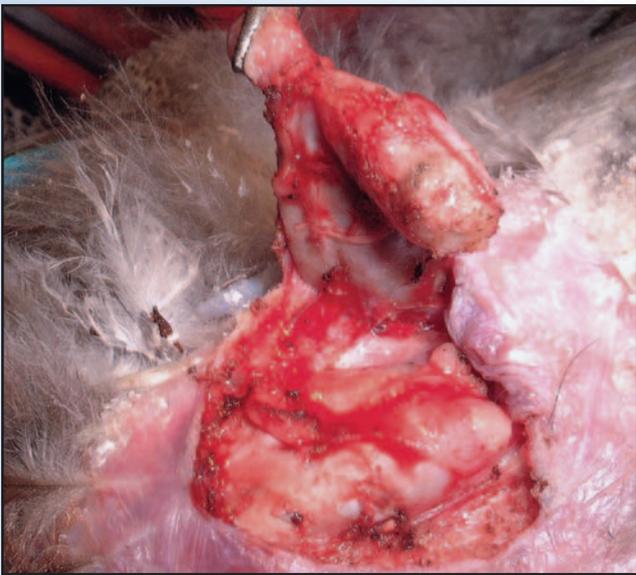


# Surgical Resolution of Soft Tissue Disorders

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Espen Odberg

## Preparation and Considerations for Avian Surgery

### PATIENT EVALUATION

A full signalment and history should be obtained and a physical examination performed prior to anesthesia and surgery (see Chapter 6, Maximizing Information from the Physical Examination and Chapter 34, Surgical Resolution of Orthopedic Disorders).

Preoperative diagnostics may include a complete blood count, serum chemistry and electrolyte profile, and other serologic or hematologic tests. The surgeon should evaluate the risk/benefit ratio for each diagnostic test, particularly in smaller avian patients (<100 g). Pre-surgical blood collection may cause hypovolemia and/or anemia that may dispose these birds to life-threatening intraoperative hemorrhage. Hematologic findings that may preclude or delay elective surgery are similar to those in domestic animals. These include the following:

1. An elevated hematocrit, which may indicate dehydration or cardiovascular compromise.
2. A decreased hematocrit. Anemic patients have increased surgical risks, particularly if there is perioperative hemorrhage.<sup>5</sup> Severe anemia (ie, PCV <20%) requires correction or treatment prior to surgery.
3. A decreased total protein, which may delay healing as well as indicate underlying metabolic disease.
4. Leukocytosis, which may indicate an infectious or inflammatory process, requiring pre-, peri- and post-operative antimicrobial therapy. Perioperative antibiotic or antifungal agents should be administered when indicated.

5. Hypocalcemia that may pose an anesthetic risk, compromise cardiac and neurologic function, and impair bone healing subsequent to fracture repair.<sup>1</sup> Evaluation of both total calcium and ionized calcium is strongly recommended prior to surgery<sup>1</sup> (M. Stanford, personal communication, 2000), particularly in those patients with associated malnutrition or history of egg production.
6. Organ system disease (eg, renal, pancreatic), which may require medical therapy prior to surgery and may influence anesthetic choices.
7. Hepatic insufficiency which may debilitate the patient due to decreased hepatic production of clotting factors as well as reduced liver function, that may affect various critical aspects of patient homeostasis.
8. Reduced thrombocyte counts, which may predispose the patient to coagulopathy.
9. Electrolyte imbalances.<sup>1,5,8</sup>

Radiographs and ultrasonography may be utilized in establishing a diagnosis, treatment plan and prognosis, as well as determining the patient's degree of anesthetic and surgical risk.

Cardiovascular function should be thoroughly evaluated prior to anesthesia and surgery. Arrhythmias, murmurs, tachycardia, bradycardia and pulse abnormalities (pulse deficits or jugular pulses) should be investigated with radiographs, electrocardiology, echocardiography and evaluation of blood pressure.<sup>5,87</sup>

Anorexia, disease and stress may all contribute to nitrogen imbalance. Starvation and disease may result in a hypermetabolic state, and stress may cause an initial hypometabolic state followed by a hypermetabolic state. Hypermetabolism increases the body's protein requirement. Birds have a higher protein requirement than mammals. Protein demands are further increased because there is increased need for tissue repair, blood cell production and antibody production with surgery.<sup>5,87</sup>

Carbohydrates are a nitrogen-sparing energy source and are recommended for correction of a stress-related negative nitrogen balance. A successful postsurgical patient requires a positive nitrogen balance to facilitate tissue repair, and a source of non-protein energy to meet their increased caloric requirements.<sup>5</sup> Patients with a decreased blood glucose level should be supported intravenously with dextrose as part of their fluid therapy pre- and intraoperatively.<sup>1</sup>

Resting basal metabolic rate (BMR) may be determined by using the formula  $BMR \text{ kcal/kg per day} = (K)BW^{.75}$ . Additional energy is required for growth, reproduction, disease and tissue repair. Severe trauma and sepsis may increase the patient's energy requirements 1.5 to 3 times

their resting requirement. There are several commercially available supplemental diets that can be utilized to meet these nutritional requirements, ranging from juvenile hand-feeding formulas to avian critical care diets<sup>5</sup> (see Chapter 7, Emergency and Critical Care).

Malnutrition may lead to obesity, vitamin A deficiency and other nutritionally related diseases. These conditions may pose anesthetic and surgical risks, and predispose the patient to infection, delayed healing and/or coagulopathies.<sup>5</sup>

## PATIENT PREPARATION

### Fasting

Birds normally maintain relatively low hepatic glycogen stores. Liver glycogen stores may decrease as much as 90% during a 24 to 36 hour fast and possibly more in small birds. However, it is important for the crop to be completely empty prior to anesthetizing the patient to prevent regurgitation and aspiration. Therefore, general guidelines include a short fast of 2 to 4 hours for birds <300 g body weight, 5 to 8 hours for birds >300 g body weight, 2 to 4 hours for frugivores and 24 to 36 hours for larger raptor species weighing 2 to 4 kg. It is generally recommended to leave water available until 1 hour prior to anesthesia.<sup>5</sup>

Decreased gastrointestinal motility may alter these recommendations. The crop should be thoroughly palpated immediately prior to anesthesia. If surgery must be performed and the crop is not completely empty, fluid or liquefied food may be aspirated through a feeding tube and/or the head should be elevated during the surgery to prevent regurgitation and aspiration of crop contents. It is advisable to intubate these patients to protect the airway.<sup>5</sup> Following intubation, cotton balls or gauze can be placed in the caudal pharynx to prevent reflux of crop contents.

Anesthesia and analgesia are indicated to promote patient comfort and reduce pre-, peri- and postoperative stress (see Chapter 8, Pain Management and Chapter 33, Updates in Anesthesia and Monitoring).

### Positioning

Patient positioning varies with the surgical approach. Lateral and dorsal recumbent positions are most common (Fig 35.1). Respiration may be impaired when the avian patient is placed in ventral recumbency. Procedures that may require ventral recumbency include excision of the uropygial gland, surgery of the pygostyle and excision of dorsal feather follicle cysts.<sup>1</sup>

When the patient has been properly positioned, atraumatic adhesive tape such as masking or certain medical tapes may be used to secure the patient. Restraint



Espen Odberg

**Fig 35.1** | The lateral and ventrodorsal patient positions are most commonly used for avian surgery. Care should be taken to avoid placing pressure on the thorax with surgical drapes, instruments or the surgeon's hands, as birds require movement of the keel and intercostal muscles to expand the thorax for respiration. Tape that is not traumatic to skin and feathers, such as masking or certain medical tape, may be used to position the patient.



Espen Odberg

**Fig 35.2** | Prior to surgery, all feathers 2 to 3 cm from the surgical site should be removed. Standard aseptic technique applies to avian surgery. Chlorhexidine diacetate (0.05%), povidone iodine (1.0%) or chlorhexidine gluconate (4%) rinsed with alcohol and saline are all effective for presurgical skin disinfection.

boards are commercially available and are preferred by some surgeons. It is helpful to secure the patient to a platform that then may be repositioned as needed to facilitate intraoperative adjustments in surgical access.<sup>1</sup>

Birds require movement of the keel and intercostal muscles for respiration, therefore, care should be taken to avoid placing any pressure on the thorax with surgical drapes, instruments or the surgeon's hands.<sup>1</sup>

## THERMOREGULATION

Hypothermia is a significant concern, particularly in small avian species. Several heating systems exist including circulating water heating pads, electric heat pads, heated forced air systems and overhead heat sources. Some of these may not provide adequate supplemental heat to the patient and others may mechanically interfere with the surgeon and/or anesthetist<sup>5,67</sup> (see Chapter 33, Updates in Anesthesia and Monitoring).

