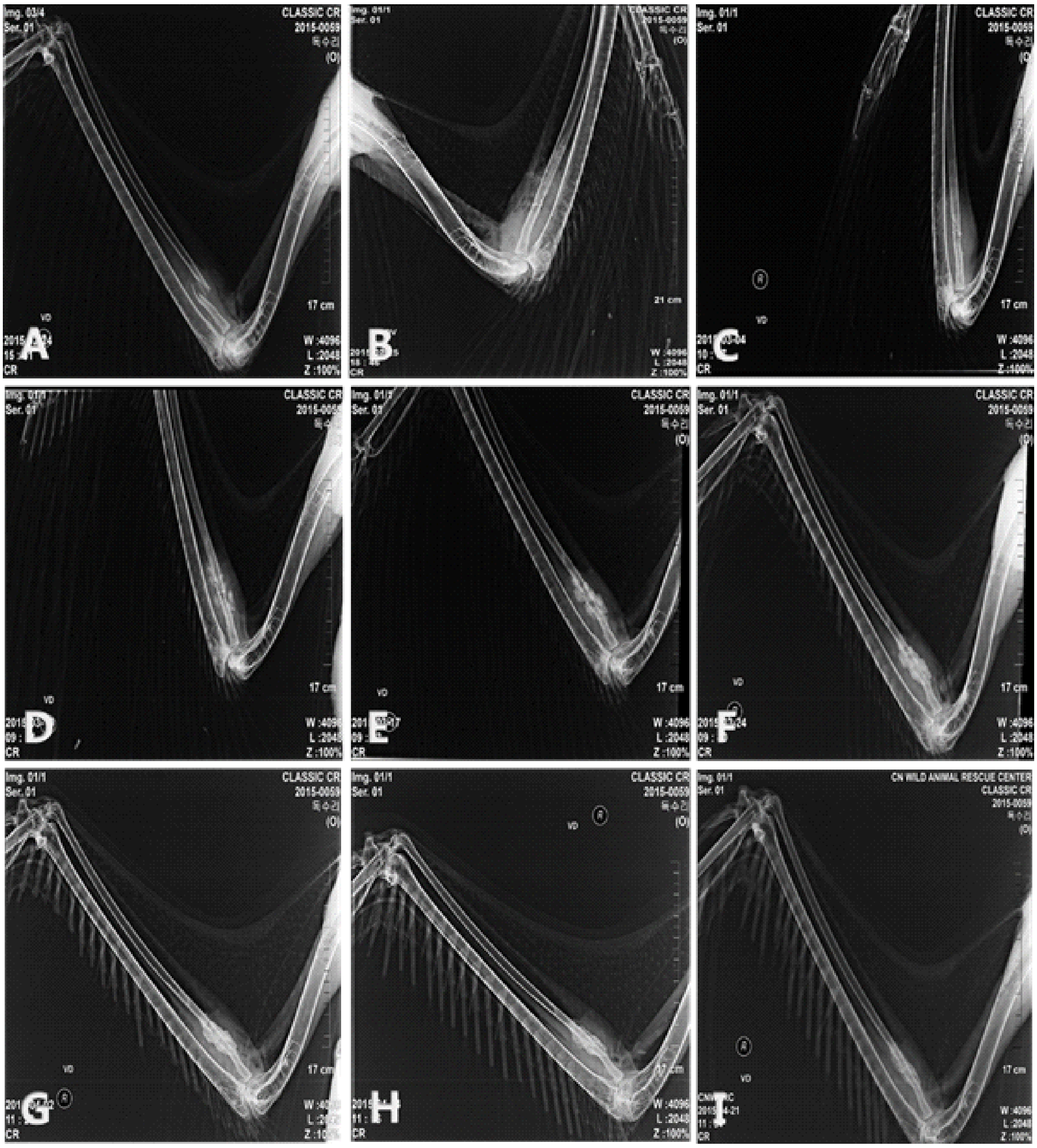

Fig 3. 3. Radiographs show the right radius closed, transverse fracture in Cinereous vulture (*Aegypius monachus*) 2015-0059 (A). Radiographs were taken in order to confirm to be fixed shuttle pin and wire properly and accurately after operation (B). POD 7th (C), radiographs were taken several times in order to confirm to fixation during the physical therapy POD 13th (D), POD 20th (E), POD 27th (F), POD 36th (G), POD 48th (H), and POD 55th before the release (I).

(4) Radius fracture including other fractured sites

The data for 28 raptors that occurred fracture of radius and other sites was tabulated (excluding humerus fracture) (Table 3.7).

The fracture of both radius and ulna was the most commonly confirmed in 22 raptors (78.6%) among the 28 raptors that was occurred other sites together with the fractured radius. The elbow luxation together with radius fracture was found in 5 raptors (17.9%). There were 28 individuals with the confirmed radius fractures. However, one raptor showed both sides radius fractures then, became the 29 cases of the radius fractures. The fracture location of the radius was occupied as mentioned bellow; there were 8 cases (27.6%) in the proximal part, 17 cases (58.6%) in the diaphysis part and 4 cases (13.8%) in the distal part. Out of these, the most common part of fracture was diaphysis. The ulna fracture location that fractured the radius and ulna together among 22 cases, was occupied as mentioned bellow; there were 4 cases (13.6%) in the proximal part, 16 cases (72.7%) in the diaphysis part and 2 cases (9.1%) in the distal part.

The radius fracture condition about 29 cases was classed as 15 cases in closed fractures (51.7%) and 14 case in open fractures (48.3%). In the cases of 22 ulnar fractures in both the radius and ulnar fractures simultaneously, open fracture and closed fracture were 11 cases (50.0%) respectively. The fracture type of radius was classified into 3 cases (10.3%) in the comminuted fracture, 23 cases (79.3%) in transverse fracture of simple fracture, 2 cases (6.9%) in oblique/spiral fracture of simple fracture and 1 case (3.4%) in the segmental fractures. The fracture type of ulna with radius fracture simultaneously was classified into 7 cases (31.8%) in the comminuted fracture, 5 cases (22.7%) in transverse fracture of simple fracture, 6 cases (27.3%) in the oblique/spiral fracture of simple fracture and 4cases (18.2%) in the segmental fractures.

Within the 29 raptors that were medically treated for fracture together with the radius and ulna, the results of radius treatment methods were classed as follows; there were 19 raptor (65.5%) in case of using IM pin, 8 raptor (27.6%) in case of using figure of eight bandage, 1 raptor (3.4%) in case of using IM pin with wire and 1 raptor (3.4%) in case of using the shuttle pin. Out of these, the IM pin was used most frequently.

In the cases of the 22 raptors that identified as ulnar fracture with radial fracture, 11 raptors (50.0%) were medically treated with IM pin. Therefore, IM pin was used most frequently (Fig 3.4-5). The mean union time that measured for 16 cases was 18.0(±5.0) days after the initiation of the radius fracture surgery or bandage treatment. The average time to union about 14 cases of ulnar fractures with radial fracture also was 20.5(± 6.9) days. It took time until the pin removal or taking off bandage. The results of the treated raptors showed as follows, there were 14 raptors (50.0%) in case of release, 7 raptors (25.0%) in case of euthanasia, 6 raptors (21.4%) in case of dead and 1 raptor (3.6%) in case of captive.

Table 3. 7. Classification of fractured radius with other sites on 28 individuals

Registration Number	Species Name	Physical condition		Description of fracture				Clinical category	Treatment method[d]	Interval to union or removal of fixator(day)	period	Outcome (Identification metal ring)[e]
		Weight (g)	BCS	Fracture Site	Fracture Zone[a]	Fracture Condition[b]	Fracture Type[c]					
2014-0013	Eurasian buzzard (*Buteo buteo*)	930	3	Rt. Radius, Free vert.	(R)Mi	(R)Cl/ (Tv)Cl	(R)Tr/ (Tv)Si	4	(Rt)R:(IM) 2.0mm Tv:Restrict movement/ Sling		16	Eu/Brhavior disorder
2014-0160	Eurasian hobby (*Falco subbuteo*)	172	2	Rt. Radius, Rt. Ulna	(R)Pr/ (U)Mi	(R)Op/ (U)Op	(R)Tr/ (U)Co	6	(Lt)R:(IM) 0.8mm (Lt)U:(IM) 1.2mm		15	Eu/Necrosis
2014-0289	Eurasian eagle owl (*Bubo bubo*)	1138	2	Lt. Radius, Lt. Ulna	(R)Di/ (U)Di	(R)Cl/ (U)Cl	(R)OS/ (U)OS	4	(Rt)R/U:8 Shaped Bandage	(Rt)R/U :27	148	Re (140-01359)
2014-0361	Eurasian eagle owl (*Bubo bubo*)	1960	2	Lt. Radius, Lt. Ulna	(R)Mi/ (U)Mi	(R)Op/ (U)Cl	(R)Tr/ (U)Co	4	(Lt)R:(IM) 1.8mm (Lt)U:(TIF) IM 2.4mm ESF 1.6mm (2)		18	Eu/Necrosis
2014-0619	Oriental scops owl (*Otus sunia*)	64	2	Rt. Radius, Rt. Ulna	(R)Di/ (U)Di	(R)Cl/ (U)Cl	(R)Tr/ (U)OS	4	(Rt)R/U:8 Shaped Bandage		215	De/Accident in cage
2014-0641	Common kestrel (*Falco tinnunculus*)	216	4	Rt. Radius, Upper beak	(R)Pr/ (UB)Di	(R)Cl	(R)Tr/ (UB)Si	4	(Rt)R:8 Shaped Bandage	(Rt)R:17	59	Re (080-09544)
2015-0078	Common kestrel (*Falco tinnunculus*)	176	2	Lt. Radius, Lt. Ulna	(R)Di/ (U)Mi	(R)Op/ (U)Cl	(R)Tr/ (U)Se	5	(Lt)R:(IM) 0.9mm (Lt)U:(IM) 1.0mm	(Lt)R:20 (Lt)U:14	50	Re (080-05955)
2015-0093	Eurasian eagle owl (*Bubo bubo*)	1558	2	Lt. Radius, Lt. Ulna, Lt. Coracoid	(R)Mi/ (U)Mi	(R)Op/ (U)Cl/ (Cc)Cl	(R)Co/ (U)Co/ (Cc)Tr	6	(Lt)R:(IM) 1.8mm Cerclage wire 0.4mm (Lt)U:(TIF) IM 2.4mm ESF 1.1mm (2)		22	Eu/Necrosis
2015-0385	Common kestrel (*Falco tinnunculus*)	148	2	Lt. Radius, Lt. Ulna	(R)Mi/ (U)Mi	(R)Cl+/ (U)Cl+	(R)Tr/ (U)Se	5	(Lt)R:(IM) 0.7mm (Lt)U:(IM) 1.0mm		7	De/Unknown
2015-0869	Northern goshawk (*Accipiter gentilis*)	570	2	Rt. Radius, Rt. Ulna	(R)Mi/ (U)Mi	(R)Cl/ (U)Cl	(R)Tr/ (U)Tr	2	(Rt)R:(IM) 0.9mm (Rt)U:(IM) 2.0mm	(Rt)R:21 (Rt)U:13	66	Re (100-09745)
2016-0001	Eurasian sparrowhawk (*Accipiter nisus*)	242	3	Lt. Radius, Lt. Ulna	(R)Mi/ (U)Mi	(R)Op/ (U)Cl	(R)Co/ (U)Co	5	(Lt)R:(IM) 0.8mm (Lt)U:(IM) 1.4mm		5	De/Unknown
2016-0007	Eurasian Sparrow	258	3	Rt. Radius,	(R)Mi/	(R)Op/	(R)Tr/	5	(Rt)R:(IM) 0.8mm	(Rt)R:18	72	Re

	Hawk (*Accipiter nisus*)			Rt. Ulna	(U)Mi	(U)Op	(U)Se		(Rt)U:(IM) 1.4mm	(Rt)U:25		(070-00131)
2016-0054	Eurasian buzzard (*Buteo buteo*)	808	2	Rt. Radius, Rt. Ulna, Lt. Radius	(RtR)Mi /(U)Mi/ (LtR)Mi	(RtR)Op/ (U)Op/ (LtR)Cl	(RtR)Tr/ (U)Co/ (LtR)Tr	6	(Lt)R:(IM) 1.0mm (Lt)U:(IM) 1.4mm Cerclage wire 0.35mm (Rt)R:Bandage	(Lt)R:29 (Lt)U:34 (Rt)R:20	279	Re
2016-0061	Cinereous vulture (*Aegypius monachus*)	7000	3	Lt. Radius, Lt. Ulna	(R)Pr/ (U)Pr	(R)Op/ (U)Op	(R)Tr/ (U)Tr	6	(Lt)R: (shuttle pinning) Shuttle pin (1ml syringe) (Lt)U: (shuttle pinning) Shuttle pin (10ml syringe)		18	Eu/Necrosis
2016-0204	Brown hawk owl (*Ninox scutulata*)	204	2	Rt. Radius, Rt. Ulna	(R)Mi/ (U)Mi	(R)Cl/ (U)Cl	(R)Tr/ (U)Tr	2	(Rt)R:(IM) 0.8mm (Rt)U:Bandage	(Rt)R:16 (Rt)U:29	47	Re (080-0688)
2016-0642	Oriental scops owl (*Otus sunia*)	62	3	Rt. Radius, Lt. Tibiotarsus, Lt. Coracoid	(R)Mi/ (Ti)MI	(R)Cl/ (Cc)Cl/ (Ti)Cl	(R)Tr/ (Cc)Tr/ (Ti)Tr	3	(Rt)R:8 Shaped Bandage (Lt)Ti: Splint		5	De/Unknown
2016-0890	Common kestrel (*Falco tinnunculus*)	218	3	Lt. Radius, Lt. Ulna	(R)Mi/ (U)Mi	(R)Op/ (U)Op	(R)Tr/ (U)OS	4	(Lt)R:(IM)0.6mm (Lt)U:8 Shaped wire 0.2mm	(Lt)R:13 (Lt)U:25	67	Re (080-09486)
2016-0921	Eurasian Sparrow hawk (*Accipiter nisus*)	280	4	Rt. Radius, Rt. Ulna	(R)Mi/ (U)Mi	(R)Cl/ (U)Op	(R)Tr/ (U)OS	3	(Rt)R:(IM) 0.8mm (Rt)U:(IM) 1.4mm		3	De/Unknown
2016-0923	Common kestrel (*Falco tinnunculus*)	180	2	Lt. Radius, Lt. Ulna	(R)Di/ (U)Mi	(R)Op/ (U)Op	(R)OS/ (U)OS	5	(Lt)R:(IM) 0.6mm (Lt)U:8 Shaped wire 0.2mm	(Lt)R/U :16	29	Re (080-09483)
2017-0019	Cinereous vulture (*Aegypius monachus*)	8300	2	Rt. Radius, Rt. Elbow jt	(R)Pr	(R)Cl/ (Eljt)Lu	(R)Tr	3	(Rt)R/Ejt:Jt reduction/8Shaped Bandage	(Lt)R/Ejt :13	50	Re(150-00733 ,34(G/B))
2017-0080	Cinereous vulture (*Aegypius monachus*)	7340	2	Lt. Radius, Lt. Elbow jt	(R)Pr	(R)Cl/ (Eljt)Lu	(R)Tr	3	(Lt)R/Ejt:Jt reduction 8Shaped Bandage	(Rt)R/Ejt: 13	314	Re(150-00740 ,40(G/B))
2017-0135	Cinereous vulture (*Aegypius monachus*)	5740	2	Rt. Radius, Rt. Elbow jt	(R)Pr	(R)Cl+/ (Eljt)Lu+	(R)Tr	5	(Rt)R/Ejt:Jt reduction/ 8Shaped Bandage		37	Eu/Ankylosis

2017-0463	Common kestrel (*Falco tinnunculus*)	172	3	Rt. Radius, Rt. Ulna, Rt.Elbow jt, Lt. Tibiotarsus	(R)Mi/ (U)Mi/ (Ti)Mi	(R)Cl/ (U)Cl/ (Ti)Cl/ (Eljt)Lu	(R)Tr/ (U)Tr/ (Ti)Co	5	(Lt)R:(IM)0.8mm (Lt)U:8Shapedwire0.2 mm (Lt)Ejt:Jt reduction 8Shaped Bandage	(Lt)R/U:14	80	Re (080-09505)
2017-0579	Common kestrel (*Falco tinnunculus*)	134	1	Rt. Radius, Rt. Ulna	(R)Mi/ (U)Mi	(R)Cl+/ (U)Cl+	(R)Se/ (U)Co	7	(Rt)R:(IM) 0.8mm (Rt)U:(IM) 1.2mm		5	De/ malnutrition
2017-0852	Common kestrel (*Falco tinnunculus*)	134	1	Lt. Radius, Lt. Ulna	(R)Pr/ (U)Pr	(R)Op/ (U)Op	(R)Tr/ (U)OS	7	(Lt)R:(IM) 0.6mm (Lt)U:8 Shaped bandage	(Lt)R/U:14	57	Re (080-09511)
2017-0928	Japanese sparrowhawk (*Accipiter gularis*)	136	3	Rt. Radius, Rt. Ulna	(R)Mi/ (U)Mi	(R)Op/ (U)Op	(R)Co/ (U)Se	6	(Rt)R:(IM) 0.8mm (Rt)U:(IM) 1.2mm	(Rt)R:14 (Rt)U:23	228	Re (060-08306)
2018-0961	Oriental scops owl (*Otus sunia*)	70	2	Lt. Radius, Lt. Ulna	(R)Mi/ (U)Mi	(R)Op/ (U)Op	(R)Tr/ (U)Tr	4	(Lt)R:(IM) 0.7mm (Lt)U:(IM) 0.9mm	(Rt)R:23 (Rt)U:23	60	Eu/Flight Disorder
2018-1277	Common kestrel (*Falco tinnunculus*)	156	1	Lt. Radius, Lt. Ulna	(R)Pr/ (U)Pr	(R)Op/ (U)Op	(R)Tr/ (U)Co	8	(Lt)R:(IM) 0.6mm (Lt)U:(IM) 1.2mm	(Lt)R/(Lt)U :Still	5	Ca
Total	28											

[a]Pr=Proximal Third of the Bone; Mi=Middle Third of the Bone; Di=Distal Third of the Bone; (U)=Ulna; (R)=Radius; (Cc)=Coracoid; (Ti)=Tibiotarsus; (Tv)=Thoracic vert; (Eljt)=Elbow jt; (UB)=Upper beak
[b]Cl=Closed Fracture; Op=Open Fracture; +=Over time after fracture
[c]Tr=Transverse Fracture; OS=Oblique/Spiral Fracture; Co=Comminuted Fracture; Li=Linear Fracture; Se=Segmental Fracture; Si=Simple Fracture
[d]IM=Intramedully Pin; TIF=Tie-in Fixator; ESF=External Skeletal Fixator; (Rt)=Right; (Lt)=Left; R=Radius; U=Ulna; Eljt=Elbow jt; Cc=Coracoid
[e]Re=Released; Eu=Euthanased; Di=Died; Ca=Captive; Pe=Permenent disability

Fig 3. 4. Radiographs show an open, oblique/spiral fracture of the diaphyseal of the left ulna and an open, transverse fracture of the diaphyseal of the left radius in Common kestrel (*Falco tinnunculus)* 2016-0890 (A). The fracture was repaired using an IM pin and figure of eight wire technique. Post-operation figure (B), POD 7th (C), after pin removal on POD 13th (D), POD 25th (E), and POD 66th before the release (F).

