Over 40,000 raptors (including owls) are kept in the UK, primarily by active falconers using them to hunt quarry as a hobby, or as pest control. Any musculoskeletal disease affecting the wing or limb will impact on the bird’s ability to maintain flight or to catch and kill quarry. Many conditions that compromise musculoskeletal integrity are inherently related to inappropriate husbandry with traumatic injury less common and less predictable. Individual injuries should be assessed and treated based on location and type and it is beyond the scope of this article to cover all possible traumatic injuries. The four most common conditions affecting limb function are described in detail.

**TIBIOTARSAL FRACTURE**

Tibiotarsal fractures are the commonest orthopaedic injury of captive raptors and typically occur in the first three weeks after a bird is initially tethered. Birds that are unaccustomed to tethering, may bate (fly away from) their perch before being stopped mid-flight by the tethering leash. The force exerted on the legs is proportional to the speed of flight. The longer the leash, the further they will have flown before being stopped, the more they will have accelerated and hence the greater the force at the time of impact. The tibiotarsal anatomy predisposes the bone to fracture at a point 2-3cm distal to the tibial crest as here the cross-sectional shape of the bone alters from triangular proximally to circular with inherent loss of structural security.
Many techniques have been suggested for repair of the typical simple transverse tibiotarsal fracture. A tie-in hybrid fixator is the authors’ treatment of choice, as this provides rotational and longitudinal stability, improved reduction and alignment, without the restriction of a splint. A tie-in fixator meets the requirements for avian fracture repair, with no requirement for coaption, relatively low cost, avoidance of joint impairment and complete removal following healing. In birds, two pins in each fragment is sufficient for stability, and three may predispose to re-fracture. In the authors’ experience, use of a tie-in fixator for closed tibiotarsal fractures has a good success rate with complete return to function in the overwhelming majority.
The surgical incision is made on the medial aspect of the leg, over the fracture site. An intramedullary pin is inserted retrograde into the proximal fragment with stifle flexed, then passed normograde into the distal fragment. The proximal pin end is then bent at 90° 5mm from the exit point, and directed laterally. Threaded ESF pins are then placed lateral to medial in the proximal and distal fragments, through both cortices. ESF and IM pins are joined with a straight bar, restrained with cerclage wires and overlain with methylmethacrylate to secure the fixator.

![Figure 7 Post-operative radiographs of the fracture using a tie-in hybrid fixator.](image)

With non-eventful healing the intramedullary pin is removed 10 days post initial surgery and the ESF pins two weeks later. Radiographs are taken to assess callus formation and healing, prior to final ESF removal.

As this is primarily a disease of management, husbandry changes can reduce occurrence. Short leashes limit flight distance, hence speed and force. The leash must be long enough to allow free movement while on the perch, and keep the tail feathers off the ground. Bow perches increase incidence as potential flight length is greater, compared with block perches (preferred for initially tethering).
Figure 8 Demonstration of increased flight distance with a bow perch in comparison to a block perch, with leashes of identical length.

Bating and bating distance should be minimised. Confinement at first tethering reduces the stimulus and limits the distance for flight and hence trauma at impact, this can later be increased as the bird adapts to the tethering.

Reduction in injury can only be achieved by general education as the injury typically occurs in younger birds, before that bird has ever seen a vet. Educational courses run at the author’s workplace have a high uptake from both experienced and novice falconers with an opportunity to recommend methods to reduce risk of this and other problems.

WING TIP OEDEMA

Wing tip oedema and dry gangrene syndrome is seasonal condition affecting the metacarpus of falconiform birds. Species from warm climates, e.g. Lanner falcons and Harris’ Hawks are most commonly affected, but peregrines and other similar species, from temperate climates may also be affected. The condition occurs during the winter months (October – April) and appears to be precipitated by a period of cold or freezing weather. Disease generally affects young birds at ‘flying weight’ which have been tethered within 45cm of the ground during cold days or nights. First year birds have higher incidence due to lower weight, less well developed flight muscles and hence peripheral blood supply and some raptors’ juvenile plumage is softer, more brittle and less durable than adult plumage.

Birds typically present with an abducted or drooped wing, loss of flight performance or swollen, wet and cold wing tips.
Figure 9 Typical posture with wings held out and some swelling evident on the wing tip.

The swelling starts at the insertion point of the primary feathers and extends proximally. The more severe the case, the further the swelling ascends. The swelling is sterile, fluid filled and characterised by a pitting oedema. It is typically evident for 3 – 4 weeks before reducing. The colouration of the wing tip is dictated by the state of the circulation. In untreated cases the wing tip will change from pale pink, to pale yellow, pale brown, brown and finally black, before the darkened portion (having become dry and devitalised) drops off,
leaving a clean, healed junction, some 6 weeks later. If the initial pathology is not identified when it first occurs then sudden loss of one or both wing tips may be the first observation. It is important to appreciate that it is not the distal primary feathers falling out but the entire tip of the wing, from which the primary feathers originate, dropping off, never to re-grow. The result is a young bird whose future flight ability will at best be compromised, permanently.