### Creating a Sterile Surgical Field

In preparation for surgery the feathers should be removed in a 2 to 3 cm radius beyond the edges of the surgical site (Fig 35.2). It may not be possible to remove all the feathers from the surgical field due to skin trauma, species-specific skin fragility, location of the surgical site, need to retain flight feathers or patient body size. Removal of the rectrices or remiges, which insert into the periosteum of the associated bones, may increase postoperative pain. These larger feathers may instead be wrapped with sterile non-adherent bandage material. The remaining feathers may be retracted from the surgical field with light adhesive tape such as mask-

ing tape. A small amount of alcohol may be used to lightly wet feathers and smooth them away from the surgical site;<sup>5</sup> however, alcohol should not be used when radiosurgery or electrocautery will be employed. Alternately, sterile, water-soluble lubricant jelly may be used to smooth the feathers out of the surgical field.<sup>5</sup>

Standard aseptic surgical techniques apply to avian surgical procedures. Skin disinfectant scrub should be used to minimize the risk of bacterial contamination of the surgical site without damaging the skin. Chlorhexidine diacetate (0.05%) and povidone iodine (1%) have been found equally effective for skin preparation, and have no significant effect on wound healing. Chlorhexidine gluconate (4%) is equally effective when rinsed with alcohol or saline. Saline provides the benefit of not predisposing patients to hypothermia and does leave sufficient residual chlorhexidine solution bound to the skin. One study demonstrated that 50% of dogs developed erythema, edema, papules, wheals and weeping of serum from the skin when the skin was prepared with povidone iodine. This may suggest that chlorhexidine solutions are a less irritating class of disinfectants.<sup>5</sup>

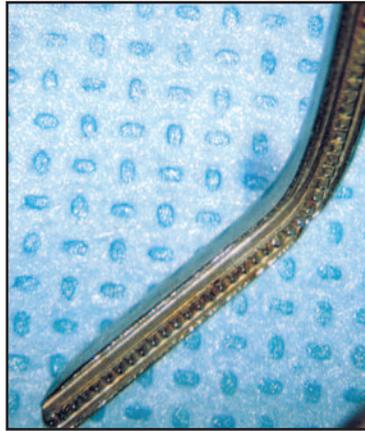
Aseptic preparation of the cloaca is difficult. Maximum disinfection can be achieved by irrigating the cloaca with chlorhexidine gluconate (4%), then infusing antibiotic ointment.<sup>5</sup>

There are several lightweight surgical drapes available. Clear adhesive drapes allow the surgeon and anesthetist to monitor the rate and depth of respiration, and may be more effective in maintaining body temperature.



Greg J. Harrison

**Fig 35.3a** | A traditional small-animal thumb forceps with teeth is shown. This instrument has a curved tip and unique jaws for handling delicate tissues.



Greg J. Harrison

**Fig 35.3b** | The forceps in Fig 35.3a have unique jaws (40x). The central row of teeth is elevated to fit into a depression on the opposite jaw. The opposing jaw has a recession for the ridge to fit in. On either side of the ridge and recession are alternating teeth and an offset space to receive a tooth. This setup maximizes tissue contact. Dr. Harrison has found this to be the most versatile instrument in avian surgery.



Espen Odberg

**Fig 35.3c** | The basic minimal surgical pack should include top-quality instruments with carbide steel inserts. Minimal requirements for a basic surgical pack include Brown-Adson tissue forceps, Adson tissue forceps, smooth-tipped and toothed Bishop-Harmon tissue forceps (used for smaller patients), a larger pair of DeBakey tissue forceps, two or more curved-tip Halstead mosquito hemostats, tenotomy or small Metzenbaum scissors, and two needle holders. The recommended needle holders include a small Mayo-Hegar or Olsen-Hegar needle holder for 3-0 to 5-0 suture, and a smaller Castroviejo or Mathieu-type needle holder for 5-0 to 8-0 suture. The surgical pack also should include small, sterilized gauze pads and cotton swabs.

## INSTRUMENTATION

Surgical instruments for avian surgery must be appropriately sized and designed to atraumatically manipulate delicate tissue (Figs 35.3a-c). Microsurgical tools such as those utilized in human vascular surgery, ophthalmic instruments and instruments specifically designed for small veterinary patients may be used. Microsurgical instruments should be of a standard length, counterbalanced and have miniature tips (Fig 35.4a). The length allows for balancing in the hand (Figs 35.4b,c). When utilized correctly, the arm provides stability while the fingers carefully move the tip. This balance, stability, and rounded shape allow for smooth, precise movement, thereby preventing any trauma to delicate tissues, blood vessels or nerves (Fig 35.4a-f). Jeweler's instruments are often used for their small size; however, these are usually not ergonomically designed for microsurgery. Several courses are available for microsurgical training. Microvascular and human plastic surgery techniques are particularly helpful with avian patients.<sup>1,4,5</sup>

Small, angled (60-90°) mosquito hemostats and hemostatic clip applicators are useful for avian celiotomies (Figs 35.4g-j). These allow increased accessibility to viscera and blood vessels located deep within the coelomic cavity. Angled DeBakey neonatal vascular clamps<sup>a</sup> are useful for ovariectomy.<sup>24</sup>

Sterile gavage and feeding tubes may be used for irrigation, to moisten tissue or to flush hollow viscera.

Tuberculin or other small syringes may be used for suction, as some traditional suction units may traumatize delicate tissues. Mini-Frazier suction tips and Poole-type suction tips may be used in avian patients. The Poole-type suction tip may be fashioned from a rubber feeding tube by creating multiple fenestrations.<sup>1,4,5</sup>

Abdominal retractors must adequately retract tissue without causing tissue trauma (Fig 35.5). Mini-Balfour and Alm retractors may be used in larger avian species such as macaws and Amazon parrots. Heiss retractors and ophthalmic eyelid retractors may be used in small avian species such as cockatiels and budgerigars. Lone Star retractors are lightweight and allow the surgeon to achieve retraction at several areas surrounding the surgical site.<sup>1,4,5</sup>

## HEMOSTASIS

Hemostasis is of the utmost importance in birds. Minor hemorrhage can result in severe compromise to these small patients. Large blood vessels are located just below the dermis and care should be taken to either avoid severing or to preempt bleeding prior to transection of these vessels. Several tools exist to assist the surgeon. These include chemical cautery agents, metal clips, radiosurgery, electrocautery and lasers.<sup>1,5</sup> Hemoclips<sup>b</sup> are small, atraumatic, stainless steel clips applied with hemostat-type applicators (Fig 35.4i). These applicators facilitate access into small, deep, difficult to reach areas.<sup>1,5</sup>



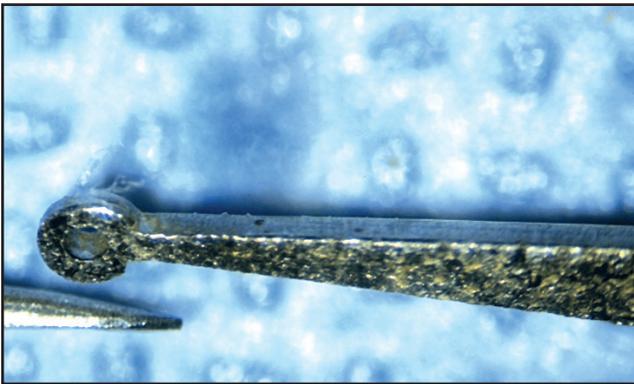
Greg J. Harrison

**Fig 35.4a** | Bottom to top: Standard delicate-tissue, small-animal thumb forceps. Regular thumb forceps. Microsurgical thumb forceps.