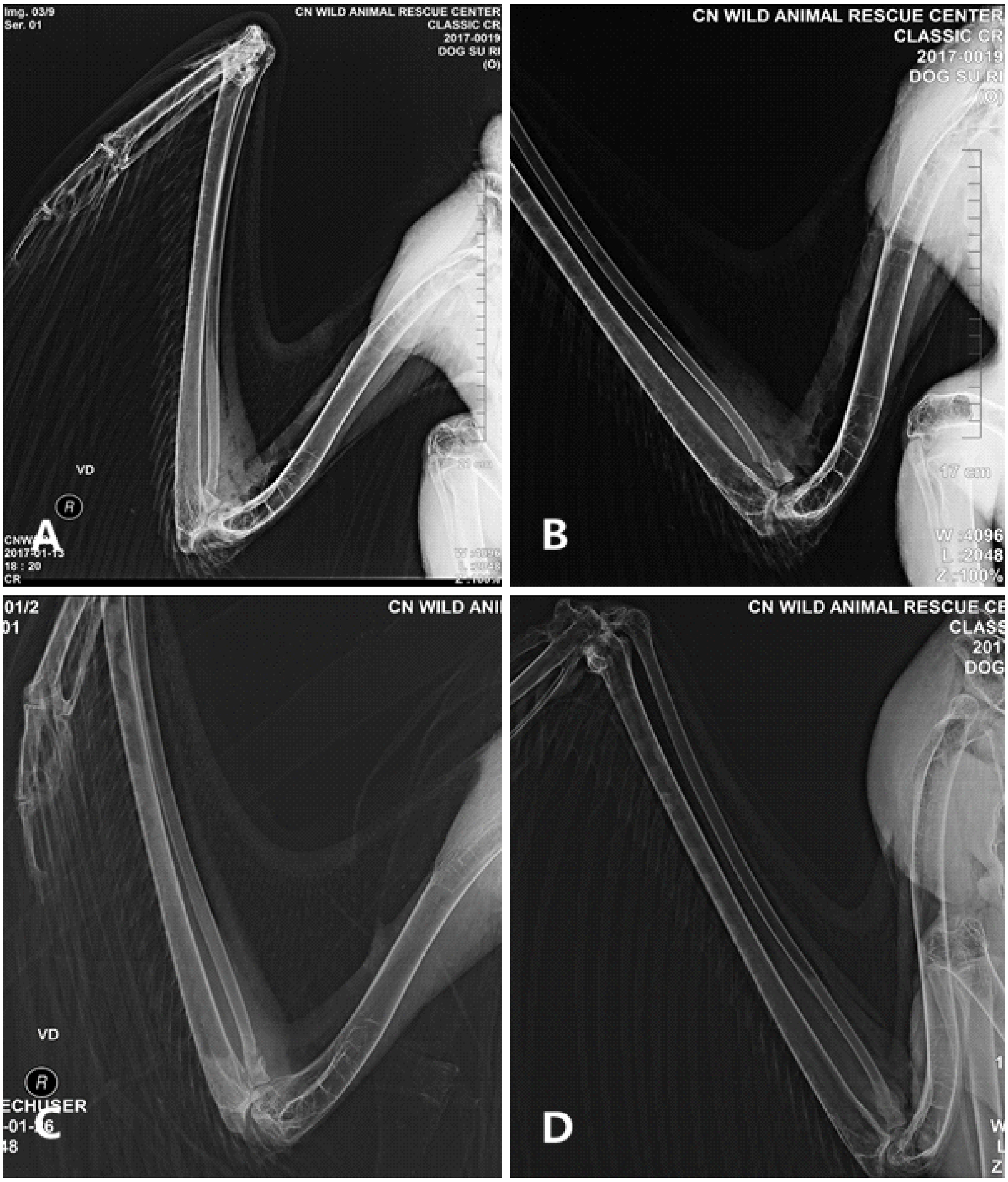

Fig 3. 5. Radiographs show a closed, transverse fracture of the proximal of the left radius closed fracture and ulna of elbow joint luxation in Cinereous vulture (*Aegypius monachus*) 2017-0019 (A). Radiographs were taken in order to confirm to reduction of the luxation site properly and accurately after figure of eight bandage (B), After treatment 13th day (C), after treatment 35th day before the release (D).

(5) Ulna fracture including other fractured sites

The data for 25 raptors that were occurred the fracture of other sites except ulnar fracture was tabulated (excluding humerus fracture, radius fracture) (Table 3.8).

In the case of 25 raptors occurred other fractures together with ulna fracture, there were 23 raptors that have only ulna fracture and 2 raptors that have ulna fracture including the other site fractures. The fracture location of the ulna was occupied as mentioned bellow; there were 4 cases (16.0%) in the proximal part, 16 cases (64.0%) in the diaphysis part and 5 cases (20.0%) in the distal part. Out of these, the most common part of the fracture was diaphysis.

The fracture condition was classed as the two cases such as 24 cases in closed fractures (96.0%) and 1 case in open fractures (4.0%). The fracture type was classified into 5 cases (20.0%) in the comminuted fracture, 6 cases (24.0%) in the transverse fracture of simple fracture, 9 cases (36.0%) in the oblique/spiral fracture of simple fracture, 4 cases (16.0%) in the segmental fractures and 1 case (4.0%) in the linear fracture.

One raptor was excluded from the data because of being died before the treatment of the ulnar. Within the 24 raptors that medically treated for fracture of ulna and other fractures, the results of ulna fracture treatment methods were classed as follows; there were 15 raptors (62.5%) in case of using figure of eight bandage, 6 raptors (25.0%) in case of using IM pin and 2 raptors (8.3%) in case of using IM pin with wire. Out of these, figure of eight bandage was used most frequently (Fig 3.6).

The average union time that measured for 21 individuals was 17.6(±6.5) days after the initiation of ulnar fracture surgery or bandage treatment.

Table 3. 8. Classification of fractured ulna with other sites on 25 individuals

Registration Number	Species Name	Physical condition		Description of fracture				Clinical category	Treatment method[d]	Interval to union or removal of fixator(day)	period	Outcome (Identification metal ring)[e]
		Weight (g)	BCS	Fracture Site	Fracture Zone[a]	Fracture Condition[b]	Fracture Type[c]					
2014-0145	Common kestrel (*Falco tinnunculus*)	128	1	Lt. Ulna	(U)Mi	(U)Cl	(U)OS	2	(Lt)U:8 Shaped Bandage	(Lt)U:17	33	Re (080-05903)
2014-0168	Brown hawk owl (*Ninox scutulata*)	164	3	Lt. Ulna	(U)Mi	(U)Cl	(U)Tr	1	(Lt)U:IM 1.6mm	(Lt)U:14	31	Re (080-05912)
2014-0445	Common kestrel (*Falco tinnunculus*)	202	3	Rt. Ulna	(U)Mi	(U)Cl	(U)Tr	1	(Rt)U:1.4mm	(Rt)U:16	150	Re (080-05929)
2014-0689	Collared scops owl (*Otus semitorques*)	198	2	Lt. Ulna	(U)Mi	(U)Cl	(U)Co	1	(Lt)U:8 Shaped Bandage	(Lt)U:12	51	Re (080-05947)
2015-0008	Common kestrel (*Falco tinnunculus*)	198	3	Lt. Ulna	(U)Mi	(U)Cl	(U)Se	2	(Lt)U:8 Shaped Bandage	(Lt)U:15	160	Re (080-05949)
2015-0009	White-tailed eagle (*Haliaeetus albicila*)	3740	2	Rt. Ulna	(U)Pr	(U)Cl	(U)Co	3	(Rt)U:8 Shaped Bandage	(Rt)U:13	298	Re (140-01387)
2015-0013	Eurasian Sparrow hawk (*Accipiter nisus*)	238	2	Lt. Ulna	(U)Mi	(U)Cl	(U)Co	2	(Lt)U:8 Shaped Bandage		8	De/Unknown
2015-0079	Collared scops owl (Otus semitorques)	238	2	Lt. Ulna	(U)Pr	(U)Cl	(U)Co	3	(Lt)U:8 Shaped Bandage	(Lt)U:13	31	Re (080-05956)
2015-0206	Eurasian eagle owl (*Bubo bubo*)	2196	2	Rt. Ulna	(U)Di	(U)Cl	(U)OS	2	(Rt)U:8 Shaped Bandage	(Rt)U:13	170	Re (140-01369)
2015-0710	Brown hawk owl (*Ninox scutulata*)	156	2	Lt. Ulna	(U)Pr	(U)Cl	(U)OS	2	(Lt)U:8 Shaped Bandage	(Lt)U:13	25	Re (080-06839)
2015-0724	Oriental scops owl (*Otus sunia*)	92	3	Rt. Ulna	(U)Mi	(U)Cl	(U)OS	1	(Rt)U:8 Shaped Bandage		26	Eu/Accident in cage
2016-0002	Eurasian buzzard (*Buteo buteo*)	846	2	Lt. Ulna	(U)Mi	(U)Cl	(U)OS	1	(Lt)U:8 Shaped Bandage	(Lt)U:8	31	Re
2016-0040	Northern goshawk (*Accipiter gentilis*)	1052	3	Lt. Ulna	(U)Di	(U)Op	(U)Co	4	(Lt)U:8 Shaped Bandage	(Lt)U:14	48	Re (110-02695)
2016-0091	Eurasian Sparrow hawk (*Accipiter nisus*)	242	3	Lt. Ulna	(U)Mi	(U)Cl	(U)Se	2	(Lt)U:8 Shaped Bandage	(Lt)U:22	30	Re (070-00133)
2016-0607	Eurasian eagle owl (*Bubo bubo*)	1962	3	Rt. Tarsometatarsus, Lt. Ulna	(U)Mi/ (Ta)Mi	(U)Cl/ (Ta)Cl	(U)OS/ (Ta)Tr	2	(Lt)U:8 Shaped Bandage (Rt)Ta :(Type2) ESF 1.1mm (4)	(Lt)U:28 (Rt)Ta:28	862	Ca

2017-0047	Common kestrel (*Falco tinnunculus*)	248	3	Rt. Ulna	(U)Mi	(U)Cl	(U)Se	2	(Rt)U:IM 1.6mm	(Rt)U:21	64	Re (080-09408)
2017-0051	Northern goshawk (*Accipiter gentilis*)	560	2	Lt. Ulna	(U)Mi	(U)Cl	(U)Se	2	(Lt)U:IM 1.6mm/ Reoperation ESF 1.1mm (3)	(Lt)U:30 Ununion/Reoperation 16	85	Re (100-12001)
2017-0054	Eurasian Sparrow hawk (*Accipiter nisus*)	256	3	Rt. Ulna	(U)Di	(U)Cl	(U)Tr	2	(Rt)U:1.6mm Semi wire 0.2mm	(Lt)U:31	57	Re (070-00149
2017-0676	Eurasian eagle owl (*Bubo bubo*)	1448	1	Rt. Ulna	(U)Mi	(U)Cl	(U)OS	2	(Lt)U:8 Shaped Bandage		5	De/ malnutrition
2017-0696	Common kestrel (*Falco tinnunculus*)	140	1	Rt. Ulna	(U)Pr	(U)Cl	(U)Tr	3	Death before operation		3	De/ malnutrition
2017-0899	Brown hawk owl (*Ninox scutulata*)	210	2	Lt. Ulna	(U)Mi	(U)Cl	(U)OS	1	(Lt)U:IM 1.2mm Cerclage wire 0.2mm	(Lt)U:20	381	Re (080-09538)
2018-0045	Cinereous vulture (*Aegypius monachus*)	6320	1	Rt. Carpometacarpus, Rt. Ulna	(U)Di/ (Cp)Mi	(U)Cl/ (Cp)Cl	(U)Li/ (Cp)OS	4	(Rt)U/Cp:8 Shaped Bandage	(Rt)Cp/U:14	299	Ca (150-00746)
2018-0247	Brown hawk owl (*Ninox scutulata*)	196	3	Lt. Ulna	(U)Mi	(U)Cl	(U)Tr	1	(Lt)U:IM 1.2mm	(Lt)U:33	73	Re
2018-0625	Oriental scops owl (*Otus sunia*)	50	2	Rt. Ulna	(U)Mi	(U)Cl	(U)Tr	1	(Rt)U:IM 1.0mm	(Rt)U:14	37	Re (050-07340)
2018-0757	Peregrine falcon (*Falco peregrinus*)	478	1	Lt. Ulna	(U)Di	(U)Cl	(U)OS	3	(Lt)U:Cerclage wire 0.3mm	(Lt)U:22	65	Re (100-12055)
Total	28											

[a]Pr=Proximal Third of the Bone; Mi=Middle Third of the Bone; Di=Distal Third of the Bone; (U)=Ulna; (Ca)=Carpometacarpus; (Ta)=Tarsometatarsus
[b]Cl=Closed Fracture; Op=Open Fracture; +=Over time after fracture
[c]Tr=Transverse Fracture; OS=Oblique/Spiral Fracture; Co=Comminuted Fracture; Li=Linear Fracture; Se=Segmental Fracture; Si=Simple Fracture
[d]IM=Intramedully Pin; TIF=Tie-in Fixator; ESF=External Skeletal Fixator; (Rt)=Right; (Lt)=Left; U=Ulna; Ca=Carpometacarpus; Ta=Tarsometatarsus
[e]Re=Released; Eu=Euthanased; Di=Died; Ca=Captive; Pe=Permenent disability

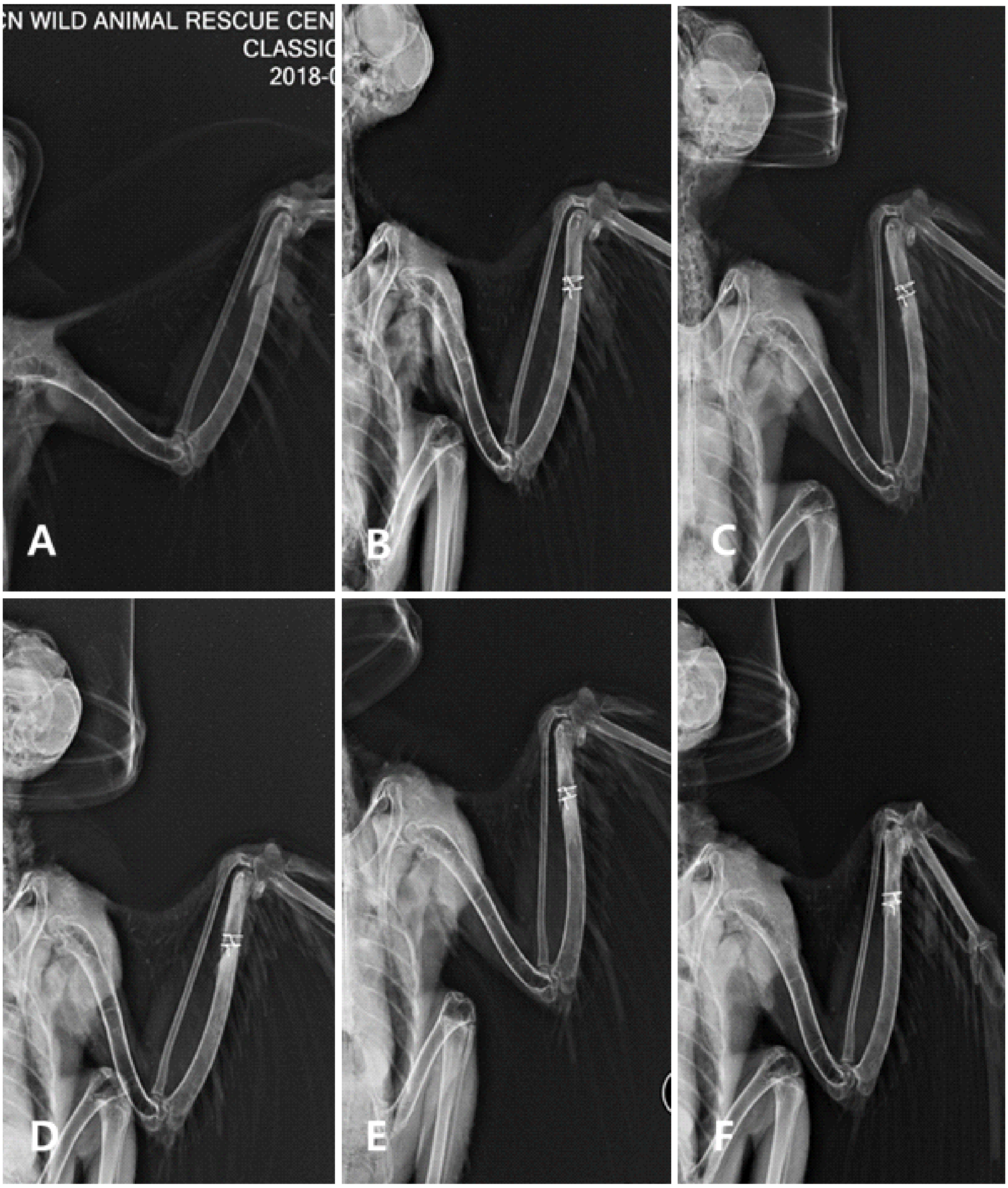

Fig 3. 6. Radiographs show a closed, oblique/spiral fracture of the distal of the left ulna in Peregrine falcon (*Falco peregrinus*) 2018-0757 (A). The fracture was repaired using a wire in ulna. Post-operation figure (B), POD 7th (C), POD 15th (D), after figure of eight bandage removal on POD 22th (E), and POD 37th before the release (F).

(6) Carpometacarpus fracture including the fracture of other sites

The data for 19 raptors that was occurred the fracture of carpometacarpus and other fractures (excluding humerus fracture, radius fracture and ulna fracture) was tabulated (Table 3.9).

In the case of 19 raptors with the fracture of carpometacarpus and other fractures, there were 17 raptors that had only carpometacarpus fracture and 2 raptors that had the fractures of other sites including carpometacarpus fractures. The fracture location (zone) of the carpometacarpus was occupied as mentioned bellow; there were 9 cases (47.4%) in the proximal part, 4 cases (21.1%) in the diaphysis part and 6 cases (31.6%) in the distal part. Out of these, the most common part of fracture was proximal part. The fracture condition of the carpometacarpus was classed as 10 cases in the closed fractures (52.6%) and 9 cases in the open fractures (47.4%). The fracture type of the carpometacarpus was classified into 4 cases (21.1%) in the comminuted fracture, 6 cases (31.6%) in the transverse fracture of simple fracture and 9 cases (47.4%) in the oblique/spiral fracture of simple fracture.