Figure 10 Oedematous wing tip in an affected kestrel

Therapy at presentation consists of gently warming the bird, maintaining it at normal room temperature (15-20°C), and stimulating wing movements. Birds with minor signs, still capable of flight, should be flown as regular gentle exercise is useful in maintaining, or re-establishing circulation to, and drainage from, the affected areas. Large vesicles should be drained in an aseptic manner three times daily, until they fail to refill (usually 7 - 10 days).
Antibiotic therapy is required to prevent concurrent gastro-intestinal gram negative overgrowth, which is sometimes a feature. The topical application of Preparation H (Whitehall Labs), which comprises yeast and shark oil, has been used by many avian clinicians in the treatment of avascular lesions and may be useful. Isoxsuprine, a and adrenoreceptor antagonist, has been recommended as a vasodilator (Lewis et al.1993). In one study (Forbes, 1992) only 21% of birds recovered without loss of primary feathers, even with early aggressive treatment, but since the introduction of Isoxuprine recovery rates have increased to 90%. Propentofylline (Vivotin, Intervet Schering-Plough) can be used as an alternative but appears less efficacious.

The condition can be avoided by free lofting (allowing birds free flight in an aviary) of susceptible birds during the risk season. Supplementary heat may also be provided, with lamps or low wattage oil filled bar heats, connected to ‘froststats’ which switch on heaters when the temperature drops to a predetermined level. No predisposed species should be tethered within 45cm of the ground during October-April.

BUMBLEFOOT
Bumble foot, (Pododermatitis) is a very common disease affecting captive but not free living raptors. It is commonest in falcons, occasionally seen in eagles and owls and rare in hawks and others. The condition may rarely arise secondary to a penetration or abrasion, but is more commonly linked to pressure necrosis of the plantar aspect of the foot. The pressure necrosis results in a breach of the dermal defence mechanism, such that pathogens on the skin, can traverse the barrier and set up localised or generalised cellulitis in the foot.
Prolonged perch ing time
Unequal weight-bearing
Uniform perching surfaces
Presence of *Staphylococcus aureus*
Lack of exercise
Poor hygiene

Table 1, **Common factors predisposing to bumblefoot**

The commonest pathogens isolated are *Staphylococcus* spp. which are not a natural commensal of raptor pedal skin. In falcons (but not hawks, eagles or owls) staphylococcal toxins can cause hypersensitivity reactions, resulting in pronounced detrimental vascular changes. Hypovitaminosis A has also been postulated as a complicating factor, although in the UK this is unlikely as so many falconry birds are fed on a day old chick diet, which is high in vitamin A.

Cooper (1978) suggested a system of classification for clinical cases:

**Type I** – mild lesions, characterised by a shiny smooth loss of dermal papillae (degenerative), or the development of a corn (proliferative). Such lesions are localised and no infection is present.

Husbandry changes, and topical treatments are often sufficient to prevent progression and allow resolution. Providing a variety of perching surfaces encourages weight bearing on different areas of the feet preventing constant loading on one specific area. Astroturf (artificial grass) assists greatly in distributing the weight on the plantar aspect of the foot. Regular cleaning is essential, as this material supports the long-term survival of bacterial contamination (unlike traditional surfaces such as cork, carpet, rubber or rope). Weight reduction and regular flying improves cardiovascular function and limits time confined to a perch and is always indicated.

**Type II** – more extensive lesions, where infection and inflammation is a feature. Subcutaneous tissues are involved, causing heat, swelling and pain, but tendons and bones remain unaffected.

Type II lesions will not respond to husbandry changes alone. The control of infection and inflammation is vital. Many cases will not respond to medical therapy as the avascular nature of the lesions prevents delivery of medication given systemically. Surgical debridement to remove necrotic areas is often necessary. The aim is to reduce the antigen load and to convert an infected necrotic lesion to one that can heal by first intention. Microbiology culture and sensitivity testing prior to surgical intervention is indicated wherever possible. Fibrous tissues build up around infected and damaged tissue very rapidly in this situation, so that application of the optimal antibiotic at the time of surgery rather than several days later is important in optimising the prognosis.
**Type III** – Chronic and severe infection with involvement of bone, tendon or ligaments.

Surgical debridement is essential to reduce contaminated, avascular regions. The use of antibiotic impregnated methylmethacrylate beads can greatly improve recovery rates in these cases. In all surgical situations, if possible the incision should be made on a non-weight bearing area of the foot so that healing is not delayed. Use of an intra operative tourniquet and a foot-holding frame is invaluable for accurate, effective surgery. The prognosis for Type III lesions is generally poor but depends on the degree and nature of damage to deeper structures. Radiography is essential to assess bone involvement as significant lysis is a grave prognostic factor.