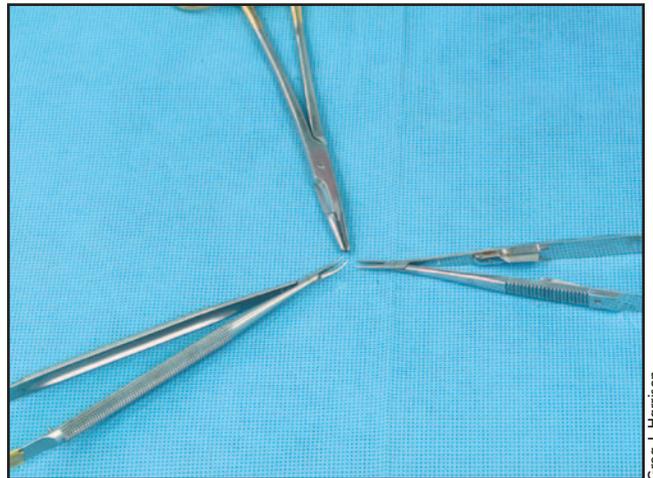
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**Fig 35.4b** | Microsurgical forceps in Fig 35.4a showing the counterbalance and scooped-out area that fits over the web of the index-thumb finger area of the operator's hand. Grasping the round handles approximates using a writing instrument.



Greg J. Harrison

**Fig 35.4c** | The two tips available for microsurgical forceps (40x). On the left bottom is a fine needle tip that tends to slip if any tissue volume is grasped. On top is a circular or ring tip with titanium dust on the contact surface to aid in grasping. This greatly improves delicate tissue handling and reduces bleeding caused by slipping with the other forceps.



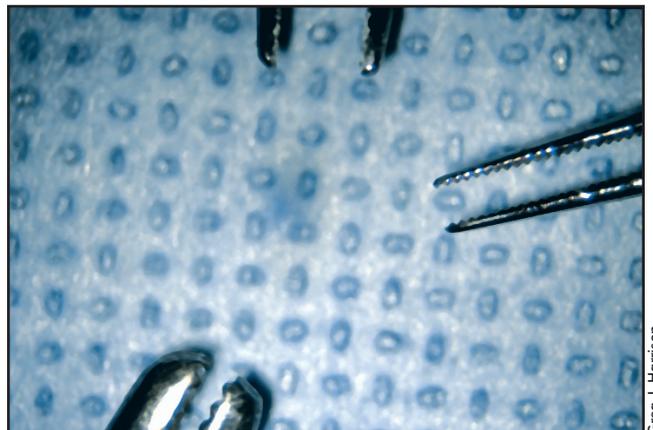
Greg J. Harrison

**Fig 35.4d** | Needle holders. Top: Standard small-animal surgical needle holder. Right: Delicate-tissue needle holder. Left bottom: Microsurgical needle holder. The extra-fine tip and the round handles allow increased speed and accuracy of suturing when handling 6-0 to 10-0 swaged-on suture material.



Greg J. Harrison

**Fig 35.4e** | Top to bottom: Delicate-surgery hemostat. Standard hemostat. Microsurgical hemostat.



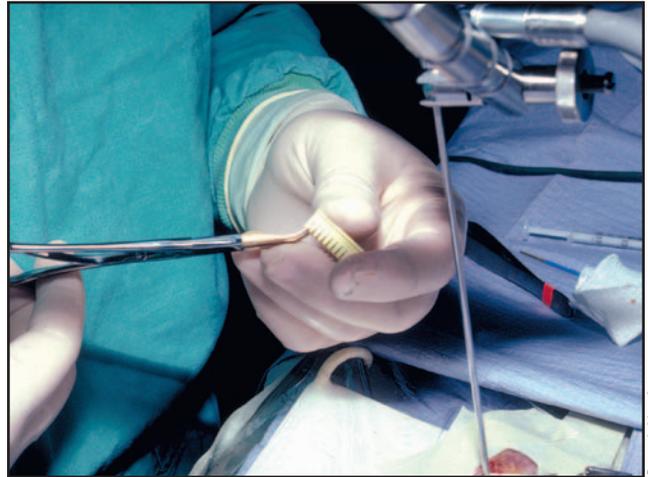
Greg J. Harrison

**Fig 35.4f** | Hemostat tips. Top: Delicate-surgery hemostat. Right: Microsurgical hemostat. Bottom: Standard hemostat. The microsurgical hemostat allows pinpoint grasping. Only the tiny area of concern is grasped. If needed these hemostats can be touched with the radiosurgery tips to coagulate the vessel contained within. Cauterization of surrounding soft tissue should be minimized to prevent unnecessary necrosis.



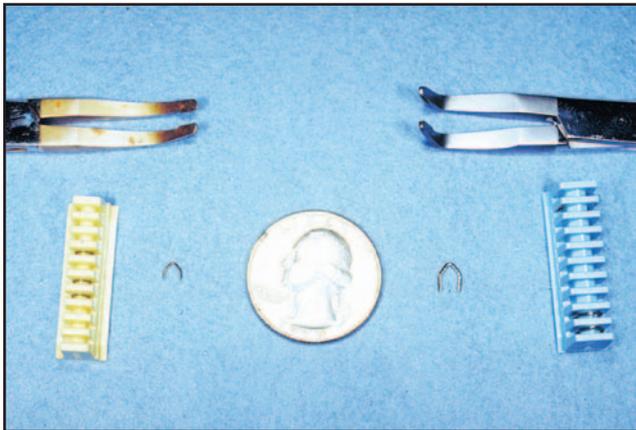
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**Fig 35.4g** | Various hemoclip applicators. Left to right: Small hemoclip with 20° tip. Small hemoclip with 90° tip. Medium hemoclip with 20° tip. Medium hemoclip with 90° tip. Top: Microsurgical forceps for size comparison.



Greg J. Harrison

**Fig 35.4h** | Loading the hemoclip applicators from a clip cartridge.



Greg J. Harrison

**Fig 35.4i** | Comparison of a small hemoclip applicator (left), a medium hemoclip applicator (right) and a US 25-cent coin.



Greg J. Harrison

**Fig 35.4j** | Side view of the hemostat applicator tips. Top: 90° tip. Bottom: 20° tip.

Gel foam, surgical spears, Monsel's solution<sup>c</sup>, chemical cautery, collagen sheets, beaded polysaccharide powder<sup>d</sup> and direct manual pressure can assist in the control of minor hemorrhage.<sup>1,5</sup>

## WOUND HEALING

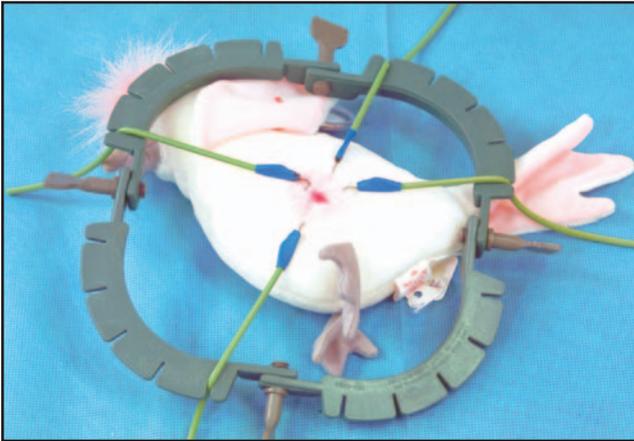
Wound healing has been thoroughly evaluated in mammals and determined to occur in a sequential series of events. These include the inflammatory stage, fibroblastic stage, epithelialization phase, contraction phase and the remodeling phase. Cellular and vascular processes of the inflammatory stage have been evaluated in chickens and are similar to that described in mammals. Birds lack significant subcuticular tissue, therefore primary skin closure is often necessary. Excessive scar tissue does not typically form in birds (Fig 35.6).<sup>5</sup>

## RADIOSURGERY

Radiosurgery utilizes high-frequency (2-4 MHz) alternat-

ing current to generate energy waves that create vibration and molecular intercellular heat (Fig 35.7a). This results in vaporization of water and rupture of affected cells while the electrode remains cool. The frequency may be manually set to cut tissues or coagulate blood vessels. Coagulation occurs when the current density dehydrates cells and coagulates the cellular contents (Figs 35.7b-e).<sup>4,5</sup>

When the radiosurgery unit is set for monopolar operation, it utilizes two electrodes: an active electrode and an indifferent electrode or ground plate. This concentrates the current density at the tip of the active (smaller) electrode. Monopolar radiosurgical technique is indicated for gross tissue manipulation in larger avian patients (>2 kg). The ground or indifferent electrode should be placed in contact with the patient as close to the surgical field as possible. Patient contact is improved with the application of a contact gel to the patient and ground. Alternatively, the ground plate may be permanently mounted under the surgery table and the patient placed



Greg J. Harrison

**Fig 35.5** | Adjustable wound retractor frame and two tension bands hooked into one another. The location and tension on the band can be adjusted after inserting the hook into the surgical tissue. Then the band is slipped into a V-shaped slot in the frame at the ideal location and the desired pressure is applied.