Within the 19 raptors that medically treated for only fracture of carpometacarpus and other site, the results of those were classed as follows; there were 9 raptors (47.4%) in case of using U shaped splint, 5 raptor (26.3%) in case of using IM pin, 2 raptors (10.5%) in case of using TIF, 2 raptors (10.5%) in case of using Type I and 1 raptor (5.3%) in case of using wire (Fig 3.7).

Table 3. 9. Classification of fractured carpometacarpus with other sites on 19 individuals

Registration Number	Species Name	Physical condition		Description of fracture				Clinical category	Treatment method[d]	Interval to union or removal of fixator(day)	period	Outcome (Identification metal ring)[e]
		Weight (g)	BCS	Fracture Site	Fracture Zone[a]	Fracture Condition[b]	Fracture Type[c]					
2014-0021	Long-eared owl (*Asio otus*)	272	2	Rt. Carpometacarpus	(Cp)Di	(Cp)Op+	(Cp)OS	4	(Rt)Cp:IM 1.0mm		196	Eu/Necrosis
2014-0041	Common kestrel (*Falco tinnunculus*)	222	3	Lt. Carpometacarpus	(Cp)Pr	(Cp)Op+	(Cp)OS	4	(Lt)Cp:U Shaped Splint	(Lt)Cp:21	175	De/Accident in cage
2014-0394	Brown hawk owl (*Ninox scutulata*)	176	3	Rt. Carpometacarpus	(Cp)Pr	(Cp)Op	(Cp)OS	3	(Rt)Cp:IM 1.0mm		23	Eu/Nonunion
2014-0471	Common kestrel (*Falco tinnunculus*)	204	3	Rt. Carpometacarpus	(Cp)Pr	(Cp)Cl	(Cp)Tr	2	(Rt)Cp:(Type1) ESF 0.9mm (2)	(Rt)Cp:36	77	Re (080-05942)
2014-0536	Common kestrel (*Falco tinnunculus*)	142	2	Rt. Carpometacarpus	(Cp)Di	(Cp)Cl	(Cp)Co	3	(Rt)Cp:U Shaped Splint	(Rt)Cp:33	52	Re
2014-0708	Eurasian buzzard (*Buteo buteo*)	716	2	Lt. Carpometacarpus	(Cp)Di	(Cp)Op+	(Cp)OS	4	(Lt)Cp:Cerclage wire 0.2mm/U Shaped Splint	(Lt)Cp:12 removed Cerclage wire:35	87	Re
2015-0184	Eurasian hobby (*Falco subbuteo*)	170	3	Rt. Carpometacarpus	(Cp)Pr	(Cp)Cl	(Cp)Tr	2	(Rt)Cp:IM 0.8mm		15	Eu/Necrosis
2015-0600	Eurasian eagle owl (*Bubo bubo*)	2048	2	Rt. Carpometacarpus	(Cp)Mi	(Cp)Op	(Cp)OS	2	(Rt)Cp:U Shaped Splint		3	De/Unknown
2015-0656	Eurasian hobby (*Falco subbuteo*)	178	2	Rt. Carpometacarpus	(Cp)Pr	(Cp)Cl	(Cp)OS	2	(Rt)Cp:U Shaped Splint	(Rt)Cp:12	40	Re (070-00129)
2016-0534	Brown hawk owl (*Ninox scutulata*)	156	2	Lt. Carpometacarpus Rt. Scapula	(Cp)Di	(Cp)Cl/ (Sc)Cl	(Cp)OS/ (Sc)Tr	3	(Lt)Cp:U Shaped Splint	(Lt)Cp:15	44	Re (080-09464)
2016-0557	Eurasian hobby (*Falco subbuteo*)	190	3	Rt. Carpometacarpus	(Cp)Di	(Cp)Op	(Cp)Tr	3	(Rt)Cp:U Shaped Splint	(Rt)Cp:17	50	Re (070-00143)
2016-0761	Brown hawk owl (*Ninox scutulata*)	174	2	Rt. Carpometacarpus	(Cp)Di	(Cp)Op+	(Cp)OS	4	(Rt)Cp:U Shaped Splint	(Lt)Cp:28	48	De/Accident in cage
2016-0828	Common kestrel (*Falco tinnunculus*)	190	3	Lt. Carpometacarpus	(Cp)Pr	(Cp)Cl	(Cp)OS	2	(Lt)Cp:IM 0.6mm		37	Eu/Necrosis

2017-0118	Eurasian buzzard (*Buteo buteo*)	1012	3	Lt. Carpometacarpus	(Cp)Pr	(Cp)Op	(Cp)Co	4	(Lt)Cp:(Type1) ESF 0.9mm (4)	(Lt)Cp:21	53	Re
2017-0249	Common kestrel (*Falco tinnunculus*)	176	3	Lt. Carpometacarpus Rt. Coracoid	(Cp)Mi	(Cp)Cl/ (Cc)Cl	(Cp)Tr/ (Cc)Tr	2	(Lt)Cp:IM 1.0mm (Rt)Cc:IM 1.0mm	(Lt)Cp:18 (Rt)Cc:18	165	Re (080-09499)
2017-0341	Eurasian hobby (*Falco subbuteo*)	156	2	Lt. Carpometacarpus	(Cp)Mi	(Cp)Cl	(Cp)Co	2	(Lt)Cp:U Shaped Splint	(Lt)Cp:21	53	Re (080-09501)
2017-0895	Common kestrel (*Falco tinnunculus*)	178	2	Rt. Carpometacarpus	(Cp)Mi	(Cp)Cl	(Cp)Co	2	(Rt)Cp:U Shaped Splint	(Rt)Cp:19	36	Re (080-09510)
2018-0017	Eurasian eagle owl (*Bubo bubo*)	1490	2	Rt. Carpometacarpus	(Cp)Pr	(Cp)Cl	(Cp)Tr	2	(Rt)Cp:(TIF)IM 1.2mm ESF 0.9mm (2)	(Rt)Cp:30	86	Re (140-01892)
2018-0689	Eurasian eagle owl (*Bubo bubo*)	1498	2	Lt. Carpometacarpus	(Cp)Pr	(Cp)Op	(Cp)Tr	3	(Rt)Cp:(TIF)IM 1.2mm ESF 1.1mm (2) 0.9mm (1)	(Rt)Cp:21	113	Re (140-01906)
Total	19											

[a]Pr=Proximal Third of the Bone; Mi=Middle Third of the Bone; Di=Distal Third of the Bone; (Ca)=Carpometacarpus; (Cc)=Coracoid; (Sc)=Scapula
[b]Cl=Closed Fracture; Op=Open Fracture; +=Over time after fracture
[c]Tr=Transverse Fracture; OS=Oblique/Spiral Fracture; Co=Comminuted Fracture; Li=Linear Fracture; Se=Segmental Fracture; Si=Simple Fracture
[d]IM=Intramedully Pin; TIF=Tie-in Fixator; ESF=External Skeletal Fixator; (Rt)=Right; (Lt)=Left; U=Ulna; Ca=Carpometacarpus; Cc=Coracoid; Sc=Scapula
[e]Re=Released; Eu=Euthanased; Di=Died; Ca=Captive; Pe=Permenent disability

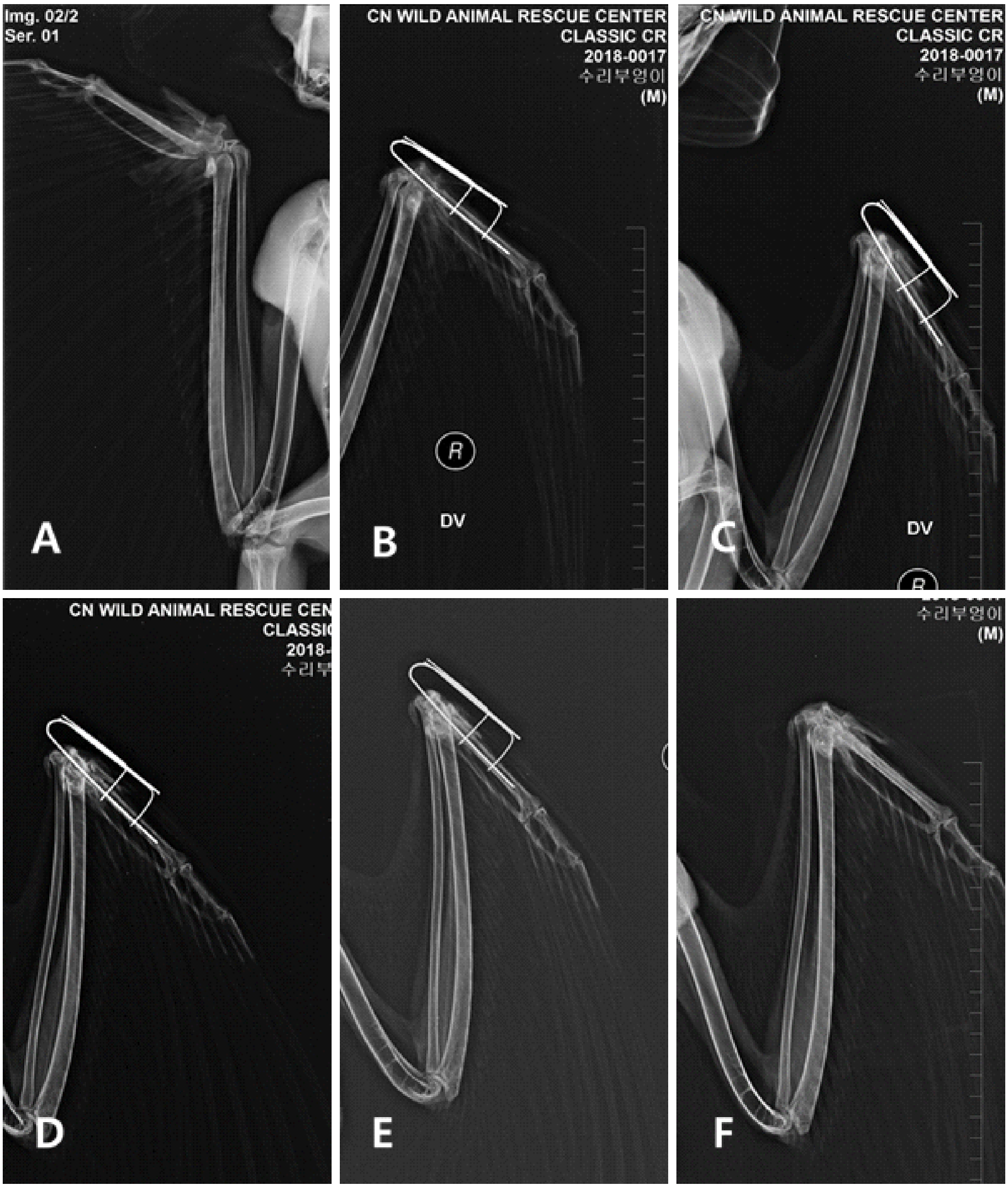

Fig 3. 7. Radiographs show a closed, Transverse fracture of the Proximal of the right carpometacarpus in Eurasian eagle owl (*Bubo bubo*) 2018-0017 (A). The fracture was repaired using an IM pin and ESF pin technique. Post-operation figure (B), POD 7th (C), POD 13th (D), POD 20th day (E), and after pin removal on POD 30th before the release (F).

(7) Femur fracture including other fractured sites

The data for 9 raptors that was generated the fracture of femur and other fracture (excluding humerus fracture, radius fracture, ulna fracture and carpometacarpus fracture) was tabulated (Table 3.10).

In the case of 9 raptors that had other fractures together with the fracture of femur, there were 4 raptors that have only femur fracture, and 5 raptors that had the femur fracture including the other site fractures. There were 9 individuals with confirmed the femur fractures. However, one raptor showed both sides the femur fractures, and then 10 cases of the femur fractures were verified. The fracture location (zone) of the femur was occupied as mentioned bellow; there were 3 cases (30.0%) in the proximal part, 4 cases (40.0%) in the diaphysis part and 3 cases (30.0%) in the distal part. All of the fracture conditions of 10 cases (100.0%) were appeared to the closed fractures. The fracture type of the femur was classified into 1 case (10.0%) in the comminuted fracture, 8 cases (80.0%) in the transverse fracture of simple fracture and 1 case (10.0%) in the oblique/spiral fracture of simple fracture.

Within the 8 raptors that medically treated for fracture of femur and other site, the results of the femur fracture treatment were classed as follows; 4 raptors (50.0%) in case of using TIF, 2 raptors (15.0%) %) in case of using splint, 1 raptor (12.5%) in case of using IM pin, and 1 raptor (12.5%) in case of using cross pinning and ESF (Fig 3.8).

Table 3. 10. Classification of fractured femur with other sites on 9 individuals

Registration Number	Species Name	Physical condition		Description of fracture				Clinical category	Treatment method[d]	Interval to union or removal of fixator(day)	period	Outcome (Identification metal ring)[e]
		Weight (g)	BCS	Fracture Site	Fracture Zone[a]	Fracture Condition[b]	Fracture Type[c]					
2014-0092	Eurasian eagle owl (*Bubo bubo*)	1570	3	Lt. Femur, Lt. Furcula, Lt. Coracoid	(F)Mi	(F)Cl/ (Cc)Cl/ (Fu)Cl	(F)Tr/ (Cc)Tr/ (Fu)Tr	3	(Lt)F:(TIF) IM 2.4mm ESF 2.0mm (Lt)Cc: IM 2.2mm	(Lt)F:IM24/ ESF31 (Lt)Cc/Fu:28	101	Re (140-01362)
2014-0144	Eurasian eagle owl (*Bubo bubo*)	1840	2	Rt. Femur, Rt. Scapula	(F)Pr	(F)Cl/ (Sc)Cl	(F)Tr/ (Sc)Tr	3	(Rt)F:Splint (Rt)Sc:Bandage	(Rt)F:Splint (Rt)Sc:14	507	Re
2015-0457	Common kestrel (*Falco tinnunculus*)	142	2	Lt. Femur	(F)Pr	(F)Cl	(F)Tr	2	(Lt)F:IM 1.2mm	(Lt):13	66	Re (080-06819)
2016-0125	Northern goshawk (*Accipiter gentilis*)	610	2	Rt. Femur	(F)Mi	(F)Cl	(F)Co	2	(Rt)F:Splint		8	De/Unknown
2016-0175	Common kestrel (*Falco tinnunculus*)	146	2	Lt. Femur	(F)Mi	(F)Cl	(F)Tr	1	(Lt)F:(TIF)IM 1.2mm ESF 1.2mm	(Lt)F:14	21	Re (080-06860)
2016-0830	Common kestrel (*Falco tinnunculus*)	122	1	Rt. Femur, Lt. Tibiotarsus	(F)Di/ (Ti)Pr	(F)Cl/ (Ti)Cl	(F)Tr/ (Ti)Tr	5			7	De/Death before operation (malnutrition)
2017-0693	Common kestrel (*Falco tinnunculus*)	228	2	Rt. Femur, Lt. Carpometacarpus Lt. Femur, Lt. Tibiotarsus	(RtF)Di/ (LtF)Mi/ (LtTi)Mi/ (LtCp)Mi	(RtF)Cl/ (LtF)Cl/ (LtTi)Cl/ (LtCp)Op	(RtF)OS /(LtF)Tr/ (LtTi)Tr/ (LtCp)Tr	5	(Lt)F/(Rt)F:(TIF) IM 0.9mm ESF 0.6mm (2) (Lt)Cp:IM 1.0mm (Lt)Ti:IM 0.9mm		3	De/Unknown
2018-0132	Eurasian buzzard (*Buteo buteo*)	724	2	Lt. Femur Rt. Furcula Rt. Coracoid	(F)Di/ (Cc)Di/ (Fu)Di	(F)Cl/ (Cc)Cl/ (Fu)Cl	(F)Tr/ (Cc)Tr/ (Fu)Tr	6	(Lt)F:Cross pin: 0.9mm (2) ESF 1.6mm (2) (Rt)Cc:8 Shaped bandage	(Lt)F:26 (Rt)Cc:19	41	De/Unknown

2018-0950	Eurasian eagle owl (*Bubo bubo*)	1136	1	Lt. Femur	(F)Pr	(F)Cl	(F)Tr	3		9	De/Death before operation (malnutrition)
Total	9										

[a]Pr=Proximal Third of the Bone; Mi=Middle Third of the Bone; Di=Distal Third of the Bone; (F)=Femor; (Fu)=Furcula; (Cc)=Coracoid; (Ti)=Tibiotarsus; (Ca)=Carpometacarpus
[b]Cl=Closed Fracture; Op=Open Fracture; +=Over time after fracture
[c]Tr=Transverse Fracture; OS=Oblique/Spiral Fracture; Co=Comminuted Fracture; Li=Linear Fracture; Se=Segmental Fracture; Si=Simple Fracture
[d]IM=Intramedully Pin; TIF=Tie-in Fixator; ESF=External Skeletal Fixator; (Rt)=Right; (Lt)=Left; F=Femor; Fu=Furcula; Cc=Coracoid; Ti=Tibiotarsus; Ca=Carpometacarpus
[e]Re=Released; Eu=Euthanased; Di=Died; Ca=Captive; Pe=Permenent disability

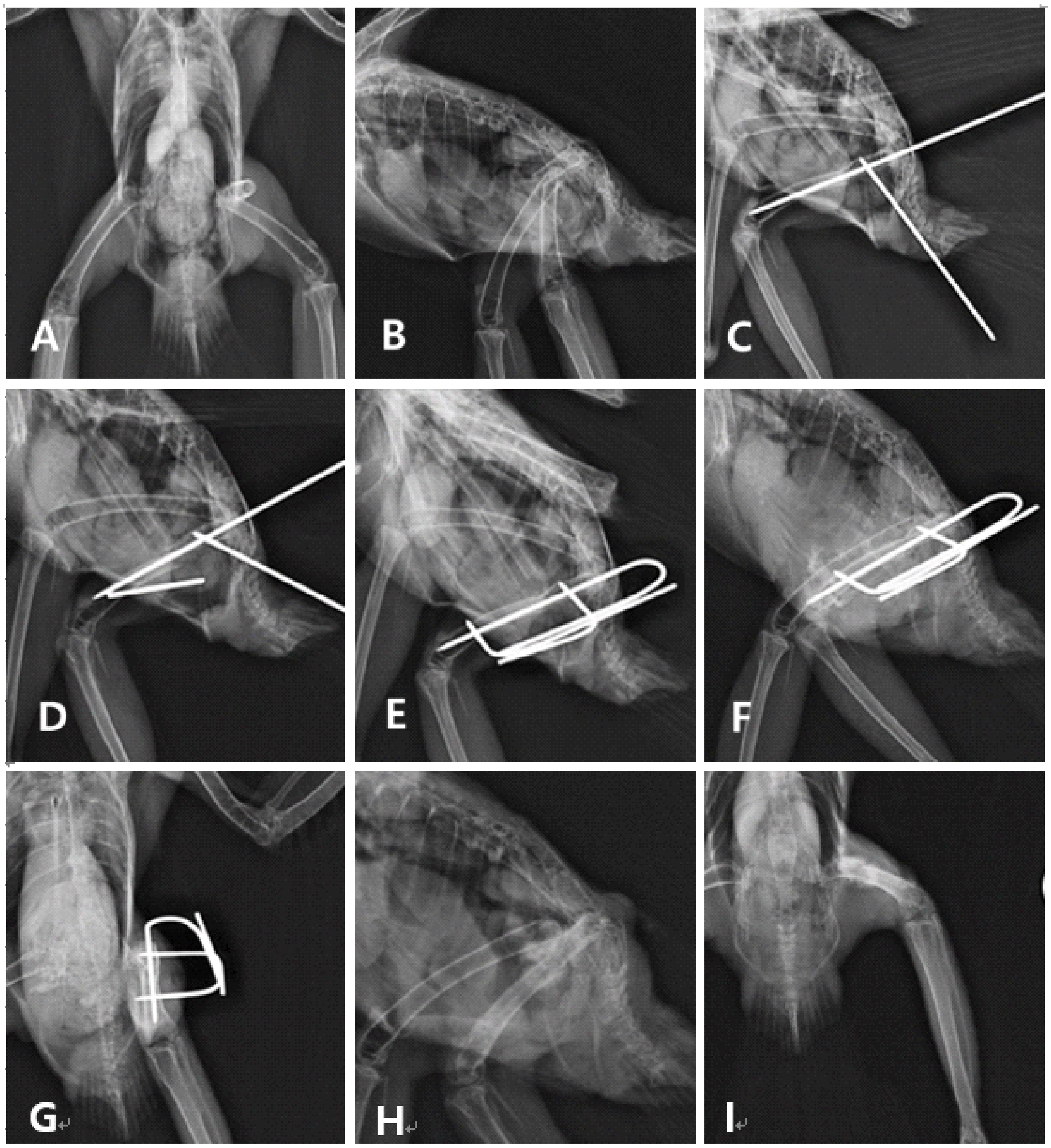

Fig 3. 8. Ventrodorsal radiograph show a closed, transverse fracture of the diaphyseal of the left femur in Common kestrel (*Falco tinnunculus*) 2016-0175 (A), lateral right view of the left femur (B), radiographs were taken several times in order to confirm to be fixed TIF properly and accurately during operation (C, D), post-operation figure (E), POD 7th (F, G), after pin removal on POD 14th before the release (H, I).