*Figure 5 Bilateral bumblefoot in an Eagle Owl*

Not only following bumblefoot surgery, but in any case where a falcon (as opposed to a hawk, eagle or owl), has any reason to excessively bear weight on one foot, the foot should be padded with a weight sparing dressing. This reduces the likelihood of bumblefoot in the excessively loaded foot. Whenever a clinician is approaching any case of bumblefoot, they must question why the lesion occurred initially. The cause is typically a perching or other husbandry issue. Unless this is addressed, the condition will reoccur following treatment and the therapeutic approach will be questioned by the owner, rather than the owners own husbandry standards.
LEAD TOXICOSIS
Lead is most commonly ingested by captive and free living raptors when shot quarry is consumed. Prey may have been killed by shooting or contain remaining shot from a previous non-fatal injury. Once ingested, acid digestion liberates toxic lead salts that are absorbed and disseminated systemically.

Raptors may be presented with any central or peripheral nerve defect. This is often seen as leg weakness, plantigrade stance sitting on meta-tarsae, grasping one leg with the other, abnormal posture or toes knuckled under. Central signs can vary from apparent normality but weakness in flight, acute onset blindness to full blown seizures.

![Figure 3 Plantigrade stance in a goshawk affected by lead toxicosis](image)

Radiography may show radio-dense particles within the proventriculus, but in larger raptors (typically those >1kg) systemic effects of intoxication progresses at a slower rate, so they may still have been fit enough to cast (including the lead pellet) up after the meal which poisoned them, so that no metallic particle is seen on radiographs. The absence of radiographic heavy metal particles does not exclude lead toxicosis as a diagnosis. Other radiographic findings may include proventricular dilation or renal enlargement.
On blood analysis there may be a mild leucocytosis, and elevation of liver parameters and in more chronic cases hypochromic anaemia. Definitive diagnosis involves blood lead assays, but if suspicion is high chelation therapy may be commenced prior to result availability.

Figure 3a Lead particles evident within the gizzard in a Gyr falcon with lead toxicosis

Where possible lead particles should be removed by careful proventricular flushing under general anaesthesia, or endoscopic retrieval. Sodium calcium edetate injections are the heavy metal chelation therapy of choice and should be administered even if lead removal is successful (for 5 days post lead removal). Fluid therapy is essential to minimise renal compromise from both lead salts and the potentially nephrotoxic effects of chelation. Post therapeutic relapses can occur due to rebound increase blood levels following release from bone deposits. In such cases, repeat chelation is indicated until bone stores are exhausted.

Whenever birds of prey present with any compromise of musculoskeletal function a thorough appraisal of husbandry is essential as there are many interactions between management and performance. Any causative or exacerbating factors must be identified to speed recovery and prevent recurrence. During hospitalisation is it crucial to avoid aggravating or creating problems by providing perching appropriate to the species and condition, sympathetic handling, preventing feather damage by placement of a tail guard and protecting vulnerable areas, such as the feet when weight-bearing is unequal, with dressings.
<table>
<thead>
<tr>
<th>Agent</th>
<th>Dosage</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ANTIMICROBIAL AGENTS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enrofloxacin</td>
<td>5-10mg/kg twice daily PO IM</td>
<td>Subcutaneous and intramuscular injection can cause localised necrosis</td>
</tr>
<tr>
<td>Amoxicillin-clavulanate</td>
<td>125mg/kg twice daily PO IM</td>
<td></td>
</tr>
<tr>
<td>Itraconazole</td>
<td>5-15mg/kg twice daily PO</td>
<td>Administer prophylactically to species predisposed to aspergillosis during periods of stress e.g. hospitalisation</td>
</tr>
<tr>
<td><strong>ANALGESICS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butorphanol</td>
<td>0.5-1mg/kg IM three times daily</td>
<td>Central opiate receptors are primarily ( \delta ) rather than ( \mu ) though efficacy studies are limited</td>
</tr>
<tr>
<td>Meloxicam</td>
<td>0.2mg/kg once daily PO</td>
<td>Ensure adequate hydration before use, avoid use in vultures and condors</td>
</tr>
<tr>
<td>Carprofen</td>
<td>2mg/kg once daily IM</td>
<td>Ensure adequate hydration before use</td>
</tr>
<tr>
<td><strong>MISCELLANEOUS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isoxuprine (Navilox, Univet)</td>
<td>5-10mg/kg once daily PO</td>
<td>Recommended therapy for wing tip oedema, combined with topical Preparation H</td>
</tr>
<tr>
<td>Propentofylline (Vivitonin, Intervet Schering-Plough)</td>
<td>5mg/kg twice daily PO for 3-5 weeks</td>
<td>Readily available in small animal practice but less effective than Isoxuprine</td>
</tr>
<tr>
<td>Sodium Calcium EDTA</td>
<td>35mg/kg IM twice daily for 5 days</td>
<td>Can be diluted and administered IV</td>
</tr>
</tbody>
</table>

Table 2, Formulary of medications

**REFERENCES**


Harcourt-brown N (2000), Birds of Prey, Anatomy, Radiology and Clinical Conditions of the Pelvic Limb, CD format from Zoological Education Network