Espen Odberg

**Fig 35.6** | The scar from a previous surgery is visible (arrow). There may be minor adhesions between skin and the abdominal wall; however, scar formation is generally minimal in the avian patient.

on a non-metal material such as a towel. Such material will prevent thermal burns to the dependent aspect of the patient. This is particularly important in thin patients with prominent bony sites that provide small conduction points that can generate high localized temperatures. The active electrode must be kept clean and free of char and debris. An excessive amount of char or debris will interfere with conduction, thereby creating drag through the tissue, inhibiting cutting action and increasing coagulation. This may delay wound healing and predispose the patient to wound dehiscence. Several types of electrode tips are commercially available. Ball-tipped electrodes create significant tissue destruction for fulguration and coagulation of large amounts of tissue; loop electrodes are useful to obtain tissue biopsies and surgically excise tissues; and fine wire electrodes are utilized for incisions. It is useful to have some tips (such as those used in dentistry) that function in a wet field for effective coagulation during hemorrhage.<sup>4,5</sup>

If cryosurgery is performed in conjunction with radiosurgery, it is important to note that radiosurgical tools will not work on frozen tissues.<sup>4,5</sup>

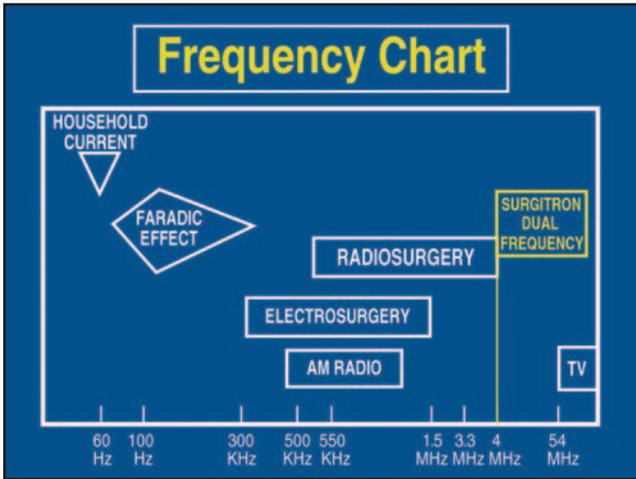
Bipolar radiosurgical forceps are useful, particularly in small avian patients (<2 kg) (Fig 35.7f). These allow for hemostatic control at the tip without the use of a ground plate, as one of the tips serves as the active electrode and the other as the indifferent electrode. The current passes from one tip, the active electrode, to the other, the indifferent electrode, without passing through the entire patient. Closer proximity of the two electrodes alters the transmitted wave currents from those transmitted by monopolar electrodes, resulting in more precise control and less reflux hemorrhage. The cut settings are used for tissue incisions. The cut/coagulation settings are indicated for vessels that are difficult to

coagulate and for controlled cutting with coagulation properties (ie, as for organ biopsy). The coagulation settings are used for tissue fulguration. The material and design of the bipolar forceps, as well as proper calibration of the machine, determine the efficiency and performance of bipolar radiosurgery (Fig 35.7e).<sup>4,5</sup>

Bipolar forceps may be used to make primary skin incisions, to incise through muscle with minimal hemorrhage, and to coagulate cutaneous blood vessels prior to incision with a scalpel blade or scissors. The skin may be grasped and elevated with thumb forceps, then incised with bipolar radiosurgical forceps. This incision is then extended by inserting the indifferent electrode of the bipolar forceps subcutaneously to the full extent of the desired incision. The forceps are then apposed with the skin between them and the incision performed is extended by dragging the tips over the full thickness of the skin. This will incise the skin and coagulate the blood vessels. Correct settings and proper use of radiosurgery does not cause discoloration of the skin lateral to the incision (ie, if the skin is discolored, tissue damage has occurred and primary intention healing is unlikely).<sup>5</sup>

Tissue incisions may be performed with monopolar tips as well. Wire-type tips may be used as an “electrosurgical scalpel”. The current should be initiated prior to touching the tissue. Often, higher settings are necessary in birds as compared to mammals due to the lower water content of the skin, which may result in less coagulation of associated vessels and hemorrhage. Cutting ability may be improved in very dry skin by moistening the skin with saline.<sup>4,5</sup> Feather follicles and their associated blood supply should be preserved whenever possible.<sup>5</sup>

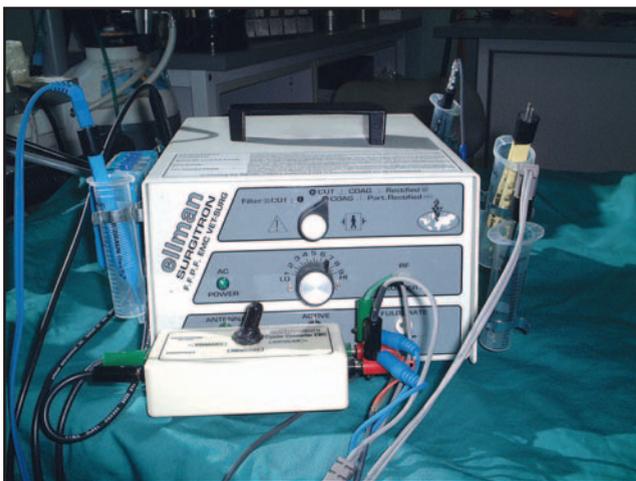
When using the bipolar forceps for hemostasis, the forceps tips are relaxed as current is applied, providing a



**Fig 35.7a** | Frequency chart.



**Fig 35.7b** | The multifrequency radiosurgery generator for performing avian surgery with minimal hemorrhage.



**Fig 35.7c** | This unit has been modified to allow multiple bipolar or unipolar hand pieces with a flick of a switch.

**Advantages of Radio Wave Surgery**

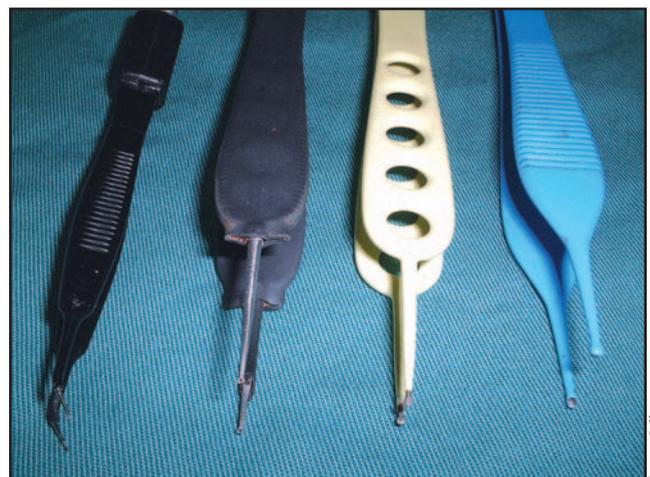
- Excellent for both cutting and coagulation
- Rapid local hemostasis
- Very little tissue damage - good cosmetic effect
- Tissue morphology preserved
- Sterilizes as it cuts
- Little postoperative pain
- Can be used with either general or local anesthesia
- Unit is lightweight and portable
- Different electrode tips for different applications
- Affordable

**Fig 35.7d** | Advantages of radio wave surgery.

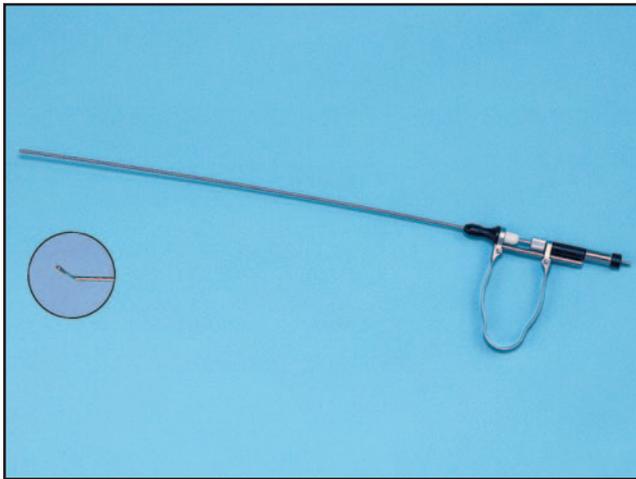
**Versatility of Radio Wave Surgery**

Waveform	Setting	Properties	Uses
Fully-filtered Fully-rectified	Cutting	90% Cutting; 10% Coagulation	Incisions; Excision; Biopsy
Fully-rectified	Blended	50% Cutting; 50% Coagulation	Incision/Excision with increased hemostasis
Partially-rectified	Coagulation	10% Cutting; 90% Coagulation	Hemostasis
Poorly-rectified	Fulguration	Minimal Cutting/Coagulation	Superficial tissue destruction