(8) Tibiotarsus fracture including the fracture of other sites

The data for 16 raptors that was generated fracture of tibiotarsus and other fracture (excluding humerus fracture, radius fracture, ulna fracture, carpometacarpus fracture and femur fracture) was tabulated (Table 3.11).

In the case of 16 raptors that had other fractures together with fracture of tibiotarsus, there were 11 raptors that have only the tibiotarsus fracture and 5 raptors that had the tibiotarsus fracture including the other site fractures. There were 16 individuals with confirmed the femur fractures. However, one raptor showed both side of the tibiotarsus fractures, and then 17 cases of the tibiotarsus fractures were verified. The fracture location (zone) of the tibiotarsus was occupied as mentioned below; there were 4 cases (23.5%) in the proximal part, 12 cases (70.6%) in the diaphysis part and 1 case (5.9%) in the distal part. Out of these, the most common part of fracture was diaphysis. The fracture conditions of tibiotarsus were 17 cases (100.0%) of the closed fractures. The fracture type of tibiotarsus was classified into 1 case (5.9%) in the comminuted fracture, 10 cases (58.8%) in the transverse fracture of simple fracture, 5 cases (29.4%) in the oblique/spiral fracture of simple fracture and 1 case (5.9%) in the linear fractures.

Within the 17 cases of raptors that medically treated for fracture of tibiotarsus and other site, the results of the tibiotarsus fracture treatment were classed as follows; 10 raptors (58.8%) in case of using splint, 3 raptors (17.6%) in case of using TIF, 3 raptor (17.6%) in case of using IM pin and 1 raptor (5.9%) in case of using IM pin with wire (Fig 3.9). Out of these, splint was used most frequently.

Table 3. 11. Classification of fractured tibiotarsus with other sites on 16 individuals

Registration Number	Species Name	Physical condition		Description of fracture				Clinical category	Treatment method[d]	Interval to union or removal of fixator(day)	period	Outcome (Identification metal ring)[e]
		Weight (g)	BCS	Fracture Site	Fracture Zone[a]	Fracture Condition[b]	Fracture Type[c]					
2014-0455	Oriental scops owl (*Otus sunia*)	50	3	Lt. Tibiotarsus, Lt. Tarsal jt	(Ti)Mi	(Ti)Cl/ (Tajt)Lu	(Ti)Li	2	(Lt)Ti:Splint		9	De/Unknown
2014-0481	Oriental scops owl (*Otus sunia*)	52	2	Rt. Tibiotarsus	(Ti)Mi	(Ti)Cl	(Ti)Tr	1	(Rt)Ti:Splint	(Rt)Ti:12	48	Re(060-05943)
2014-0523	Oriental scops owl (*Otus sunia*)	52	2	Rt. Tibiotarsus, Lt. Tibiotarsus	(RtTi)Mi/ (LtTi)Mi	(RtTi)Cl/ (LtTi)Cl	(RtTi)Tr/ (LtTi)Tr	2	(Rt)/(Lt)Ti: Splint		3	De/Unknown
2015-0210	Common kestrel (*Falco tinnunculus*)	158	2	Rt. Tibiotarsus	(Ti)Pr	(Ti)Cl	(Ti)OS	2	(Rt)Ti:Splint		3	De/Unknown
2015-0281	Tawny owl (*Strix aluco*)	354	2	Lt. Tibiotarsus	(Ti)Pr	(Ti)Cl	(Ti)Tr	2	(Rt)Ti:Splint	(Rt)Ti:9	164	Re(110-02690)
2016-0056	Northern goshawk (*Accipiter gentilis*)	1110	3	Rt. Tibiotarsus, Rt. Coracoid	(Ti)Mi	(Ti)Cl/ (Cc)Cl	(Ti)Co/ (Cc)Tr	3	(Rt)Ti:Splint (Rt)Cc :8 Shaped bandage	(Rt)Ti:21/ Cc:14	111	Re(110-02696)
2016-0296	Eurasian eagle owl (*Bubo bubo*)	1522	2	Rt. Tibiotarsus	(Ti)Mi	(Ti)Cl	(Ti)OS	1	(Rt)Ti:(TIF)IM 1.3mm ESF 1.6mm (2)	(Rt)Ti:25	154	Re(140-01874)
2016-0344	Common kestrel (*Falco tinnunculus*)	220	3	Lt. Tibiotarsus	(Ti)Mi	(Ti)Cl	(Ti)Tr	1	(Lt)Ti:Splint	(Lt)Ti:20	55	Re(080-06889)
2016-0362	Eurasian hobby (*Falco subbuteo*)	160	1	Lt. Tibiotarsus, Lt. Coracoid	(Ti)Mi	(Ti)Cl/ (Cc)Cl	(Ti)Tr/ (Cc)OS	3	(Lt)Ti:IM 0.9mm	(Lt)Ti/Cc:11	50	Re(070-00136)
2016-0641	Oriental scops owl (*Otus sunia*)	60	3	Rt. Tibiotarsus	(Ti)Mi	(Ti)Cl	(Ti)Tr	1	(Rt)Ti:Splint		9	De/Unknown
2016-0755	Brown hawk owl (*Ninox scutulata*)	176	3	Rt. Tibiotarsus	(Ti)Pr	(Ti)Cl	(Ti)OS	2	(Rt)Ti:(TIF) IM 1.1mm ESF 0.9mm (1)	(Rt)Ti:7	15	Re(080-09472)
2016-0823	Brown hawk owl	180	3	Lt.	(Ti)Mi	(Ti)Cl	(Ti)Tr	1	(Lt)Ti:IM	(Lt)Ti:21	34	De/Accident in

	(*Ninox scutulata*)			Tibiotarsus					1.0mm Cerclage wire 0.2mm			cage
2017-0306	Common kestrel (*Falco tinnunculus*)	146	2	Rt. Tibiotarsus	(Ti)Mi	(Ti)Cl	(Ti)Tr	1	(Rt)Ti:IM 1.0mm	(Rt)Ti:11	22	Re(080-09444)
2017-0359	Common kestrel (*Falco tinnunculus*)	202	3	Rt. Tibiotarsus	(Ti)Mi	(Ti)Cl	(Ti)Tr	1	(Rt)Ti:IM 1.0mm		13	Eu/Necrosis
2017-0539	Oriental scops owl (*Otus sunia*)	64	2	Lt. Tibiotarsus, Rt. Ribs	(Ti)Di	(Ti)Cl/ (Ri)Cl	(Ti)Os/ (Ri)Si	3	(Rt)Ti:Splint	(Rt)Ti:21 (Rt)Ri:9	35	Re(060-05992)
2017-0964	Eurasian eagle owl (*Bubo bubo*)	1220	1	Lt. Tibiotarsus	(Ti)Pr	(Ti)Cl+	(Ti)OS	4	(Lt)Ti:(TIF) IM 2.0mm ESF 2.0mm (3)		4	De/ (malnutrition)
Total	16											

[a]Pr=Proximal Third of the Bone; Mi=Middle Third of the Bone; Di=Distal Third of the Bone; (Ti)=Tibiotarsus; (Cc)=Coracoid; (Tajt)=Tarsal jt
[b]Cl=Closed Fracture; Op=Open Fracture; +=Over time after fracture
[c]Tr=Transverse Fracture; OS=Oblique/Spiral Fracture; Co=Comminuted Fracture; Li=Linear Fracture; Se=Segmental Fracture; Si=Simple Fracture
[d]IM=Intramedully Pin; TIF=Tie-in Fixator; ESF=External Skeletal Fixator; (Rt)=Right; (Lt)=Left; Ti=Tibiotarsus; Cc=Coracoid; Tajt=Tarsal jt
[e]Re=Released; Eu=Euthanased; Di=Died; Ca=Captive; Pe=Permenent disability

Fig 3. 9. Radiographs show a closed, oblique/spiral fracture of the proximal of the right tibiotarsus in Brown hawk owl (*Ninox scutulata*) 2016-0755 (A), lateral right view of the right tibiotarsus (B), radiographs were taken several times in order to confirm to be fixed IM pin and ESF pin properly and accurately during operation (C), POD 5th, ventrodorsal view (D), and lateral Right view (E), after pin removal on POD 7th (F).

(9) Coracoid fracture including the fracture of other sites

The data for 28 raptors that was generated other fracture together with the fracture of coracoid (excluding humerus fracture, radius fracture, ulna fracture, carpometacarpus fracture, femur fracture, tibiotasus fracture) was tabulated (Table 3.12). The fracture location of coracoid was excluded from the data because it was difficult to determine accurately it.

In the case of 28 raptors that had other fractures together with the fracture of coracoid, there were only 11 raptors had the coracoid fracture, and the 17 raptors had the coracoid fracture including the other site fractures. The 13 raptors of the 17 raptors with the coracoid fracture were found to have the furcular fracture. The fracture conditions of coracoid were 28 cases (100.0%) of the closed fractures. The fracture type of coracoid was classified into 2 cases (7.1%) in the comminuted fracture, 21 cases (75.0%) in the transverse fracture of simple fracture and 5 cases (17.9%) in the oblique/spiral fracture of simple fracture.

Within the 28 raptors that medically treated for the fracture of coracoid, the results were classed as follows; 23 raptors (82.1%) in case of using figure of eight bandage for restrict movement and 5 raptors (12.5%) in case of using IM pin (Fig 3.10).

The average union time that measured for 22 individuals was 13.5(±6.0) days after the initiation of coracoid fracture surgery or bandage treatment. After 5 raptors were coracoid fracture treatment, 2 raptors was died during the treatment. The average time for union of 3 raptors that medically treated coracoid fractures using IM pin was 22.3(±7.4) days. And the average time for union of the coracoid fracture sites about 19 raptors that medically treated with the figure of eight bandage was 12.2(±4.6) days. The results of rescue showed as stated below, that is, 19 raptors (67.9%) in case of release, 8 raptors (28.6%) in case of dead and 1 raptor (3.6%) in case of captive.

Table 3. 12. Classification of fractured coracoid with other sites on 28 individuals

Registration Number	Species Name	Physical condition		Description of fracture			Clinical category	Treatment method	Interval to union or removal of fixator(day)	period	Outcome (Identification metal ring)[c]
		Weight (g)	BCS	Fracture Site	Fracture Condition[a]	Fracture Type[b]					
2014-0659	Eurasian Sparrow hawk (*Accipiter nisus*)	256	3	Rt. Coracoid	(Cc)Cl	(Cc)Tr	1	(Rt)Cc:8 Shaped bandage	(Rt)Cc:9	41	Re(070-00116)
2014-0705	Common kestrel (*Falco tinnunculus*)	204	3	Rt. Coracoid	(Cc)Cl	(Cc)Tr	1	(Rt)Cc:8 Shaped bandage		3	De/Unknown
2015-0191	Brown hawk owl (*Ninox scutulata*)	176	3	Rt. Coracoid	(Cc)Cl	(Cc)OS	1	(Rt)Cc:8 Shaped bandage	(Rt)Cc:11	14	Re(080-05966)
2015-0391	Eurasian eagle owl (*Bubo bubo*)	1270	1	Lt. Coracoid, Lt. Furcula, Rt. Scapula	(Cc)Cl/ (Sc)Cl/ (Fu)Cl	(Cc)Tr/ (Sc)Tr/ (Fu)Tr	4	(Lt)Cc/Fu/Sc:8 Shaped bandage	(Rt)Cc/Fu/Sc:11	148	Re(140-01377)
2015-0458	Common kestrel (*Falco tinnunculus*)	172	2	Lt. Coracoid, Lt. Furcula	(Cc)Cl/ (Fu)Cl	(Cc)Tr/ (Fu)Tr	2	(Lt)Cc/Fu:8 Shaped bandage	(Lt)Cc/Fu:15	31	Re(080-06817)
2015-0599	Northern goshawk (*Accipiter gentilis*)	744	3	Lt. Coracoid, Rt. Sternocoracoidal jt,	(Cc)Cl/ (Scjt)Lu	(Cc)OS	2	(Lt)Cc:8 Shaped bandage (Rt)Scjt:Reduction/ 8 Shaped bandage	(Lt)Cc/(Rt)Scjt: 23	53	De/Accident in cage
2015-0608	Eurasian eagle owl (*Bubo bubo*)	1608	2	Rt. Coracoid	(Cc)Cl	(Cc)Tr	1	(Rt)Cc:8 Shaped bandage	(Rt)Cc:14	53	Re(140-01380)
2015-0654	Oriental scops owl (*Otus sunia*)	70	2	Rt. Coracoid	(Cc)Cl	(Cc)Tr	1	(Rt)Cc:8 Shaped bandage	(Rt)Cc:5	36	Re(060-05968)
2015-0824	Crested honey buzzard (*Pernis ptilorhynchus*)	698	2	Lt. Coracoid	(Cc)Cl+	(Cc)Tr	2	(Lt)Cc:8 Shaped bandage	(Lt)Cc:10	1095	Ca
2015-0868	Cinereous vulture (*Aegypius monachus*)	8240	3	Lt. Coracoid, Lt. Furcula	(Cc)Cl/ (Fu)Cl	(Cc)Tr/ (Fu)Tr	2	(Lt)Cc/Fu:8 Shaped bandage		7	De/Unknown
2015-0884	Northern goshawk (*Accipiter gentilis*)	564	3	Lt. Coracoid	(Cc)Cl	(Cc)Co	2	(Lt)Cc:8 Shaped bandage	(Lt)Cc:9	31	Re(100-09742)
2016-0078	Eurasian Sparrow hawk (*Accipiter nisus*)	270	3	Rt. Coracoid, Rt. Furcula, Rt. Scapula	(Cc)Cl/ (Sc)Cl/ (Fu)Cl	(Cc)Tr/ (Sc)Tr/ (Fu)Co	4	(Rt)Cc/Fu/Sc:8 Shaped bandage	(Rt)Cc/Fu/Sc:10	35	Re(070-00132)
2016-0845	Oriental scops owl (*Otus sunia*)	86	2	Rt. Coracoid, Rt. Furcula,	(Cc)Cl/ (Fu)Cl	(Cc)Tr/ (Fu)Tr	2	(Rt)Cc/Fu:8 Shaped bandage	(Rt)Cc/Fu:5	351	Re(060-05999)
2016-0850	Eurasian Sparrow hawk (*Accipiter nisus*)	146	3	Lt. Coracoid, Lt. Furcula	(Cc)Cl/ (Fu)Cl	(Cc)Tr/ (Fu)Tr	2	(Lt)Cc/Fu:8 Shaped bandage	(Lt)Cc/Fu:14	53	Re(070-00147)