**Fig 35.7e** | Versatility of radio wave surgery.

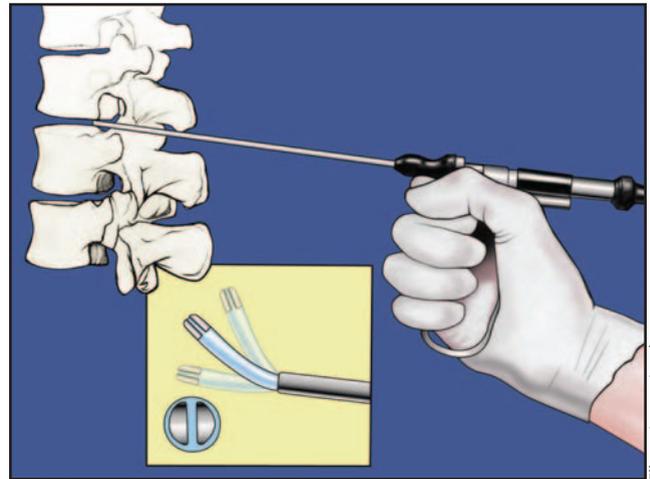


**Fig 35.7f** | Various bipolar forceps. Left to right: The Harrison modification and three custom ring-tip models.



Ellman International

**Fig 35.7g** | The trigger handle allows endoscopic bipolar applications of a radio frequency instrument.



Ellman International

**Fig 35.7h** | The trigger handle has directional control. This illustration is from use in human disc disease therapy.

small gap between the two sides through which the radio current flows, thereby sealing the vessel. It is important to clean the forceps tips frequently. Accumulated blood and tissue can adhere to the clot and subsequently destroy it when the forceps are removed. Forceps tips are currently being developed with new materials that do not accumulate blood and tissue. When using the coagulation settings, the vessel may retract within the tissue due to vasospasm. This results in temporary hemostasis until the vessel relaxes, but hemorrhage may recur. A new modification that can be used with an endoscope has been developed (Figs 35.7g,h).

## LASER SURGERY

Light Amplification by the Stimulated Emission of Radiation (LASER) relies on the production of electromagnetic radiation in response to photon emission by a lasing medium. Electrical energy excites a lasing medium (carbon dioxide, diode or argon) contained within an optical laser chamber, which, upon returning to a steadier electrical state, loses energy and generates photons in the form of electromagnetic radiation or light. These photons are directed from the optical laser chamber as monochromatic electromagnetic radiation transmitted via a series of lenses and delivery fibers in a focused and controlled laser beam. The type of lasing medium will alter the wavelength and frequency of the radiation.<sup>38,69</sup>

Carbon dioxide and diode lasers are most commonly used in veterinary medicine. Both produce an immediate region of vaporization, surrounded by a zone of irreversible photothermal necrosis and a zone of reversible edema. Laser surgical incisions seal blood vessels, nerves and lymphatics for controlled hemostasis, analgesia and postoperative edema. Carbon dioxide lasers operate at a wavelength of 10,600 nm. They may be operated with a

focused beam, ideal for cutting, or a defocused beam, used for vaporizing tissue. They provide accurate, non-contact surgery with minimal tissue penetration and minimal collateral thermal injury (0.05-0.2 mm from the incision), as compared to the diode laser, which offers a zone of thermal injury of 0.3 to 0.6 mm from the incision. Thermal penetration is relatively superficial, penetrating only 50 to 100  $\mu\text{m}$  in depth.<sup>38,54,69</sup>

Diode lasers operate at a wavelength of 635 to 980 nm. They may be operated in direct contact with tissue (contact mode) or at a distance from tissue (non-contact mode). They have the ability to operate in a fluid environment (intestinal tract, fluid-filled coelom) and provide improved hemostasis, with the ability to coagulate blood vessels up to 2 mm in diameter, as compared to the  $\text{CO}_2$  laser, which coagulates blood vessels up to 0.6 mm in diameter. Operation results in deeper tissue penetration and is relatively less precise. Diode lasers have been used for photocoagulation of retinal and other ocular tissues, chromophores enhanced tissue ablation and coagulation, laser welding and photodynamic therapy. In addition, the diode laser has the fiberoptic ability to operate with several endoscopes.<sup>38,54,69</sup>

Laser is particularly useful for avian surgery, where hemostasis is of great concern. Surgical indications include salpingohysterectomy, orchidectomy, and limb amputation. It is also beneficial in the excision of granulomas, abscesses, and neoplasms. Endoscopic diode laser techniques provide minimally invasive access to several anatomic sites as well as endoscopic hemostatic control. Superficial lung and air sac granulomas within the cranial thoracic, caudal thoracic and abdominal air sacs have been successfully ablated with the 810-nm diode laser.<sup>21,37,61</sup>



Bob Doneley

**Fig 35.8a** | Avascular necrosis of the phalanges can occur as a result of circumferential constriction due to fibers from cage bedding or as a condition of undetermined etiology. In the case of this bird, cloth fibers became entwined around the foot, leading to the visible digit swelling and potential for necrosis of the digits. Removal of the constricting fibers, appropriate topical antibiotics and bandage application are necessary to treat this condition.



Greg J. Harrison

**Fig 35.8b** | Manmade fibers tend to entrap digits. The threads are removed using 40x magnification and a bent-tip hypodermic needle as a cutting tool. When the constricting band is not accompanied by foreign material, treatment is similar to that described in Fig 35.8a. The circumferential bands may require debridement and suturing.

## ILLUMINATION AND MAGNIFICATION

Avian surgery often requires delicate handling of small structures. Coelomic surgery is performed within a deep cavity, which obstructs visualization. Therefore, magnification and illumination equipment are essential (see Chapter 1, Clinical Practice). The ideal avian surgical light source provides optimum illumination with minimal heat transfer to the patient that may result in tissue dehydration and surgeon discomfort. (*Ed Note: Although overhead lights that produce significant heat have been shown to be effective in helping to prevent hypothermia during avian anesthesia, forced warm air blankets also are effective and do not have the disadvantage of tissue desiccation and over heating of the surgeon*). The small size of the avian patient necessitates intense light, precisely focused. This often requires changing the angle of the light to provide illumination and avoid shadows. A three-headed, flexible fiberoptic light source provides ideal illumination and the ability to change the focal area of the light. Often, 250-watt bulbs with no less than 20,000 lux are required.<sup>1,4,5</sup>

Ocular head loupes and operating binoculars with a halogen light source also may be used for magnification and illumination. These allow the surgeon to set the light source on the surgical site, and magnification and illumination move with the surgeon. Operating microscopes are useful for avian patients, particularly those weighing less than 1 kg, and are advantageous for handling blood vessels in larger birds as well. An operating microscope with a lens objective approximately 150 power and a

12.5 power binocular objective is most useful.<sup>1,4,5</sup>

A less expensive but also less effective option for increased magnification and illumination includes adjustable magnifiers with attached lights available for sewing and other home uses.

## SUTURE MATERIALS AND ADHESIVES

Significant information is available regarding appropriate selection of suture material in veterinary and human medicine. Suture material utilized in birds must be minimally reactive and of an appropriate size. Tissue reaction to five suture materials has been evaluated in pigeons at 3, 7, 15, 30, 60, 90 and 120 days following implantation in the body wall. These include polyglactin 910, polydioxanone, monofilament nylon, medium chromic catgut and stainless steel. Pigeons developed a marked granulocytic inflammatory response to medium chromic catgut that diminished during the evaluation period. The suture was still present at the end of the study, indicating prolonged absorption of the material. Polyglactin 910 caused the most inflammatory reaction and was the most quickly absorbed, being completely gone by day 60. Polydioxanone, like polyglactin 910, is absorbed by hydrolysis. Unlike polyglactin 910, however, it caused minimal tissue reaction and absorption was occurring by day 120. Nylon and stainless steel are non-absorbable materials that caused minimal tissue reaction. However, the stiffness may make them mechanically irritating to surrounding tissues, and these were more often associated with hematoma, seroma and caseogranuloma formation.

This study concluded that chromic catgut should be avoided; slowly absorbed monofilament and synthetic materials absorbed by hydrolysis rather than proteolysis are recommended when prolonged wound healing is expected. Rapidly absorbed, braided, synthetic suture materials absorbed by hydrolysis are recommended when the benefit of rapid absorption outweighs the disadvantage of possible pronounced inflammatory reaction. Monofilament suture material has the advantage of minimizing trauma and cutting of tissue when compared to multifilament material. Taper-point needles are usually indicated in avian surgery, as compared to cutting needles to prevent tearing of tissues being sutured. Cutting needles may be useful for suturing thicker, tougher tissues such as the feet of larger species.<sup>4,5,10</sup>

Cyanoacrylate tissue adhesives hold tissues in apposition to allow healing. The cyanoacrylate monomer is a liquid that polymerizes in a small amount of water present in tissues. However, it is important not to allow the acrylic to run between the apposed tissues, as this physical barrier will delay wound healing. One should be cautious when using these adhesives in the presence of anesthetic gases with which they are reactive. They may also cause ocular irritation and vomiting in avian patients. The fumes of some cyanoacrylate tissue adhesives may cause respiratory irritation as well.<sup>5</sup>

## POSTOPERATIVE CARE

Postoperatively, the patient should be placed into a temperature-controlled incubator once it is able to stand without ataxia. Temperature should be set according to each individual's optimal requirements (27-30° C or 81-86° F for most psittacines) and supplemental humidified oxygen is beneficial to those patients at risk for hypoxia/hypercapnea during recovery.<sup>1,5,9,41</sup>

Perches should be avoided until the bird has recovered sufficiently to balance and grip well. Once the patient can balance and grip, perches of low height are recommended. Food and water are not introduced until the patient has fully recovered to prevent regurgitation and aspiration.<sup>1,5,9,41</sup>

The likelihood of postoperative self-trauma varies with the species, the individual patient and the surgical procedure performed. Avian patients generally do not traumatize their surgical incisions. Some clinicians advocate leaving longer-than-average suture ends to allow the bird to groom these as they would a feather.<sup>1,5,9,41</sup>

Occasionally an Elizabethan or other collar is necessary to provide a mechanical barrier to self-induced trauma to the surgical site. In all cases where a collar is first applied, the bird should be monitored following the col-

lar application. Agitation, depression, or inability to access food or water must be noted and corrected. If the bird can still traumatize the surgical site, collar adjustment also would be needed. Applying the collar prior to surgery may enhance acceptance of an Elizabethan or foam collar. This allows the bird to adjust to the collar, thus minimizing postoperative stress. Antianxiety or sedative medications such as diazepam may be given prior to collar application to decrease stress. Initially applying a small collar and increasing the size as necessary also may improve patient acceptance. Some birds will not tolerate restraint collars and customized body suits may be used to prevent self-trauma.<sup>1,5,9,41</sup>

## Soft Tissue Surgery

### SKIN

Birds have a relatively thin, dry epidermis. In feathered regions, the skin may be only 10 cell layers thick. The dermis is loosely attached to the underlying muscle fascia with very little subcutaneous tissue except in the distal extremities where it is firmly adhered to the underlying bone.<sup>9</sup>

### Constriction and Avascular Necrosis of the Digits

Avascular necrosis of the phalanges of the pelvic limbs may occur secondary to circumferential constriction caused by fibers, scabs or necrotic tissue. These constrictions compromise vascular flow to and from the distal phalanx, leading to edema and necrosis (**Figs 35.8a,b**). If detected early, the toe may be salvaged and amputation avoided. This condition is particularly common in pediatric patients. Proposed etiologies include low relative humidity, egg fiber-related strictures from hatching, septicemia and ergot-like intoxication. Increasing the environmental humidity and applying topical creams to promote hydration of the affected tissue may be effective in resolving early lesions. Eschars should be debrided and the digit cleaned and bandaged with a hydroactive dressing and allowed to heal by secondary intention. If tissue fibers are the inciting cause, a full-thickness linear skin incision should be made over the dorsal aspect of the constricted region. This area is then bandaged with a hydroactive dressing to prevent scab formation.

Complete healing may require weeks to months. A circumferential excision of the constricted region followed by anastomosis of the skin may be performed. The constricted tissue is surgically removed with a scalpel blade. One to two subcutaneous sutures are placed to prevent excessive tension on the skin repair. The skin edges are apposed with several simple interrupted sutures placed superficially to prevent disruption of the vascular supply

by resulting eversion of the skin edges, which will delay wound healing. After the skin edges are apposed, 2- to 3-mm superficial release incisions should be made on the lateral and medial aspects of the digit at the site of the anastomosis. This will allow postoperative swelling to occur without constriction. A hydroactive dressing is applied and the digit bandaged. Magnification and illumination such as a head loupe or operating microscope are useful to visualize the fibers.<sup>1,9</sup>

If the distal phalanx has developed complete avascular necrosis, amputation is necessary. Amputation should be performed just proximal to the proximal end of the necrotic tissue, where a good vascular supply still is present. An incision is made in the skin and subcutaneous tissue circumferentially. One or two sutures are placed in the subcutaneous tissue to relieve tension on the skin incision. Several simple interrupted sutures are placed in the superficial epidermis to prevent eversion of the skin edges, which will delay healing. The digit is bandaged and sutures removed in 10 to 14 days<sup>1,9</sup> (see Amputation of Digit later in this chapter).

It is best to avoid the use of electrocautery or radiocoagulation to prevent damage to the minimal vascular supply of the digits. If a tourniquet is utilized to control hemorrhage, it should be used for only a limited time to avoid vascular compromise.<sup>1,9</sup>

Passerines are prone to developing avascular necrosis of the pelvic limbs or digits due to entanglement with synthetic fibers such as nesting string. Microsurgical tools or a bent 25-gauge needle may be used to remove the constricting fibers. The tip of the needle can be used to elevate the fibers and the edge of the needle used to sever the material. A hydroactive dressing is applied and the area bandaged.<sup>1,9</sup>

Passerines also may develop constrictions secondary to hyperkeratosis or to the development of excessively large scales over the pelvic limbs and digits. Malnutrition and *Knemidokoptes* sp. infection have both been implicated as etiologies. These conditions may predispose the patient to *Staphylococcus* spp. infections. In most cases, skin lesions will resolve with correction of nutritional problems or treatment with ivermectin. In severe cases, it may be necessary to surgically debride these hyperkeratotic lesions or enlarged scales. Microsurgical instruments and magnification are useful for manipulating these small structures. Antibiotic emollient creams will soften and hydrate the skin while treating bacterial infection.<sup>1,9</sup>

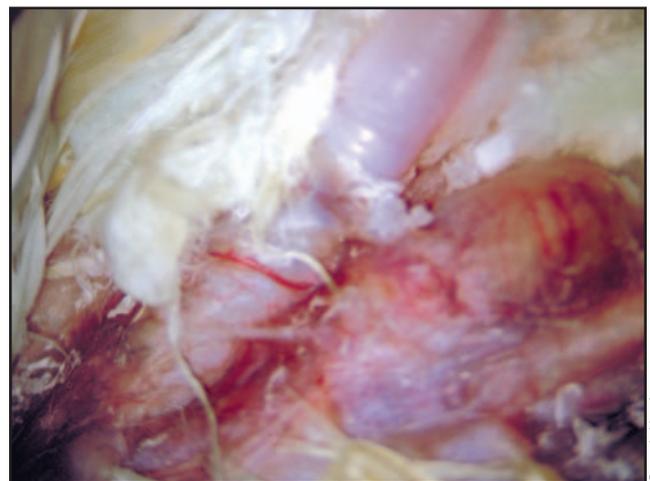
### Feather Cysts

Feather cysts are usually formed as a result of injury to or deformation of the follicle.<sup>3,6b</sup> Direct trauma, mechanical and chemical cautery also are inciting causes.