2016-0888	Northern goshawk (*Accipiter gentilis*)	680	2	Rt. Coracoid, Rt. Sternocoracoidal jt	(Cc)Cl/ (Scjt)Lu	(Cc)Tr	2	(Rt)Cc:8 Shaped bandage		3	De/Unknown
2016-0939	Eurasian Sparrow hawk (*Accipiter nisus*)	284	4	Lt. Coracoid, Lt. Furcula	(Cc)Cl/ (Fu)Cl	(Cc)Tr/ (Fu)Tr	2	(Lt)Cc/Fu:8 Shaped bandage	(Lt)Cc/Fu:8	14	Re(070-00148)
2017-0032	Northern goshawk (*Accipiter gentilis*)	466	1	Lt. Coracoid, Lt. Furcula	(Cc)Cl/ (Fu)Cl	(Cc)OS/ (Fu)Tr	3	(Lt)Cc/Fu:8 Shaped bandage	(Lt)Cc/Fu:10	15	De/Accident in cage
2017-0098	Northern goshawk (*Accipiter gentilis*)	574	2	Rt. Coracoid, Rt. Furcula,	(Cc)Cl/ (Fu)Cl	(Cc)OS/ (Fu)Co	3	(Rt)Cc/Fu:8 Shaped bandage	(Rt)Cc/Fu:14	33	Re(100-09750)
2017-0176	Eurasian eagle owl (*Bubo bubo*)	1774	3	Rt. Coracoid, Lt. Tarsometatarsus,	(Cc)Cl/ (Ta)Cl	(Cc)Tr/ (Ta)OS	2	(Rt)Cc:8 Shaped bandage (Lt)Ta :Splint	(Rt)Cc:21 (Lt)Ta:26	33	Re(140-01882)
2017-0347	Brown hawk owl (*Ninox scutulata*)	210	4	Lt. Coracoid, Lt. Furcula, Lt. Ribs,	(Cc)Cl/ (Fu)Cl/ (Ri)Cl	(Cc)OS/ (Fu)Tr	3	(Lt)Cc:IM 1.0mm (Lt)Fu:8 Shaped bandage	(Lt)Cc:14 (Lt)Fu:14	23	Re(080-09445) –
2017-0875	Eurasian hobby (*Falco subbuteo*)	158	3	Rt. Coracoid	(Cc)Cl	(Cc)Tr	1	(Rt)Cc:IM 0.9mm	(Rt)Cc:28	247	Re(060-08304)
2018-0018	Eurasian Sparrow hawk (*Accipiter nisus*)	262	3	Lt. Coracoid	(Cc)Cl	(Cc)Tr	1	(Lt)Cc:IM 0.8mm	(Lt)Cc:25	45	Re(070-00152)
2018-0064	Eurasian Sparrow hawk (*Accipiter nisus*)	158	3	Rt. Coracoid	(Cc)Cl	(Cc)Tr	1	(Rt)Cc:IM 0.9mm		6	De/Unknown
2018-0463	Common kestrel (*Falco tinnunculus*)	162	2	Rt. Coracoid, Rt. Furcula	(Cc)Cl/ (Fu)Cl	(Cc)Tr/ (Fu)Tr	2	(Rt)Cc:IM 0.9mm (Lt)Fu:8 Shaped bandage		15	De/Unknown
2018-0626	Common kestrel (*Falco tinnunculus*)	126	2	Rt. Coracoid, Sternum	(Cc)Cl	(Cc)Co	3	(Rt)Cc:8 Shaped bandage	(Rt)Cc:14	50	Re(080-09588)
2018-0984	Brown hawk owl (*Ninox scutulata*)	244	4	Lt. Coracoid, Lt. Furcula	(Cc)Cl/ (Fu)Cl	(Cc)Tr/ (Fu)Tr	2	(Rt)Cc/(Lt)Fu:8 Shaped bandage	(Lt)Cc/Fu:14	32	Re(080-09536)
2018-1061	Eurasian eagle owl (*Bubo bubo*)	1586	2	Lt. Coracoid, Lt. Furcula,	(Cc)Cl/ (Fu)Cl	(Cc)Tr/ (Fu)Tr	2	(Lt)Cc/Fu:8 Shaped bandage		11	De/Unknown
2018-1171	Tawny owl (*Strix aluco*)	340	1	Rt. Coracoid	(Cc)Cl	(Cc)Tr	2	(Rt)Cc:8 Shaped bandage	(Rt)Cc:14	22	Re
Total	28										

[a]Cl=Closed Fracture; Lu=Luxation; (Cc)=Coracoid; (Fu)=Furcula; (Sc)=Scapula; (Ri)=Ribs; (Scjt)=Sternocoracoidal jt
[b]Tr=Transverse Fracture; OS=Oblique/Spiral Fracture; Co=Comminuted Fracture; Li=Linear Fracture; Se=Segmental Fracture; Si=Simple Fracture
[c]Re=Released; Eu=Euthanased; Di=Died; Ca=Captive; Pe=Permenent disability

Fig 3. 10. Radiographs show a closed, transverse fracture of the left coracoid in Eurasian Sparrow hawk (*Accipiter nisus*) 2018-0018 (A), lateral right view of the left coracoid (B), radiographs were taken to confirm to be fixed IM pin properly and accurately during operation (C), POD 6th (D), POD 13th (E), after pin removal on POD 25th (F).

(10) Furcular fracture including the fracture of other sites

The data for 16 raptors that were generated other fractures together with the fracture of furcular (excluding humerus fracture, radius fracture, ulna fracture, carpometacarpus fracture, femur fracture and tibiotasus fracture) was tabulated (Table 3.13). The fracture location (zone) of furcular was excluded from the data because it was difficult to determine accurately it.

In the case of 16 raptors that were generated other fractures together with fracture of furcular, there were 8 raptors that had the only furcular fracture. 6 raptors of 16 raptors with furcular fracture were found to have the sternocoracoidal joint luxation. However, one raptor showed both side of the furcular fractures, and then 17 cases of the furcular fractures were verified. The fracture condition of furcular was 17 cases in the closed fractures (100.0%). And the fracture type of furcular was classified into 17 cases (100.0%) in the transverse fracture of simple fracture. Using furcular fractures were medically treated with a figure of eight bandage, all of 16 raptors were treated with motion restriction (Fig 3.11).

After five individuals among six individuals that were dislocated sternocoracoidal joint were returned then figure of eight bandage was carried out. The average union time that measured for 13 individuals was 10.4(±3.0) days after the initiation of bandage treatment. It took time until taking off bandage. The results of rescue showed as follows, that is, 13 raptors (81.3%) in case of release, 2 raptors (12.5%) in case of dead and 1 raptor (6.3%) in the case of euthanasia.

Table 3. 13. Classification of fractured furcular with other site on 16 individuals

Registration Number	Species Name	Physical condition		Description of fracture			Clinical category	Treatment method	Interval to union or removal of fixator(day)	period	Outcome (Identification metal ring)[c]
		Weight (g)	BCS	Fracture Site	Fracture Condition[a]	Fracture Type[b]					
2014-0234	Common kestrel (*Falco tinnunculus*)	174	3	Rt. Furcula, Sternum,	(Fu)Cl/ (St)Cl	(Fu)Tr	2	(Rt)Fu:8 Shaped bandage	(Rt)Fu:13	29	Re(080-05546)
2015-0619	Eurasian eagle owl (*Bubo bubo*)	2428	2	Rt. Furcula, Lt. Furcula	(Fu)Cl	(Fu)Tr	1	(Rt/Lt)Fu:8 Shaped bandage	(Rt/Lt)Fu:12	49	Re(140-01382)
2015-0628	Eurasian hobby (*Falco subbuteo*)	236	2	Rt. Furcula	(Fu)Cl	(Fu)Tr	1	(Rt)Fu:8 Shaped bandage	(Rt)Fu:7	48	Re(070-00127)
2015-0669	Eurasian hobby (*Falco subbuteo*)	218	2	Rt. Furcula	(Fu)Cl	(Fu)Tr	1	(Lt)Fu:8 Shaped bandage	(Lt)Fu:11	33	Re(070-00128)
2015-0690	Brown hawk owl (*Ninox scutulata*)	204	2	Rt. Furcula, Rt. Sternocoracoidal jt	(Fu)Cl/ (Scjt)Lu	(Fu)Tr	2	(Rt)Scjt:Reduction (Rt)Fu:8 Shaped bandage	(Rt)Scjt/Fu: 11	23	Re(080-06837)
2015-0721	Oriental scops owl (*Otus sunia*)	74	3	Lt. Furcula, Lt. Sternocoracoidal jt, Rt. Sternocoracoidal jt	(Fu)Cl/ (RtScjt)Lu/ (LtScjt)Lu	(Fu)Tr	3	(Rt)Scjt:Reduction (Lt)Fu:8 Shaped bandage	(Rt)Scjt/ (Lt)Fu:12	21	Re(060-05975)
2015-0829	Common kestrel (*Falco tinnunculus*)	188	2	Lt. Furcula, Rt. Sternocoracoidaljt,	(Fu)Cl/ (Scjt)Lu	(Fu)Tr	2	(Rt)Scjt:Reduction (Lt)Fu:8 Shaped bandage	(Rt)Scjt/ (Lt)Fu:10	47	Re(080-06846)
2016-0043	Northern goshawk (*Accipiter gentilis*)	638	3	Rt. Furcula	(Fu)Cl	(Fu)Tr	1	(Rt)Fu:8 Shaped bandage		65	Eu/Brhavior disorder
2016-0173	Oriental scops owl (*Otus sunia*)	76	3	Lt. Furcula, Lt. Scapula, Lt. Sternocoracoidal jt	(Fu)Cl/(Sc) Cl/(Scjt)Lu	(Fu)Tr/ (Sc)Tr	3	(Lt)Fu/Sc/Scjt:8 Shaped bandage		4	De/Unknown
2016-0403	Eurasian hobby (*Falco subbuteo*)	178	4	Rt. Furcula	(Fu)Cl	(Fu)Tr	1	(Lt)Fu:8 Shaped bandage	(Lt)Fu:6	37	Re(070-00135)
2016-0829	Common kestrel (*Falco tinnunculus*)	198	3	Rt. Furcula	(Fu)Cl	(Fu)Tr	1	(Rt)Fu:8 Shaped bandage	(Rt)Fu:14	46	Re(080-09477)
2017-0029	Common kestrel (*Falco tinnunculus*)	168	2	Rt. Furcula, Rt. Sternocoracoidal jt	(Fu)Cl/ (Scjt)Lu	(Fu)Tr	2	(Rt)Fu:8 Shaped bandage (Rt)Scjt :Reduction	(Rt)Fu/ Scjt:14	29	Re(080-09489)

2017-0037	Cinereous vulture (*Aegypius monachus*)	8840	3	Lt. Furcula	(Fu)Cl	(Fu)Tr	1	(Lt)Fu:8 Shaped bandage	(Lt)Fu:5	5	Re(150-00718,17(G/B))
2017-0038	Cinereous vulture (*Aegypius monachus*)	8780	3	Rt. Furcula	(Fu)Cl	(Fu)Tr	1	(Rt)Fu:8 Shaped bandage	(Rt)Fu:12	15	Re
2017-0821	Eurasian hobby (*Falco subbuteo*)	186	4	Lt. Furcula, Lt. Scapula	(Fu)Cl/ (Sc)Cl	(Fu)Tr/ (Sc)Tr	2	(Lt)Fu/Sc:8 Shaped bandage	(Lt)Fu/Sc:8	23	Re(080-09507)
2018-0933	Oriental scops owl (*Otus sunia*)	50	2	Lt. Furcula, Lt. Sternocoracoidal jt,	(Fu)Cl/ (Scjt)Lu	(Fu)Tr	2	(Lt)Fu:8 Shaped bandage (Lt)Scjt :Reduction		3	De/Unknown
Total	16										

[a]Cl=Closed Fracture; Lu=Luxation; (Cc)=Coracoid; (Fu)=Furcula; (Sc)=Scapula; (Scjt)=Sternocoracoidal jt
[b]Tr=Transverse Fracture
[c]Re=Released; Eu=Euthanased; Di=Died; Ca=Captive; Pe=Permenent disability

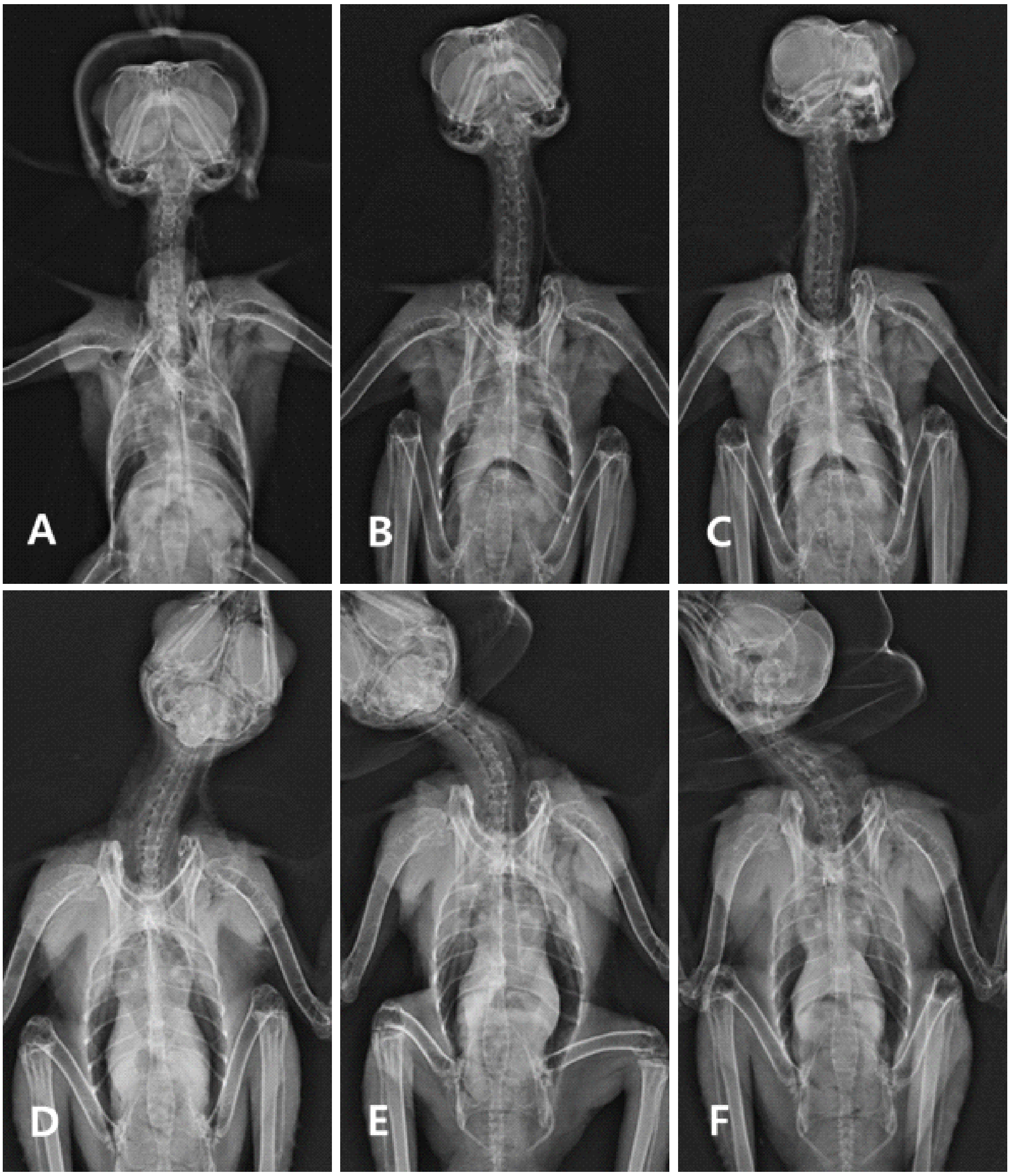

Fig 3. 11. Radiographs show a closed, transverse fracture of the right furcula (clavicle) and the right sternocoracoidal joint luxation in Common kestrel (*Falco tinnunculus*) 2017-0029 (A), radiographs were taken several times in order to confirm to be fixed properly and accurately during treatment, and then restrict movement with figure of eight bandage (B, C), after treatment 8th day (D), and remove figure of eight bandage after treatment 14th day (E), after treatment 21th day (F).

(11) Scapular fracture including the fracture of other sites

The data for 8 raptors that occurred fracture of scapular and other fracture (excluding humerus fracture, radius fracture, ulna fracture, carpometacarpus fracture, femur fracture, tibiotasus fracture and coracoid fracture) was tabulated (Table 3.14). The fracture location (zone) of scapular was excluded from the data because it was difficult to determine accurately.

In the case of 8 raptors that had other fractures together with the fracture of scapular, there were 7 raptors that had the only scapular fracture and 1 raptor that had the lower beak fractures including the scapular fracture. The fracture condition of scapular was 8 cases in the closed fractures (100.0%). And the fracture type of scapular was classified into 8 cases (100.0%) in the transverse fracture of simple fracture. The scapular fractures were medically treated with a figure of eight bandage, and all of 8 raptors were treated with motion restriction.

The average union time that was measured for 8 individuals was 11.5(±4.4) days after the initiation of bandage treatment of scapular. It took time until taking off bandage. As results of rescue, it was appeared that 8 raptors (100.0%) were released to nature.

Table 3. 14. Classification of fractured scapula with other sites on 8 individuals

Registration Number	Species Name	Physical condition		Description of fracture			Clinical category	Treatment method	Interval to union or removal of fixator(day)	period	Outcome (Identification metal ring)[c]
		Weight (g)	BCS	Fracture Site	Fracture Condition[a]	Fracture Type[b]					
2014-0477	Oriental scops owl (*Otus sunia*)	86	3	Lt. Scapula	(Sc)Cl	(Sc)Tr	1	(Lt)Sc:8 Shaped bandage and Body Wrap	(Lt)Sc:8	67	Re(060-05937)
2014-0498	Eurasian eagle owl (*Bubo bubo*)	1520	2	Lower beak, Lt. Scapula	(Sc)Cl/(LB)Cl	(Sc)Tr/(LB)Si	2	(Lt)Sc:8 Shaped bandage and Body Wrap	(Lt)Sc:18	410	Re(140-01368)
2014-0632	Japanese Sparrow hawk (*Accipiter gularis*)	104	2	Lt. Scapula	(Sc)Cl	(Sc)Tr	1	(Lt)Sc:8 Shaped bandage and Body Wrap	(Lt)Sc:7	19	Re(060-05946)
2015-0439	Common kestrel (*Falco tinnunculus*)	164	1	Rt. Scapula	(Sc)Cl	(Sc)Tr	1	(Lt)Sc:8 Shaped bandage and Body Wrap	(Rt)Sc:18	35	Re(080-06816)
2016-0804	Oriental scops owl (*Otus sunia*)	68	2	Rt. Scapula	(Sc)Cl	(Sc)Tr	1	(Lt)Sc:8 Shaped bandage and Body Wrap	(Rt)Sc:8	8	Re(060-05982)
2017-0666	Brown hawk owl (*Ninox scutulata*)	182	2	Rt. Scapula	(Sc)Cl	(Sc)Tr	1	(Lt)Sc:8 Shaped bandage and Body Wrap	(Rt)Sc:6	16	Re(080-09500)
2017-1047	Northern goshawk (*Accipiter gentilis*)	560	4	Lt. Scapula	(Sc)Cl	(Sc)Tr	1	(Lt)Sc:8 Shaped bandage and Body Wrap	(Lt)Sc:14	23	Re(090-07471)
2018-1204	Eurasian buzzard (*Buteo buteo*)	844	3	Lt. Scapula	(Sc)Cl	(Sc)Tr	1	(Lt)Sc:8 Shaped bandage and Body Wrap	(Lt)Sc:14	21	Re
Total	8										

[a]Cl=Closed Fracture; (Sc)=Scapula
[b]Tr=Transverse Fracture; Si=Simple Fracture
[c]Re=Released; Eu=Euthanased; Di=Died; Ca=Captive; Pe=Permenent disability

(12) Other fractures

The other fractures were summarized in the fractures that were not classified the before. The data for 19 raptors that occurred fracture sites including other fractures was tabulated (Table 3.15).

The other fractures were classed as the locations such as 5 cases in the thoracic vertebrae fracture, 5 cases in the ribs fracture, 4 cases in the upper beak fracture, 3 cases in the sternum fracture, 1 case in the lower beak fracture and 1 case in the synsacrum fracture. Most individuals were medically treated with the physical restraint of movement. For instance, the thoracic vertebrae fracture was medically treated with sling method. As the results of rescue, it showed 12 raptors (63.2%) in case of release, 6 raptors (31.6%) in case of dead and 1 raptor (5.3%) in case of euthanasia.