Damage to one side of the follicle may result in asymmetrical feather growth. The developing feather may then grow in an arch back toward the body, forming a feather cyst (Figs 35.9a-i). Certain species of canaries, particularly the Norwich, Gloucester and their cross-breeds, may develop cysts as a result of abnormally formed feathers (Fig 35.10). These birds have been genetically selected to produce a downy, soft feather type that predisposes them to feather cysts. Malnutrition, viral, bacterial and parasitic infections may result in formation of feather cysts as well.<sup>1,9,36b</sup>

The surgeon should examine the cyst to determine whether it contains a viable or devitalized feather. Perform an initial evaluation of the feather by making a small incision at the distal aspect of the cyst and examining the contents. Every attempt should be made to salvage viable feathers and tissue, particularly those involving tail rectrices and flight feathers.<sup>1,9</sup>

If excision is required, use of a scalpel blade offers the benefit of complete excision of the affected follicle without damage to adjacent follicles. Damage to adjacent feather follicles and/or their blood supply may disrupt feather formation and result in the formation of additional feather cysts. Radiosurgical fulguration has been performed successfully; however, the adjacent feather follicles may be damaged due to difficulty in controlling the extent of tissue destruction. Feather cysts typically have good vascular supply, so hemostasis is required.

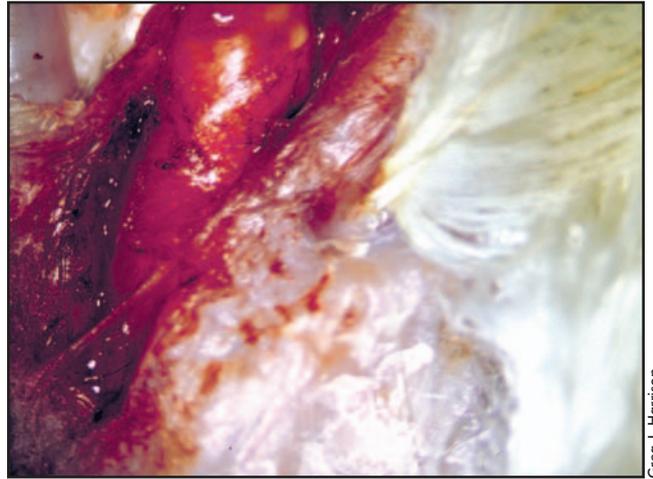


**Fig 35.9a** | Feather cysts in parrots usually form as a result of injury to the follicle. Direct trauma to the feather follicle can result in abnormal feather growth, thus promoting feather cyst formation. Improper wing trim, malnutrition, viral, bacterial and parasitic infections may result in the formation of poor-quality feathers that are easily damaged. This cyst has formed in the follicle of the dorsal major covert overlying primary remex VIII. While the cyst is dorsal, this follicle inserts on the ventral aspect of the major metacarpal bone. The underlying primary feather structures form the strongest boundary, so the cyst herniates dorsally. Approaching the cyst from this dorsal aspect fails to address the germinal tissue found at the point of insertion.



Greg J. Harrison

**Fig 35.9b** | Incising alongside the cyst using radiofrequency bipolar forceps.



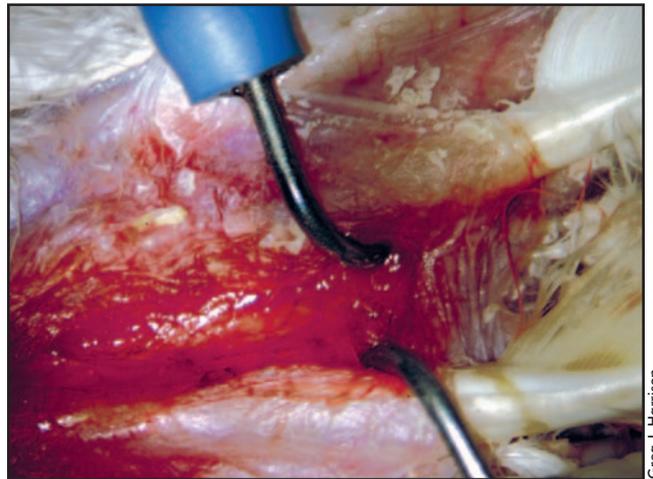
Greg J. Harrison

**Fig 35.9c** | Freeing the cyst dorsally from surrounding feather structures.



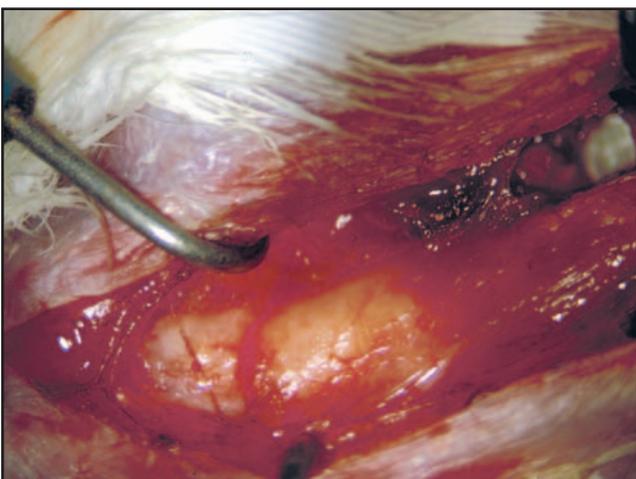
Greg J. Harrison

**Fig 35.9d** | Next the ventral surface of the wing is incised between primary VII and VIII, allowing access to the insertion of the cystic follicle on the ventral aspect of the metacarpal bone of the manus.



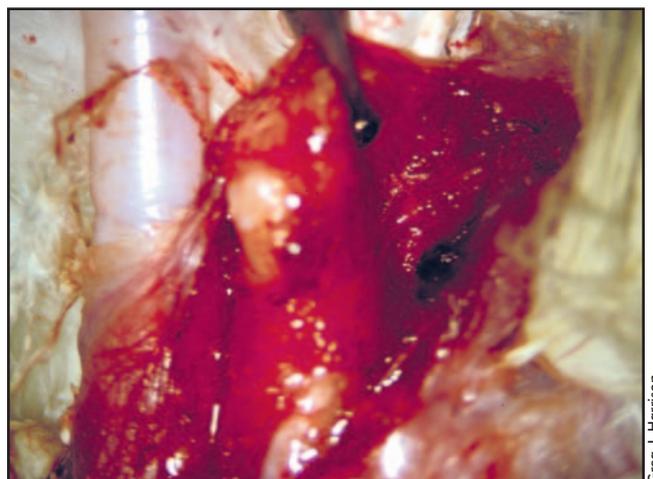
Greg J. Harrison

**Fig 35.9e** | Retractor bands used to improve the view and hold the unaffected follicular tissues out of the way of the radio wave's energy field to avoid damage. In Harrison's opinion, feather damage and failure to resect the point of insertion are the major causes of cyst surgery failure and cyst recurrence.



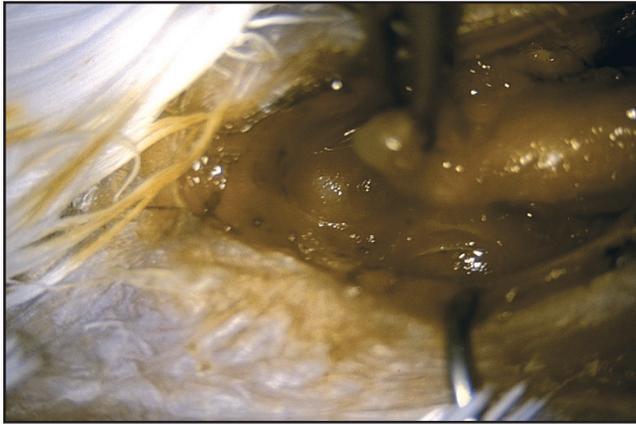
Greg J. Harrison

**Fig 35.9f** | Dissection of the follicular tissue. Retractor bands are repeatedly relocated to minimize trauma during cyst removal.