Table 3. 15. Classification of the rest fracture on 19 individuals

Registration Number	Species Name	Physical condition		Description of fracture			Clinical category	Treatment method	Interval to union or removal of fixator(day)	period	Outcome (Identification metal ring)[c]
		Weight (g)	BCS	Fracture Site	Fracture Condition[a]	Fracture Type[b]					
2014-0057	Cinereous vulture (*Aegypius monachus*)	7480	2	Upper beak		(UB)Si	1	UB:Restrict movement	UB:14	315	Re (150-00704, 62(B/W))
2014-0272	Common kestrel (*Falco tinnunculus*)	176	2	Lower beak	(LB)Cl	(LB)Si	1	LB: Restrict movement	LB:14	37	Re (080-05908)
2014-0273	Common kestrel (*Falco tinnunculus*)	200	2	Sternum	(St)Cl	(St)Si	1	St:Restrict movement	St:7	20	Re (080-05906)
2014-0291	Brown hawk owl (*Ninox scutulata*)	172	3	Upper beak		(UB)Si	1	UB:Restrict movement	UB:7	8	Re (080-05913)
2014-0436	Eurasian eagle owl (*Bubo bubo*)	1494	2	Thoracic vert	(Tv)Cl		1	Tv:Restrict movement/Sling	Tv:21	129	Re (140-01365)
2015-0012	Eurasian eagle owl (*Bubo bubo*)	980	2	Thoracic vert	(Tv)Cl		1	Tv:Restrict movement/Sling		25	De/Unknown
2015-0036	Common kestrel (*Falco tinnunculus*)	160	3	Upper beak		(UB)Si	1	UB:Restrict movement	UB:11	12	Re (080-05950)
2015-0699	Chinese Sparrow hawk (*Accipiter soloensis*)	116	2	Thoracic vert	(Tv)Cl		1	Tv:Restrict movement/Sling		4	De/Unknown
2015-0712	Oriental scops owl (*Otus sunia*)	72	2	Synsacrum	(Sy)Cl	(Sy)Si	1	Sy:Restrict movement	Sy:7	17	Re (060-05973)
2015-0888	Short-eared owl (*Asio flammeus*)	292	2	Thoracic vert	(Tv)Cl		1	Tv:Restrict movement/Sling		6	De/Unknown
2016-0374	Eurasian eagle owl (*Bubo bubo*)	1558	2	Lt. Ribs	(Ri)Cl	(Ri)Si	1	(Lt)Ri:Restrict movement	(Lt)Ri:6	40	Re (140-01862)
2016-0661	Common kestrel (*Falco tinnunculus*)	180	2	Sternum	(St)Cl	(St)Si	1	St:Restrict movement	St:12	40	Re (080-09456)
2016-0927	Common kestrel (*Falco tinnunculus*)	198	3	Free vert	(Tv)Cl		1	Tv:Restrict movement/Sling		6	De/Unknown
2017-0027	Cinereous vulture (*Aegypius monachus*)	8220	3	Rt. Ribs	(Ri)Cl	(Ri)Si	1	(Rt)Ri:Restrict movement	(Rt)Ri:4	4	Re (150-00717, 16(G/B))

2017-0169	Brown hawk owl (*Ninox scutulata*)	174	2	Rt. Ribs	(Ri)Cl	(Ri)Si	1	(Rt)Ri:Restrict movement		4	De/Unknown
2017-0271	Brown hawk owl (*Ninox scutulata*)	170	3	Rt. Ribs	(Ri)Cl	(Ri)Si	1	(Rt)Ri:Restrict movement		7	De/Unknown
2017-0325	Brown hawk owl (*Ninox scutulata*)	192	3	Sternum	(St)Cl	(St)Si	1	St:Restrict movement	St:18	35	Re (080-09464)
2017-0627	Brown hawk owl (*Ninox scutulata*)	162	2	Rt. Ribs	(Ri)Cl	(Ri)Si	1	(Rt)Ri:Restrict movement		27	Eu/Flight Disorder
2017-0885	Brown hawk owl (*Ninox scutulata*)	152	2	Upper beak		(UB)Si	1	UB:Restrict movement	UB:10	14	Re (080-09509)
Total	19										

[a]Cl=Closed Fracture; (LB)=Lower beak; (UB)=Upper beak; (St)=Sternum; (Tv)=Thoracic vert; (Sy)=Synsacrum; (Ri)=Ribs
[b]Si=Simple Fracture
[c]Re=Released; Eu=Euthanased; Di=Died; Ca=Captive; Pe=Permenent disability

(13) The joint dislocation

The joint dislocation of raptors was classed as 14 individuals except raptors that included fracture. The data for 14 raptors that occurred dislocation was tabulated (Table 3.16).

The joint dislocation of 14 individuals was classed as 5 different group; 2 raptors in the shoulder joint luxation, 3 raptors in the elbow joint luxation, 2 raptors in the carpal joint luxation, 4 raptors in the sternocoracoidal joint luxation and 3 raptors in the stifle joint luxation. One of the 4 cases of the sternocoracoidal joint was fixed with IM pin after confirming re-dislocation after treatment.

The average union time of the reduction that measured for 6 individuals was 19.2(±7.6) days after the initiation of fracture surgery or bandage treatment. It took time until pin removal or taking off bandage. As the results of rescue, it showed that 6 raptors (42.9%) in case of release, 4 raptors (28.6%) in case of euthanasia, 3 raptors (21.4%) in case of dead and 1 raptor (7.1%) in case of captive.

Table 3. 16. Classification of the luxation on 14 individuals

Registration Number	Species Name	Physical condition		Description of Luxation		Clinical category	Treatment method	Interval to location(day)	period	Outcome (Identification metal ring)[b]
		Weight (g)	BCS	Luxation Site	Luxation Condition[a]					
2014-0665	Northern goshawk (*Accipiter gentilis*)	788	2	Rt. Carpal jt	(Cajt)Lu	1	(Rt)Cajt :Reduction/8 Shaped bandage and Body Wrap		797	Eu/Flight Disorder
2015-0043	Eurasian eagle owl (*Bubo bubo*)	1482	2	Lt. Stifle jt	(Stjt)Lu	1	(Rt)Stjt :Reduction/Splint/Sling		28	Eu/Necrosis
2015-0676	Eurasian eagle owl (*Bubo bubo*)	1696	2	Lt. Stifle jt	(Stjt)Lu	1	(Lt)Stjt :Reduction/Splint/Sling		13	De/Unknown
2015-0760	Eurasian eagle owl (*Bubo bubo*)	1398	1	Lt. Elbow jt	(Eljt)Lu	2	(Lt)Eljt :Reduction/8 Shaped bandag and Body Wrap		28	Eu/Flight Disorder
2016-0042	Northern goshawk (*Accipiter gentilis*)	552	2	Lt. Carpal jt	(Cajt)Lu	1	(Lt)Cajt :Reduction/8 Shaped bandage and Body Wrap		19	De/Unknown
2016-0203	Brown hawk owl (*Ninox scutulata*)	190	3	Rt. Shoulder jt	(Shjt)Lu	1	(Rt)Shjt :Reduction/8 Shaped bandage and Body Wrap	(Rt)Shjt:26	33	Re(080-06869)
2017-0050	Eurasian Sparrow hawk (*Accipiter nisus*)	186	1	Lt. Sternocoracoidal jt	(Scjt)Lu	2	(Lt)Scjt :8 Shaped bandag and Body Wrap		6	De/ (malnutrition)
2017-0090	Common kestrel (*Falco tinnunculus*)	224	2	Lt. Sternocoracoidal jt	(Scjt)Lu	1	(Lt)Scjt :Reduction/8 Shaped bandag and Body Wrap	(Rt)Scjt:26	50	Re(080-09409)
2017-0913	Eurasian hobby (*Falco subbuteo*)	158	2	Rt. Elbow jt	(Eljt)Lu	1	(Lt)Eljt :Reduction/8 Shaped bandag and Body Wrap		12	Eu/Brhavior disorder

2018-0306	Eurasian hobby (*Falco subbuteo*)	188	2	Lt. Elbow jt	(Eljt)Lu	1	(Lt)Eljt :Reduction/8 Shaped bandag and Body Wrap	(Lt)Eljt:8 Shaped bandage	93	Re(080-09531)
2018-0309	Japanese Sparrow hawk (*Accipiter gularis*)	150	3	Rt. Stifle jt	(Stjt)Lu	1	(Rt)Stjt :Reduction/Splint/Sling	(Rt)Stjt:16	19	Re(060-08305)
2018-0448	Common kestrel (*Falco tinnunculus*)	186	3	Lt. Sternocoracoidal jt	(Scjt)Lu	1	(Lt)Scjt :Reduction/8 Shaped bandag and Body Wrap	(Lt)Scjt:14	34	Re(080-09568)
2018-0728	Brown hawk owl (*Ninox scutulata*)	176	3	Lt. Sternocoracoidal jt	(Scjt)Lu	1	(Lt)Scjt :IM 1.0mm/8 Shaped bandag and Body Wrap	(Lt)Scjt:25	64	Re(080-09533)
2018-1229	Northern goshawk (*Accipiter gentilis*)	614	3	Lt. Shoulder jt	(Shjt)Lu	1	(Lt)Shjt :Reduction/8 Shaped bandage and Body Wrap	(Lt)Shjt:Still	11	Ca
Total	14									

[a]Lu=Luxation; (Cajt)=Carpal jt; (Stjt)=Stifle jt; (Eljt)=Elbow jt; (Shjt)=Shoulder jt; (Scjt)=Sternocoracoidal jt
[b]Re=Released; Eu=Euthanased; Di=Died; Ca=Captive; Pe=Permenent disability

3) The treated method according to fracture sites

Among 192 individuals of the raptors that medically treated with fracture, there were 187 individuals including the humerus, radius, ulna, carpometacarpus, femur, tibiotarsus, tarsometatarsus and coracoid. The 5 individuals among 192 individuals were excluded because they died before medically treated. The treated method of the fracture sites was analyzed based on the medical records (Table 3.17).

About the 187 individuals among the 221 cases of the fractures sites, non-invasive treatment with a figure of eight bandage and splint were used like there are 86 cases (38.9%), the surgery with IM pin were used like there were 68 cases (30.8%), and TIF were used (14.5%) like there were 32 cases (14.5%). TIF method was the most used for humerus fracture treatment, and relatively IM pin was used for treatment of the radial fracture.

Table 3. 17. Classification of treatment according to fracture site

Fracture Site	Surgical Treatment Method									Total (%)
	TIF (%)	TIF +wire (%)	IM (%)	IM +wire (%)	TypeIorII/ TypeI+ Cerclage wire (%)	Cross pinning/ Cross pinning +ESF (%)	Cerclage wire / 8 Shaped wire (%)	Shuttle pin (%)	8 bandage/ Splint (%)	
Humerus	22(10.0)	9(4.1)	11(5.0)	6(2.7)	1(0.5)	2(0.9)	0(0.0)	0(0.0)	7(3.2)	58(25.9)
Radius	0(0.0)	0(0.0)	21(9.5)	1(0.5)	0(0.0)	0(0.0)	0(0.0)	2(0.9)	13(5.9)	37(16.7)
Ulna	2(0.9)	0(0.0)	17(7.7)	3(1.4)	0(0.0)	0(0.0)	4(1.8)	1(0.5)	19(8.6)	46(20.8)
Carpometacarpus	2(0.9)	0(0.0)	6(2.7)	0(0.0)	2(0.9)	0(0.0)	1(0.5)	0(0.0)	9(4.1)	20(9.1)
Femur	3(1.4)	0(0.0)	1(0.5)	0(0.0)	0(0.0)	1(0.5)	0(0.0)	0(0.0)	2(0.9)	7(3.2)
Tibiotarsus	3(1.4)	0(0.0)	5(2.3)	1(0.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	10(4.5)	19(8.6)
Tarsometatarsus	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(0.5)	0(0.0)	0(0.0)	0(0.0)	2(0.9)	3(1.4)
Coracoid	0(0.0)	0(0.0)	7(3.2)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	24(10.9)	31(14.0)
Total	32(14.5)	9(4.1)	68(30.8)	11(5.0)	4(1.8)	3(1.4)	5(2.3)	3(1.4)	86(38.9)	221(100.0)

4) Fracture sites union period according to fracture sites

The fracture site was medically treated with the proper surgery technique or the treated method according to the individual characteristics and fracture status. As a result of treatment of fracture sites, the data for 175 fractures were collected about 10 fracture sites of the 147 individuals as follows; The fracture sites were composed of humerus, radius, ulna, carpometacarpus, femur, tibiotarsus, tarsometatarsus, coracoid, furcula and scapula (Table 3.18).

Table 3. 18. The time it takes to remove the pin or union the fracture after fracture surgery or treatment (Day)

Fracture Site	Interval to union or removal of fixator (day)	Number of Cases (%)
Humerus	17.7[a](±5.6)[b]	30(17.1)
Radius	19.2(±5.5)	23(13.1)
Ulna	19.0(±6.9)	33(18.9)
Carpometacarpus	23.4(±7.7)	14(8.0)
Femur	19.6(±8.3)	5(2.9)
Tibiotarsus	15.8(±6.4)	10(5.7)
Tarsometatarsus	25.7(±2.5)	3(1.7)
Coracoid	14.5(±6.3)	26(14.9)
Furcula	10.7(±3.2)	21(12.0)
Scapula	11.8(±4.4)	10(5.7)
Total	17.0(±6.8)	175(100.0)

[a]the mean day
[b]standard deviation of the mean day

5) The hospitalization period of the release individuals depending on the fracture sites

The hospitalization period of 124 individuals until the release after the fracture treatment, was classified by fracture sites (table 3.19). As a result of the treatment, there were 139 released individuals. However, individuals that release delayed due to missing the right time to get the objects released owing to the course of treatment of the birds such as the summer migratory birds and the winter migratory birds were excluded. The raptors were not released until the new feathers grow on the site where the feather was severely damaged were excluded.

The hospitalization period of 9 individuals about fracture of other sites together with fractured tibiotarsus was the longest 72.7(±56.1) days. In the case of the fracture of the other sites together with carpometacarpus, the hospitalization period of 12 fractured individuals was 71.3(±37.5) days. The average hospitalization period for 124 individuals was 51.4(±35.5) days.

Table 3. 19. The hospitalization period of the released individual according to the fracture site

Fracture site	Hospitalization period	Number of Cases(%)
Humerus/Humerus with other site	58.1(±20.5)	15(12.1)
Radius/Radius with other site	52.8(±16.3)	14(11.3)
Ulna with other site	67.1(±47.6)	17(13.6)
Carpometacarpus with other site	71.3(±37.5)	12(9.6)
Femur with other site	62.7(±40.1)	3(2.4)
Tibiotarsus with other site	72.7(±56.1)	9(7.3)
Coracoid with other site	40.8(±30.0)	17(13.7)
Clavicle(Furcula) with other site	31.2(±13.8)	13(10.5)
Scapula with other site	27.0(±19.4)	7(5.6)
other site	32.4(±34.7)	11(8.9)
Joint	48.8(±26.6)	6(4.8)
Mean of Total	51.4(±35.5)	124(100.0)

6) The results of individuals of fracture treatment

Among the 450 individuals that were diagnosed with the fracture, 201 individuals that could not be healed were excluded, and then 249 individuals were medically treated with the fracture treatment. The results of the treatment of 249 individuals were classified according to their medical records (Table 3.20).

In total 249 individuals, 139 individuals (55.8%) recovered to normal condition after rehabilitation and treatment. Then, returned to nature. The 58 individuals (23.3%) were dead during the treatment, and 44 individuals (17.7%) were euthanasia in a humane method when it was judged that it was difficult to return to nature even after treatment. The 8 individuals (3,2%) were in the process of treatment or disability animals that could not be returned to nature on December 31st 2018, then they were captive for the purpose of the research and education.

Table 3. 20. Classification of treatment results according to fracture part of 249 individuals

Fracture site	Released (%)	Died (%)	Euthanased (%)	Captive/ Permanent disability (%)	Number of cases (%)
Humerus/Humerus with other site	18(7.2)	13(5.2)	25(10.0)	3(1.2)	59(23.7)
Radius/Radius with other site	19(7.6)	9(3.6)	7(2.8)	1(0.4)	36(14.5)
Ulna with other site	19(7.6)	3(1.2)	1(0.4)	2(0.8)	25(10.0)
Carpometacarpus with other site	12(4.8)	3(1.2)	4(1.6)	0(0.0)	19(7.6)
Femur with other site	4(1.6)	5(2.0)	0(0.0)	0(0.0)	9(3.6)
Tibiotarsus with other site	9(7.6)	6(2.4)	1(0.4)	0(0.0)	16(6.4)
Coracoid with other site	19(7.6)	8(3.2)	0(0.0)	1(0.4)	28(11.3)
Clavicle(Furcula) with other site	13(5.2)	2(0.8)	1(0.4)	0(0.0)	16(6.4)
Scapula with other site	8(3.2)	0(0.0)	0(0.0)	0(0.0)	8(3.2)
other site	12(4.8)	6(2.4)	1(0.4)	0(0.0)	19(7.6)
Joint	6(2.4)	3(1.2)	4(1.6)	1(0.4)	14(5.6)
Total	139(55.8)	58(23.3)	44(17.7)	8(3.2)	249(100.0)

7) The results of Clinical score according to treatment outcome

For 249 individuals that medically treated with fracture, the clinical status according to the condition of fracture site was scored and arranged based on scores (Table 3.21). The results of the analysis of the clinical average score according to the results of treatment of the fracture sites were as follows; there were 2.12 scores for return to the nature, 2.72 scores for the dead during the treatment and 3.30 scores for euthanasia. The average clinical score of 249 individual fractures was 2.51 scores.

Table 3. 21. The clinical score classification of fracture according to result of treatment of fracture site

Fracture site	Number of Cases (%)	Released	Died	Euthanased	Captive/ Permanent disability	Mean of Clinical score
Humerus/Humerus with other site	59(23.7)	2.50	3.30	3.60	3.33	3.17 (±1.6)[a]
Radius/Radius with other site	36(14.5)	3.63	3.89	5.00	8	4.08 (±1.8)
Ulna with other site	25(10.0)	1.89	2.33	1.00	3	2.00 (±0.9)
Carpometacarpus with other site	19(7.6)	2.67	3.33	2.75	0.0	2.79 (±0.9)
Femur with other site	9(3.6)	2.25	4.2	0.0	0.0	3.33 (±1.7)
Tibiotarsus with other site	16(6.4)	1.89	2.00	1.00	0.0	1.88 (±1.0)
Coracoid with other site	28(11.3)	2.05	1.88	0.0	2	2.00 (±0.9)
Clavicle(Furcula) with other site	16(6.4)	1.54	2.5	1	0.0	1.63 (±0.7)
Scapula with other site	8(3.2)	1.13	0.0	0.0	0.0	1.13 (±0.4)
other site	19(7.6)	1	1	1	0.0	1 (±0.0)
Joint	14(5.6)	1	1.33	1.25	1	1.14 (±0.4)
Mean of Total	249(100.0)	2.12 (±1.3)	2.72 (±1.6)	3.30 (±1.8)	3.38 (±2.1)	2.51 (±1.6)

[a]SD; standard deviation

4. Discussion

The 249 individuals among the 450 individuals diagnosed with fracture. The remaining 201 individuals could not be treated. Among the 201 individuals that could not be treated, the 155 individuals were euthanized in humane way. Before performing euthanasia, considering and examining the condition of the fracture site, radiography, and pain reaction to determine carefully based on the dignity of life was an important euthanasia procedure to remember.

In the case of rescued raptors due to fracture, they were not aware of the pain caused by the fracture and continued to use their fractured wings or legs. As a result, the sharp bone fragments easily tore the soft tissue causing the open fracture or compound facture (31, 48). Therefore, most of the raptors admitted to the wildlife rescue center often had severe soft tissue damage and lacerations due to bone fragment. They were often unable to treat. As a result, 47.1% among 155 cases of euthanasia owing to fracture and trauma was not able to be treated due to damaged nerve by fracture. The 10.3% of them was loss of bone fragments or of below the fracture region due to the open fracture. The 3.9% was showed the severe comminuted fracture that it was impossible to treat medically. In addition, the 12.9% of them was unable to treat due to the delayed over time after fracture. The 9.7% of them was generated necrosis of soft tissues. The treatment could be given to those that were discovered or rescued earlier. Therefore, if the current rescue system for the distressed individuals was reinforced and modified. It was thought that more raptors receive the appropriate treatment within a reasonable time.

The basic tests such as physical examination, blood test, visual examination, palpation and radiography for raptors that were suspected for the fracture trauma were important in selecting the appropriate curative procedure or treatment depending on the condition of individual and fracture site. The radiography should be to shot in two directions from the ventrodorsal and right lateral so that both wings and legs are symmetrical in the photographs (3, 40). If the images were taken symmetrically and compared, it is possible to reduce the errors in reading the fracture site. As the results of two-way, ventrodorsal and lateral directions, the radiographs could be used to diagnose the fracture more accurately because the fracture site could be read in three dimensions.

The fractured raptors had severe trauma and mental stress. After an absolute stability being taken, the respiratory anesthesia was performed depending on the conditions of the rescued birds. Then the medical treatment such as physical examination and radiography and the surgery was carried out (19). In case the simple check for 10-15 minutes and first aid, the gas anesthesia was conducted by anaesthetic masks to minimize the stress, but if it took more than 10-15 minutes, or if invasive surgery and artificial respiration was necessary, put a rescued bird under anesthesia after intubating of ET tube (20, 44). Unlike mammals, the trachea of birds had complete circular cartilage. The ET tube without the cuff should be recommended while treating because it could be easily infected due to the extremely delicate trachea mucosa (33, 47). Intubation of ET tube should be performed only on the opened glottis. The ET tube should be used because the glottis would be seriously damage if glottis was closed. If the size of the selected ET tube was larger than trachea, it could also cause a serious damage on trachea. If the ET tube was smaller than the trachea, it could cause breathing difficulties because anesthesia was not working well. Therefore, it was recommended to have the slight gap between an inner radius of the glottis and an outer radius of the ET tube. The slightly smaller ET tube compared to the glottis should be used (20).

Most fractured avian patients that met with a disaster are under severe stress because of physical and psychological reasons such as external injury that resulted from collision, the initial trauma due to external injury and the additional stress of physical restraint. Therefore, the fracture assessment and surgery should be performed after taking maximum stability (2). Pre-operative primary blood tests such as PCV, blood glucose, plasma protein and biochemical tests were helpful in identifying the conditions of the injured bird (2, 10).

The most important principles in repositioning fractured avian wing were to minimize the damage of the soft tissue around the site of the fractures, to arrange bone fractures in order of correct position, and finally to stabilize fracture condition in original form of bone by matching them up properly (6, 28). The functions of muscle, tendon, ligament and joint must be normal and harmonious because it is essential for the flight of the bird (7, 39).

The avian bone is generally thin and contains high concentration of calcium, and therefore if the fracture occurs, it occurs longitudinally (16, 31). The open fracture and comminuted fracture, which are the main cause of the fracture, were caused mainly by the lack of soft tissue in the peripheral and a poor-developed periosteum (10, 39). The humerus and femur had features like pneumatic bone that medullary cavity of bones connect to the air sac. During the surgery, blood and debris were removed. The debridement washed with water might result in asphyxia, air sacculitis, or pneumonitis (7, 31). The callus formation in the avian species was similar to the mammals. The birds, however, got a faster recovery than the mammals (2, 49). The endosteal callus formation in the endosteum made the stabilized the fractured bone faster than the periosteal callus formation if the bone fracture was properly aligned and adjusted well (19, 31). The closest part of the joint in particular should be taken with care to minimize the damage of the soft tissue and the stiffness of the joint (ankylosis). Excessively a prolonged bandage attachment (more than two weeks) should be avoided as it might result in the atrophy of the muscle and ligament, and other joint problem (7, 10).

In the fractured humerus, the effect of the pectoral muscle that is attached to the ventral of the pectoral crest and deep pectoral muscle move longitudinal direction of the body whereas the biceps brachii muscle moves the distal humerus laterally upward (26, 31). Therefore, after the fracture, the distal fragment was pulled toward the shoulder joint by muscles, which seriously resulted the bone fragments to overlap each other. If a rigid fixation of the fractured site could not be ensured, the muscles could be severely damaged with the tearing of the skin. Then the fracture bones protruded outward due to the violent motion of the wings. Therefore, using a proper wrapping bandage, constraint without motion must be required to minimize the damage on the soft tissue (2, 16).

Even though the approach method to the fractured humerus during surgery could involve both dorsally or ventrally. The dorsal approach was preferred to reduce the technical risk (7, 10, 31). If the bird was under anesthesia, the ventrodorsal position would stabilize the breathing of the bird. Thus, this position was preferred in avian species because the vessel injury and nerve damage was less likely to happen (31). When approached dorsally in operation, it should be done with care because it could cause a damage on axillary nerve and radial nerve (10, 34).

The method of reducing the fractured humerus were different a little bit depending on the size of the individual, the condition of the fracture, and the site and type of the fractures. In the closed fracture on the proximal humerus with less severe dislocation, the figure-of-eight bandage was used as treatment. Most of the fractured humerus could mostly be reduced with an orthopedic surgery (39). In treatment method of this study, 7 cases (3.2%) were used with figure of eight bandage while most of them were operated with TIF or IM pin.

There was a little difference in orthopedic reduction of humerus according to the anatomical locations. Pins such as TIF in humerus shaft; cross-pin and TIF in distal humerus; and cross-pins using K-wire or cross-pin with tension band in proximal region were used (10, 39). In the case of small raptor, a sterile disposable hypodermic needle was used instead of IM pin (42). Since it had less amount of muscles to protect the bone. The fractured humerus occurred in the middle and lower middle part (7, 19, 45). As a result, in the analysis of this study data, 51.7% of the individuals that could be treated with the humerus fracture were identified as the fractured diaphysis. TIF was the most common surgical method in humerus fracture. In medical operation, both IM pins and ESF pins were used the reduction of the bone gap or periarticular fracture (10, 16, 31). When using the TIF method on a small raptor, applying both ESF and IM pin would produce iatrogenic fracture due to the spatial limitation in more than 50% of the medullary canal (19). If bone fragmentation was seen around the fracture site, the fragment of the bone should be fixed using a cerclage wire. If the fractured lines were observed, a cerclage wire should be used before the insertion of the ESF pin to prevent iatrogenic fracture or another surgical procedure should be done. If the fractured site was too close to the shoulder joint or elbow joint with no space available to use the ESF, a figure of eight bandage or cross-pinning should be used.

The diameter of 50 to 65% of the medullary cavity should be the diameter of the IM pin to be used in operation (2, 10, 16). When the IM pin was inserted in the proximal direction, there should be no injury to the shoulder joint. When the IM pin was inserted into the distal direction, a good care should be taken to not damage triceps tendon and elbow joints on the distal humerus (7, 16). When the IM pin was inserted the proximal direction in the shoulder joint to reduce damage, it should be inserted from the lateral side of the lumen of the humerus as far as possible and should be careful not to penetrate the elbow joint while performing the insertion from distal side (19).

When performing surgical operation of the fractured ulnar, the dorsal approach was preferred (31). The radial nerve of the humerus passes through the elbow joint, between ulna and radius. The radial artery and nerve exists in parallel, therefore, when approaching the fractured site, the blood vessels and nerves should be carefully avoided (10, 31, 34). When approaching the radial fractured site, radius could easily be accessed by pulling the extensor metacarpi radialis muscle. When approaching the fractured ulna, it could also be easily accessed by pulling the extensor metacarpi ularis muscle (16, 47).

If the closed fracture of only radius did not deviate significantly from the radial shaft fracture, the figure of eight bandage could be used to heal the fractured site (31). When using a figure of eight bandage, it was advised not to put much force on the fractured site. It is good for the raptors to stay in a quiet and dark place without stress. However, it was effective to use an IM pin and an figure of eight bandage together on the radial open fracture or fracture site was severely deviated or the fracture site was located near the elbow or wrist joint. A radial fracture near the joint often resulted in the fusion of the radial and ulna due to the fusion of the fragments. The size of IM pin used in the radial fracture could be minimize the dislocation by using a pin with the 90% of the internal diameter of the bone. In the reduction of the radial fracture, the IM pin was inserted from the fractured site to the direction of the wrist joint. Then the IM pin from the wrist joint was inserted in the direction of the elbow joint in the reverse direction (31). While the wrist joint was folded, and the IM pin was inserted by moving away from the wrist joint to minimize the damage on the wrist joint. The pin should be not contaminated when inserted in the opposite direction from the wrist joint. And it was good to insert the pin to the end of the radius of elbow joint. If not inserted until the end of radius of elbow joint, the fractured site might be displaced or else the fracture might occur at the end of the inserted pin. It was advisable to be careful that the IM pins do not protrude through the elbow joint.

The proximal fracture of the radius and dislocation of the ulna in the elbow joint often occurred in the event of a collision with the electric wire. With small raptors, it was easy to return the dislocated ulna after the surgical reduction of the radius. Returning the dislocated ulna without reduction of the fractured radius, the reconstructed ulna would be re-dislocated frequently and the operation time would increase. However, in a large raptor such as a vulture, the proximal radius fracture and ulnar dislocation of the elbow were treated without reduction of the radius fracture. As a result, even if the closed radius fracture and elbow dislocation of ulna simultaneously, the treatment method might vary depending on the size of the raptor. Once the radius dislocation of elbow joint and ulna fracture were identified. The reduction of the radius luxation in elbow joint was done before the surgery on the fractured ulna. It was believed that radius supports the elbow and wrist joints during the ulna fracture surgery.

In the fractured ulna, the closed fracture was confirmed, and if the fracture site did not deviate significantly or if a closed fracture occurred near the elbow, the figure of eight bandage could be used without surgery but careful observation was required. Occasionally, due to the influence of the figure of eight bandage, In the case of the segmental fractures, the fracture site might be displaced from the first condition of fracture, and resulted in nonunion and malunion. In this case, operation techniques, such as Type I, IM pin, Intramedullary shuttle pin and TIF, were used depending on the condition and size of the raptor (31, 39). In the case of large birds of prey such as Cinereous vulture and Eurasian eagle owl, TIF or Type I surgery techniques were used to reduce the fracture. In the open fracture of small raptors such as Common kestrel, Brown hawk-owl and Oriental scoops owl, it was advisable to reduce the fracture site using IM pin, IM pin with cerclage wire and figure of eight wire to minimize the weight (25). When using the IM pin for fracture operation, it was recommended that the size of the pin should be 50% of the diameter of the bone lumen (10, 16). There were two methods of insertion of the IM pin in the ulnar fracture site. One method is to insert in the direction of the elbow joint from the fractured site to the wrist in the opposite direction (10). In this case, the lateral insertion of the uncontaminated pin should be sensed being inserted as much as possible. Especially, be careful not to penetrate or damage the elbow joints. The other method was to insert the pin in the forward direction at the elbow joint. The inserted part of pin was inserted between the second and third feather of the secondary feathers (10, 16, 39). It was better to refer to the radiograph to determine the pin insertion site. When the pin was inserted into the ulna, the first insertion of the pin should be perpendicular to the ulna, then gradually tilt the pin along the direction of the ulna (39). At this time, if the direction of the pin change with force, the artificial fracture might occur.

In the fractured radius and ulna, all eight out of eight fractures of the only radius fracture were closed fractures. In the cases of the radius and ulna fracture, the open fracture and closed fracture were 11 cases respectively. Only in ulna fractures, 24 cases (96.0%) of the 25 closed fractures were found. Therefore, in the case of a fracture of the radius and ulna, most of them were the closed fracture. However, the fractured radius and ulna simultaneously increased the probability of the open fracture.

If the fracture of the radius and ulna was a closed fracture at the same time, the fracture of radius could be treated by surgical operation whereas the ulna could be treated with a figure of eight bandage. However, if the fracture of the ulna deviated much from the normal range, it was better to use the IM pin for reduction. In the case of an open fracture of the radius and ulna, IM pin was used for reduction on both of them because the soft tissues of muscle and skin were severely damaged. In the case of the open fractured ulna, using the IM pin, soft tissue severely damaged relative to the closed fracture. For this reason, if the wire of eight shaped figure was used in reduction instead of IM pin, the weight and dislocation of the fracture site could be minimized.

When collision occurred, the open and comminuted fractures were common on the carpometacarpus that was located at the tip of the wing when a strong impact was concentrated in a small part (39). Approaching the fractured carpometacarpus in operation could be possible in both dorsal and ventral direction (10, 31, 34). After reading the radiograph of fractured site of the carpometacarpus, the treatment method or surgical procedure was selected. If the fracture site was aligned on the radiograph and the fracture was not severely dislocated in palpation, the U-shaped SAM splint should be used to fix the fracture regardless of open or closed fracture, and then the fractures should be treated with a figure of eight bandage. If the fracture site of the carpometacarpus that could not be treated using a U-shaped splint, the site of the fracture should be arranged and treated using the IM pin or TIF method. The surgical site for the carpometacarpus was preferred to be approached in dorsal direction better than ventral direction. Because the nerve and blood vessels passed through the ventral part. Due to lack of the skin that would pull in suture after the incision, the access to the back was better. In the case of the carpometacarpus fracture, it was better to insert the IM pin side by side in front of the complete bony lumen with folding the carpal joint so that there is minimal joint damage. The fracture site was aligned and the IM pin was inserted retrograde to the distal part of the bone. When bone reduction with only IM pin, it was better to select the diameter of the pin corresponding to 80% of lumen. A large size bird of prey, Eurasian Eagle Owl, was operated by TIF method. In this case, the size of the diameter of IM pin used about 40% of the diameter of the bone lumen and the ESF pin was selected considering the size of the IM pin. In fractured site of a carpometacarpus, vascular injury and avascular necrosis were resulted in the lacking amount of the soft tissues (39). During the carpometacarpus fracture treatment, 3 individuals were identified as avascular necrosis and then euthanized. Therefore, it was necessary to minimize the damage of the blood vessels while performing an operation. When using a U-shaped splint, the problems with circulation of the blood should be carefully pressed at the fractured site.

Among the 249 individual with the treatable fractures, the 163 fractures were observed in humerus, radius, ulna and carpometacarpus at the thoracic limb. The 30 fractures at the pelvic limb such as femur, tibiotarsus and tarsometatarsus were found to be relatively less compared to the site of the wing. Because the femur was surrounded by a large amount of muscle in general, the closed fractures could be observed (45). All of the femoral fractures of the 9 treatable individuals were the closed fractures. The femur with the open fracture needed to be cleaned with care. In the proximal fracture, it is connected with the air sac, so it was be better to avoid cleaning with water (45).

There were two methods to approach the site of the fractured femur. One way was to approach outward after lying down in the lateral recumbency and the other way was to approach inward. The nerve, artery and vein of the ischiatic should carefully be avoided when approaching inward (31). In addition, because of the difficulty in using the external pin fixation and the difficulty in the post-operative care, most operations were performed by approaching outward instead of approaching inward.

When approaching the fractured site of femur, it was advisable to accurately identify the fractured site of the femur and to incise the fracture site based on the greater trochanter and stifle joint of the femur. To approach the fractured site after incision, if the iliotibialis muscle and femorotibialis externus or iliofibularis muscle were pulled, it was easily approached to the fracture site after incision (10, 31). When approaching outward, the major arteries, nerves and veins were located under the iliofibularis muscle and could be approached carefully (3).

The methods used for fracture reduction were Plate, Type Ⅰ, IM pin and shuttle pins (31). When the diaphysis of the femur was fractured, the TIF method was generally used (45). When the IM pin was inserted, it must pass through the greater trochanter of the femur outside the hip joint and then insert the IM pin in the reverse direction after aligning the fractured site. At this time, insertion of the IM pin should be pushed as far as possible from the femoral side to avoid being damaged to the hip joint, and the IM pin could normally come out to the greater trochanter position. In addition, when inserting the pin in the reverse direction, it should be carefully inserted in the stifle joint.

The fracture of the tibiotarsus was frequently observed in the site of the pelvic limb (5). In addition, because most of the fracture occurred in the midshaft, it was easy to reduction as an operation (3, 45). In this study, 17 fractures out of the 30 treatable pelvic limb fracture were identified in the tibiotarsus.

The access method from the craniomedial incision had a priority in the tibiotarsus fracture. It was difficult to approach the outside because of two arteries side by side between fibula and tibiotarsus (7). In the craniomedial incision, the traction of the cranial tibial muscle and medial gastrocnemius muscle could identify the fracture of femur (3, 10). In addition, when approaching the craniomedial side, it was possible to avoid the access to the nerves, arteries and veins.

The method of reduction of the tibiotarsus was reduced using various methods such as IM pin, ESF , Type II and TIF (4, 16). When the fractured site was reduced using the IM pin, it was inserted into the tibial crest and inserted through the proximal and distal part of fracture (31). When inserting the IM pin, the person interested should be careful not to damage the stifle joint (52). If it was difficult to insert the IM pin into the tibial crest, after insertion of the pin at the fracture site, the pin should be inserted as far as possible in the direction of the tibial crest. At this time, the insertion of the pin by folding the stifle joint could reduce the damage of the joint. The diaphysis fracture of tibiotarsus was medically operated using the TIF method that was using the IM pin with ESF (10, 31). The IM pin size should be selected considering the ESF pin insertion space. However, only using ESF pin should be avoided because of the difficulty of aligning the fracture with the reduction of the fractured site (45). When the IM pin was only used to reduction the fracture, it was necessary to fix the distal part of femur and the proximal part of the tarsometatarsus with a splint and bandage because the IM pin was weak against the rotation of the fractured site. In the case of both fractured of tibiotarsus, it was advisable to use a sling after the surgery to minimize the limb movement if necessary.