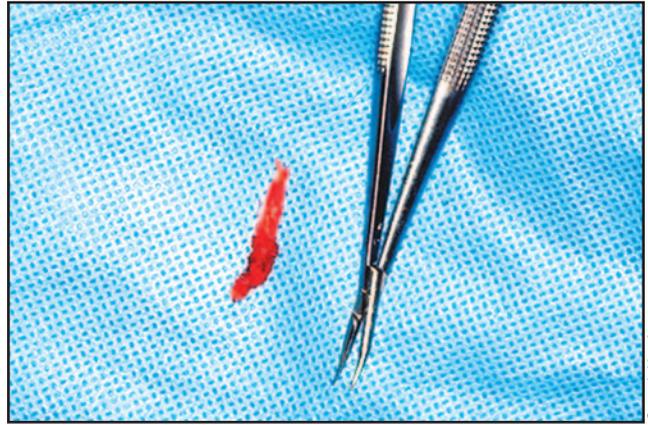
Greg J. Harrison

**Fig 35.9g** | The freed follicle is traced to its insertion and the nutrient vessel is coagulated.



Greg J. Harrison

**Fig 35.9h** | The full cystic follicle is removed intact.



Greg J. Harrison

**Fig 35.9i** | Cyst removed intact and microsurgical needle holder.



Espen Odberg

**Fig 35.10** | Multiple feather cysts can occur on the body, either over a regional area or in a particular feather tract. Multiple cysts may be removed surgically using an elliptical or fusiform excision followed by primary closure with a simple continuous pattern using a monofilament suture.

A tourniquet, direct manual pressure applied to the surgical site or polysaccharide beads<sup>d</sup> may aid in hemostasis. The site may be sutured or left to heal by second intention and bandaged with a hydroactive dressing. As adjacent feathers begin to regrow, debris should be removed carefully and the bandage changed frequently to prevent interference with developing feathers. Laser excision may improve hemostasis. Occasionally the cyst contains necrotic material but the follicular epithelium is not damaged, making new feather growth possible. In these cases, the follicle is incised and necrotic material removed. The follicle is then irrigated with sterile saline and the edges of the incision apposed. The site may be bandaged and local and/or systemic antibiotic therapy initiated. New feather growth must be carefully monitored for formation of cysts and disfigurement of new feathers. Feathers may fail to regrow if the epithelium has been severely damaged.<sup>1,9</sup>

Occasionally a cystic follicle may be salvaged by marsupialization, particularly if there is a single cyst or a large follicle. An incision is made over the center of the cyst

with a scalpel blade parallel to the direction of feather growth. Hemorrhage is controlled with a tourniquet, manual pressure or by ligation. Radiocautery or chemical hemostatic agents may damage the epithelium and further damage the follicle. The contents of the cyst are removed and the lining sampled for cytology and bacterial culture. Redundant tissue is excised and the follicle irrigated with sterile saline solution. The margin of the cyst is then sutured to the adjacent skin using a simple continuous pattern with a fine monofilament suture. New feather growth must be carefully monitored for formation of further cysts or disfigured feathers. Feathers may fail to form if the epithelium is severely damaged.<sup>1,9</sup>

Occasionally multiple feather cysts are present on the body, either over a regional area or in a particular tract. Multiple cysts may be removed using an elliptical or fusiform excision followed by primary closure with a simple continuous pattern using a monofilament suture material. Radical excision of an entire pterygia of affected feathers has been described. This is typically necessary in canaries. A fusiform incision is made around the affected pterygia. The primary vascular supply to the tract, and any large blood vessels are ligated or coagulated. The affected follicles are removed along with the surrounding skin. The remaining skin edges are apposed using a simple continuous pattern with a monofilament suture.<sup>1,9</sup>

Feather cysts of the tail may be severe and disfiguring. Birds may traumatize these and develop secondary infections. Cysts can be excised as described previously. Amputation of the pygostyle is an option in those patients suffering from multiple cysts or those that have severe trauma to the surrounding soft tissues and underlying bone. This is performed by blunt dissection to the coccygeal vertebrae and disarticulation at the sacrococcygeal junction. Soft tissues are closed routinely and care should be taken not to enter the cloaca. Intraoperative hemorrhage and postoperative pain may be severe, and hemostasis and analgesia are crucial to a successful outcome.<sup>1,9</sup>

## Skin and Follicular Biopsy

Skin biopsy is indicated as part of a diagnostic process for dermatoses including feather dysplasia, feather-destructive behavior, auto-mutilatory conditions, ulcerative dermatitis, hyperkeratinization and feather loss (see Chapter 13, Integument). Selection of biopsy sites is crucial to accurate diagnostic results. A sample with an actively growing feather, an entire follicle and surrounding skin should be obtained for conditions affecting the feathers. The surgical site should be gently prepared, avoiding vigorous scrubbing that may irritate the skin and alter the histopathology results. The follicle is grasped with atraumatic forceps and the feather, follicle and skin excised with scissors or a blade. Disposable skin punch biopsy instruments also work well. Minimal pressure should be exerted with these biopsy punches due to the thin avian skin and absence of significant subcutaneous tissue. It is best to avoid cautery prior to excising the sample to prevent cellular and tissue changes to the edges, which may complicate histopathologic analysis. Radiosurgery may be used to control hemorrhage after the sample is obtained. Closure is routine.<sup>57</sup>

## Cranial Skin Defect Repair with an Advancement Pedicle Flap

Soft and hard tissue injury to the cranium may occur due to trauma from various sources including predator attack or attack from other birds, ceiling fan injuries and cage trauma. Species that commonly “flush” such as quail may be susceptible to cranial trauma if the caging does not have significant height to allow for flight. Soft tissue injuries that expose the cranium may result in chronic, non-healing wounds and devitalized cranial bone, which impedes formation of granulation tissue and epithelial migration. The skin covering the cranium is firmly adhered to the cranium. Primary and secondary closure of larger wounds may be difficult once skin edges have begun to fibrose. In addition, closure may create tension when apposing the skin edges, creating deformation of the eyelids and even exposure keratitis. Some wounds may be allowed to heal by second intention under a hydrophilic bandage material.<sup>27,73</sup>

A pedicle advancement flap is preferable to simple closure to surgically resolve larger defects to the soft tissue covering the cranium. Advancement flaps remain continuous with the donor site thereby maintaining blood supply to the subdermal plexus within the flap. Pedicle advancement flaps have a greater chance of remaining viable, as compared to free grafts, particularly when the recipient site is poorly vascularized. In addition, full thickness skin and subcutaneous grafts will provide normal feather coverage if they contain pterygiae.<sup>33,55,62-65,73</sup>

Initially, the wound is assessed to determine the degree of

necrosis of the skin and cranial bone, and to examine the size of the defect to be repaired. The cranial skin is undermined and the skin edges are debrided, removing just enough skin to obtain a good vascular supply. If necessary, small rongeurs may be used to carefully remove devitalized bone; obviously, the cranium should not be completely penetrated. Initiating two skin incisions at the lateral aspects of the caudal end of the defect creates the pedicle flap. These incisions are continued caudolaterally over the cervical region. Divergence of the lateral incisions creates a wider base that increases the blood supply to the subdermal plexus, and compensates for the tendency for inadvertent convergence of the incisions when applying lateral skin tension where the skin is more mobile.<sup>33,55,62-64</sup> These incisions should be made with either a scalpel blade or sharp surgical scissors to maintain integrity of the ends of the blood vessels that will be advanced cranially. The pedicle is undermined bluntly to prepare the flap for advancement. The skin flap is advanced rostrally and the skin edges apposed with small monofilament suture in a simple continuous or interrupted pattern using a taper-point needle.<sup>27,73</sup>

If the defect is too large to correct with a single surgery, the initial procedure should close as much of the defect as possible and the remaining defect can be covered with a hydroactive dressing. A second surgical flap may be created or a staged closure of the defect using horizontal mattress sutures may be performed to completely repair the defect.

## Repair of Ulcerative Lesions of the Sternum (Carina of the Keel)

Ulcerative lesions to the carina of the keel are most often traumatically induced (see Chapter 1, Clinical Practice). Thermal burns, foreign bodies, poxvirus, mycobacteriosis or other stressful situations such as heat and overpopulation have been implicated as well. Improper wing trimming, particularly in heavier bodied birds (African grey parrots and Amazon parrots) may cause the bird to impact the floor when it attempts to fly. This trauma may create a bruise or a laceration of the skin over the carina. Scars from previous traumatic episodes are often evident upon routine physical examination. Auto-mutilation of the tissue overlying the carina may occur as well. Secondary bacterial infection, often involving anaerobes, is common in this location.<sup>39</sup>

Traumatic lesions of the carina often heal readily if the patient is prevented from falling and re-injuring the site. Conversely, repeated trauma and/or auto-mutilation may cause more severe and chronic lesions. These lesions may require extensive surgical debridement. Extensive lesions may prevent primary closure and may heal by second intention.