The tarsometatarsus fractures that could be treated are relatively rare cases (19). Besides, because there were relatively few soft tissues within tarsometatarsus, most of the fractures were caused by the open fractures and injuries of the blood vessel. Therefore, most of the foot or digits edema was observed (10, 45). Most of the rescued individuals with fractured tarsometatarsus was mostly due to the leg-hold trap. As a result, most cases had nerve, blood vessel and muscle cut or untreatable comminuted fracture or lost below the fractured site. The operation method of the tarsometatarsus fracture was by using splint, External fixation Type II, and IM pin (10, 45).

The approach to the tarsometatarsus fracture was from the lateral side, and the back of the tarsometatarsus had a U-shaped bone with a groove. The flexor tendons passed into the grooves (3, 10, 31). The extensor tendons, arteries and nerve were passed to the anterior part of the tarsometatarsus (10). The fixation of the external fixation pin from the anterior to the posterior should be avoided (45). The Type II method was the most stable for fixing the fracture of the tarsometatarsus (31). However, during Full-pin insertion, the flexor tendons in the groove and the extensor tendons in the anterior should be avoided. This was because, if there is ligament damage, it might not be possible to release due to the problems in moving the digit.

The furcular and coracoid at the entrance of the thoracic inlet often collapsed at the same time when colliding with an artificial structure such as a building window or a vehicle (31). The sternocoracoidal joints between the coracoid and the sternum were also dislocated due to the collision.

If the coracoid fracture did not shift much or the weight of the individual was less than 300-500g, instead of doing surgical treatment, the fractured wing could be fixed to the body with the figure of eight bandage. Then the injured individual was restricting the movement in the cage that was possible to treat the fracture. (17, 41, 48). After confirming the fracture location of the coracoid by radiography, a surgical retractor was used to align the fractured site as much as possible. It was effective in treating fractures and has a good prognosis. It was advisable for reduction of the fracture site using an IM pin if the body weight was over 500g or if the fracture site was severely deviated to make it difficult to align with the retractor (7, 30). When approaching the coracoid fracture site, the superficial pectoral muscle and deep pectoral muscle should be approached after incision or blunt dissection. When the IM pin was inserted at the fractured site, it should carefully avoid perforating the pericardium and the heart through the sternum (31). In the case of the fractured individual with a severe comminuted fracture, the prognosis should be judged without operation after the maintenance of the bandage. The dislocation of the sternocoracoid joint was not common (12). It was usually dislocated to the inside of the sternum by collision, but sometimes it was dislocated to the outside of the sternum. If the sternocoracoidal joint was dislocated, it could be returned to its original state using a surgical retractor. The luxation of the sternocoracoidal joint was easier to reduction the inner sternal dislocation than to reduction the outer sternal dislocation.

When it was impossible to perform an operation of the fractured site such as scapular, sternum, and ribs, individuals were restricted movement. In addition, the treatment was performed while restricting stimulation by creating an environment in which the stability could be found. Fortunately, in the case of a beak fracture, there were no confirmed cases of severe fracture to perform a surgical operation. In the case of dislocation, the dislocated site was returned, and a figure of eight bandage was used to limit the movement. Some injured ligaments around the dislocated area were treatable, but the individuals that could not be treated were euthanized. The diverse treatment methods for the joint dislocation were needed.

Based on the medical records of 249 raptors that were able to treat the fractures, items such as the data such as fracture type, fracture condition, fracture zone, the dislocation, the body condition score, the time after the fracture, the state of the fracture and the physical condition were clinically scored and summarized. However, the clinical score that was analyzed in this study meant a scoring the clinical status. The scoring of the clinical status also meant not only the physical condition of the surgery site, but also the fidelity of the body that was appropriate for the surgery. However, there was a slight deficiency. Therefore, after additional investigation concerning clinical symptoms such as infectious diseases or poisoning, head trauma, respiratory problems and severe trauma other than fractures, the clinical scores were performed. Obtaining research data on many individuals in the future, it will become more accurate data on the surgery of fractured raptor.

The clinical condition of the fracture site was also scored for treatable raptors except those that were not treatable. For this reason, there was not significant differences in the clinical scores of the fracture site between the returned individuals after fracture treatment and those that died during the treatment. Therefore, after obtaining the results of the data of the clinical score of the fracture site concerning all the raptors diagnosed with the fracture and the treatment, the clinical scores were summarized as the results of medical treatment were arranged. The results of clinical treatment of the fractured site concerning the diagnose individuals with fracture could be predicted using the clinical score of the fractured site.

The correct cure must be properly selected according to the site, zone, type, direction, condition, and depending on the elapsed time of the fracture. The treatment method on surgery should be cautiously decided after accurately understanding and considering the physical conditions and the size of the fractured raptor (7). Because the adjacent soft tissue and vessel tended to be adhesive by the beginning of the formation of the connective tissue and callus, and then because of the following heavy damage on the nerves and blood vessels resulted during the surgery. The fracture surgery should be performed for the fast recovery as soon as possible (10). When it came to the open fracture with inflammation, the person interested had best inflammation treatment preliminary to the surgery (26). Unlike the ordinary mammals, birds had feathers instead of furs, the feathers around the surgical area were removed, and the surrounding surgical sites were fixed with the micropore tape (3M; Anseong, Korea) not to leave a residue behind to secure a clear view (19). Both heartbeat and temperature was monitored by Audio patient monitor (A.M.Bicford Inc.; Newyork. USA) and digital thermometer (45).

It was important to prevent infection after surgery by administering analgesics such as meloxicam (0.5mg/kg orally, q 12h Metacam, Boehringer Ingelheim Vetmedica, Seoul, Korea) and antibiotics such as enrofloxacin (15mg/kg orally, q 12h; Bytril flavorur Tablets, Bayer HealthCare, Seoul, Korea) or clindamycin. (10mg/kg orally, q 24h; Fullgram Cap, SAMJIN, Seoul, Korea). In addition, the disinfection and antibiotic ointment should be applied after post-operative treatment to prevent infection. Especially, the pin insertion site was easily infected therefore, the infection should be carefully prevented. After the surgery, the radiographs should be performed at regular intervals. The cartilage formation should be carefully checked at the fractured site. It was also necessary to remove the pin or remove the bandage after confirming the availability through palpation.

As pin was removed after fracture surgery and when using bandage and splint, the length of time until the fracture was united as follows; it took 17.7(±5.6) days for the humerus, 19.2(±5.5) days for radius, 19.0(±6.9) days for ulna and 23.4(±7.7) days for carpometacarpus. The longer the distance from the body to the distal side, the longer it took to union. However, in the pelvic limb, it took 19.6(±8.3) days for the femur, 15.8(±6.4) days for the tibiotarus, and 25.7(±2.5) days for the tarsometatarsus. The time for union of the fractured pelvic limb did not take longer as the wings moved away from the body. Because it was presumed that the number of pelvic limb fracture was relatively small compared to the number of thoracic limb fractures. In this analysis, it was assumed that the time of union might be different depending on the type of fracture, condition of fracture and size of species. But these cases were excluded because of insufficient population. If more data was available for the union of the fracture in the future, more studies on the fracture union are needed.

If there was some mobility of patients after the removal of the pin, it was necessary to limit the movement for 2-3 days by taping the fractured site. If the active range of motion (AROM) was sufficient to maintain the normal function of the fractured joints around the fracture site, and if there was no problem with the onset ligament, it should be moved to a room with a larger space rather than the intensive care unit. It was necessary to observe the movement of the surgical site for the fracture. However, if there was a problem with the function of the joint on the surgery site, the movement should be checked while performing the passive range of motion (PROM), processing physical therapy.

If it was evaluated that there was no problem with the mobility of the joint, it was necessary to start the rehabilitation at the outdoor cage. If it was evaluated that there was no problem in hunting food and flying to the masthead, it was necessary to select an appropriate place and time to release to the nature according to the characteristics of the species. Accidents occur during rehabilitation or inhabiting cage at outdoor. As a result, it was impossible to return to the nature due to the fractures or fatal injuries. Therefore, it was necessary to be careful not to cause accident in the rescue center.

The average length of time that was taken for the fractured individuals to return to the nature was 51.4(±35.5) days. It was assumed that there would be a difference according to the condition of the fractured site as well as the state of the individual and the characteristics of the species. Therefore, if collecting the data about more raptors that returned to the nature after the fracture treatment in the future, the data would be helpful to the treat wild raptors.

The basic data was made using the medical records of 249 raptors that were medically treated for the fracture and dislocation at the Wild Animal Rescue Center for five years from January 2014 to December 2018. The data such as the type and status of the fracture, surgery and treatment method, clinical scores, and fracture union were analyzed. The basic analytical data of this study would be a basic reference when selecting the appropriate methods for the treatment of raptors that were diagnosed with the fractures and dislocations.

5. Conclusion

There were 450 raptors that were admitted to the wildlife rescue center from January 2014 to December 2018. The admitted raptors were diagnosed with fracture and dislocation. Among the admitted 450 individuals, 249 raptors were able to receive medical treatment.

1. There was 201 raptors that were euthanized. Among the euthanized raptors, the main cause was due to the damaged nerves by 73 raptors (47.1%).

2. The TIF methods were used to treat the fractured humerus. The instrument of IM pin for radius and the figure of eight bandage for fractured coracoids were the mostly used.

3. The analysis of the healing time that was taken to remove the pins or to union of the fracture after the treatment revealed that the union period needed the average of 17.0(±6.8) days.

4. Among the treated 249 raptors, the 139 raptors (55.8%) returned to nature after the treatment for the fracture and dislocation.

According to the fracture treatment sites, the analysis results of the clinical status average scores were as follows; there were 2.12 score that return to nature, 2.72 score that died during the treatment and 3.30 score for euthanasia. The lower the clinical score of fracture condition, the better the prognosis of fracture treatment.

General Conclusion

The Raptors that were admitted at the Chungnam Wild Animal Rescue Center were rescued from various causes of distress. They were then returned to the nature after receiving treatment and rehabilitation. In this study, the causes of distress and diagnosis of the rescued raptors have been analyzed. The types, treatment, and the outcomes of the fractured and dislocated raptors were analyzed as well.

The largest number of the rescued raptors were identified as a Common kestrel (*Falco tinnunculus)*. The collision with the building or electric wire was the main cause of the distress according to the analysis. The fractures and dislocations were the common part of the distress and the diagnosis results.

The raptors that were diagnosed with fractures and dislocations were seen mostly in the humerus of the thoracic limb. With the 7 long bones of the raptors, the assessment of the type of fracture was analyzed; the common fracture condition of the closed fracture, the zone of the fracture mostly in diaphysis, and the common fracture type as transverse fracture.

The euthanized raptors that were diagnosed with the fracture were impossible to give a medical treatment due to the damaged nerve. Treatment and operation were performed using the most appropriate and optimum methods for the individual. Among the methods of treating the fracture site; TIF method was used for treatment of humerus fracture and IM pin was mostly applied to the radius operation. The mean time taken for the fracture site to union was 17(±6.8) days after the treatment.

The preoperative fracture condition of the raptor was clinically scored. By comparing the clinical score and the result of the treatment, the individuals that returned to the nature had the average of 2.12(±1.3) score. Therefore, the lower the clinical score, the more individuals returned to the nature. The clinical score of the fracture condition can be used as an indirect index to determine the prognosis of a fractured raptor.

Unlike other western countries, in Korea, there are not enough basic data about the diagnosis, treatment, rehabilitation of raptors and the release of the raptors to the nature. Therefore, this study was analyzed to see the results of diagnosis and the treatment of the fractured raptors that were rescued in Chungnam. It will be the essential data for the future veterinarians who are interested in wildlife.

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국문초록

충남지역에서 구조된 맹금류의 골절 치료에 관한 연구

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본 연구는 2014년 1월부터 2018년 12월까지(5년간) 충남야생동물 구조 센터에 접수된 맹금류 1,238개체를 대상으로 초기 진료 기록을 바탕으로 조난 원인에 따른 유형 분석 및 초기 진단과 치료에 따른 결과를 비교 분석하였다. 그리고 골절로 진단된 450개체에 대한 조난 원인과 골절 유형에 대해 분석하였으며 골절 치료가 가능한 249개체에 대한 수술방법, 치료법과 치료에 따른 결과를 분석하였다

최근 5년동안 충남 야생동물 구조 센터로 구조된 맹금류는 2목 3과 18종 1,238개체였으며, 천연기념물로 등록된 종은 14종 1,120개체(90.5%), 멸종위기종은 11종 536개체(43.3%)였다. 구조된 개체 중 가장 많은 비중을 차지한 종은 천연기념물로 등록된 황조롱이로 344개체(27.8%)였다. 연구 조사기간인 5년 중 2015년에 276개체(22.3%)로 가장 많은 맹금류가 구조되었으며, 4계절 중 번식기가 포함된 여름철 구조 비율이 503개체(40.7%)로 가장 높았다. 충남 지역 중 아산시가 224개체(18.1%)로 가장 많이 구조된 지역이었다. 맹금류의 다양한 조난 원인에서 전선 또는 건물과의 충돌이 453개체(36.6%)로 가장 많았으며, 진단 결과에서 골절 및 탈구가 450개체(36.3%)로 가장 많은 것으로 나타났다. 치료 결과 자연복귀는 전체 1,238개체 중 690개체(55.7%)로 나타났다.

골절 및 탈구로 진단된 450개체 중 가장 많이 발생된 개체는 황조롱이로 99개체(22.0%)였으며, 골절 및 탈구의 발생원인 중에서는 건물/전선과의 충돌이 286개체(69.8%)로 가장 많이 확인되었다. 그리고 450개체에서 701개의 골절 및 탈구가

확인되었으며, 날개 부분의 골절 및 탈구가 405개(57.8%)로 가장 많은 것으로 나타났다. 그 중 상완골에서 151개(40.8%)로 가장 많았다. 골절로 진단된 개체에 대한 임상적 범주 분석 결과에서는 임상적 범주 4에 해당하는 개체가 204개체(45.3%)로 가장 많았다. 골절 개체 450개체에서 안락사 개체수는 199개체(44.2%)였다.

골절로 진단된 450개체 중 치료가 불가능한 개체는 201개체였으며 그중 73개체(47.1%)가 신경손상으로 인하여 치료가 불가능하였다. 치료가 가능한 249개체에 대하여 골절 및 탈구 위치, 골절 유형, 임상 평가 점수, 골절 수술 및 치료방법, 골절 유합 시간, 치료 결과 등을 분석한 결과, 상완골 수술에는 TIF, 요골 수술에는 IM pin, 오훼골 골절 치료에는 8자 포대를 사용하는 치료 방법이 가장 많이 사용되었다. 골절 치료 개체의 핀 제거 또는 유합할 때까지 걸리는 기간에서 부척골은 25.7(±2.5)일로 가장 많은 시간이 필요했으며, 쇄골이 10.7(±3.2)로 가장 빨리 유합되는 것을 확인하였다. 골절 치료 결과 249개체 중 139개체(55.8%)가 자연으로 복귀했으며 58개체(23.3%)는 치료 중 폐사, 44개체(17.7%)는 치료 중 또는 치료가 끝난 후 자연으로 복귀가 불가능하다고 판단하여 안락사, 8개체(3.2%)는 치료 중이거나 자연복귀가 불가능한 영구 장애로 나타났다.

골절 부위 치료 결과에 따른 임상적 상태 점수를 분석한 결과 자연복귀시킨 개체의 경우 2.12점, 폐사되는 경우 2.72점, 안락사되는 경우는 3.38점으로 나타났다. 즉, 구조되어 온 조류의 골절상태에 대한 임상적 점수가 낮을수록 자연으로 복귀될 수 있는 가능성이 높았다. 따라서 치료 전 골절상태의 임상 점수는 골절 개체의 예후를 판단하는데 유용한 지표로 사용될 수 있을 것으로 판단된다.

주요어: 맹금류, 조난원인, 충돌, 외상, 골절유형, 임상점수

감사의 글

지금의 제가 야생동물수의사로 성장하고 발전할 수 있도록 많은 가르침과 조언을 해주신 제주대학교 수의과대학 모든 교수님들께 감사드립니다.

충남야생동물 구조센터에서 근무할 때 많은 도움을 주시고 충남센터 자료를 사용할 수 있게 허락 해주신 박영석 센터장님 감사드립니다. 또한 김병수 구조본부장님과 이준우 실장님께도 감사드립니다. 충남센터에서 함께 근무를 하면서 힘들 때 마다 서로에게 힘이 되어준 김희종 수의사, 이문희 수의사, 현용선 수의사, 오제영 수의사, 박용현, 정병길, 김문정, 안병덕, 김봉균, 선동주, 이준석, 신다혜 재활관리사 외 근로학생 및 자원봉사자들께 감사드립니다. 또한, 충남센터에서 근무를 할 때 야생동물에 대한 아낌없는 조언을 해주신 김영준 선생님께 감사드립니다.

충남센터에서 근무하게 되면서 인연이 된 후 많은 도움을 주신 생물자원관 김순옥 박사님 그리고 안정화 박사님과 전혜숙 선생님께도 감사드립니다. 충남센터에서 일을 하면서 힘들 때 마다 많은 도움과 조언을 해주신 김혜권 박사님과 최성준 박사님, 전북센터 임혜린 수의사에게도 감사드립니다.

제주야생동물 구조센터에서 많은 도움을 주신 진태정 행정실장님, 안재호 수의사, 이정훈 재활관리사에게도 감사드립니다. 제주야생동물 구조센터와 처음 인연을 맺을 때 알게 되었던 이제욱 수의사, 그리고 학부생일 때 제주센터에서 봉사활동을 하면서 야생동물에 대한 다양한 정보를 주었던 이상 수의사, 문경하 수의사 그리고 대학원생일 때 많은 도움을 준 김윤기 수의사, 장영혜 수의사와 민동원 재활관리사에게도 감사드립니다.

심사위원장이신 이경갑 교수님 그리고 이주명 교수님, 서종필 교수님께서 논문이 잘 마무리되도록 해주신 많은 조언과 충고에 진심으로 감사드립니다. 바쁜 시간에도 멀리 제주까지 오셔서 논문 지도해주신 충북대학교 김근형 교수님께도 감사드립니다. 저의 대학원 석사, 박사 과정 중 많은 도움과 아낌없는 조언을 해주신 윤영민 지도 교수님께 감사드립니다.

지금까지 저를 믿고 지켜봐 주신 부모님께 감사드립니다. 만날 때 마다 항상 응원의 말씀을 잊지 않고 해주신 장모님께도 감사드립니다. 먼 외국에서 열심히 공부하면서 틈틈이 응원해준 동생과 타지에서 힘들게 공부하면서 잊지 않고 응원해준 처제에게 감사의 마음을 전하고 싶습니다. 마지막으로 직장과 학위논문 때문에 서로 떨어져 살면서 제대로 가정을 돌봐주지 못함에도 불구하고 항상 곁에서 힘이 되어주고 믿음을 준 사랑하는 아내, 그리고 아들에게 고맙다는 말과 미안하다는 말을 전하고 싶습니다.

야생동물 수의사로서 이제 막 첫 걸음 내 딛는 순간에....