Case study: successful fight wound management in a Tunisian eyed lizard (*Timon pater*)

Extensive fight wounds are common in co-habiting reptiles. This case study describes the management of a large fight wound in a 1-year-old entire female Tunisian eyed lizard. Primary closure was initially attempted but subsequent postoperative infection and wound breakdown led to successful management by secondary intention healing. This case demonstrates the amazing capacity for healing of large integument defects in lizards that receive appropriate medical support.

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Tunisian eyed lizards (*Timon pater*), a member of the lacertid family, are native to North Africa. Inquisitive, relatively easy to care for and tame, they make rewarding pets. Groups of males and male-female pairs cohabit successively; however, housing females together often results in physical aggression and fight wounds. This case study looks at the management of an extensive full skin thickness fight wound covering two-thirds of the dorsolateral body wall of a 1-year-old entire female Tunisian eyed lizard.

The reptile integument

Reptile skin comprises scales arranged in regular geometric patterns, with a superficial keratinised epidermis and underlying supporting dermis. Scales are attached to the underlying musculature by thin connective tissue. The epidermis comprises three layers: the stratum corneum, intermediate zone, and stratum germinativum. The outer stratum corneum is made from alpha and beta keratin and covered with the 'oberhautchen', a heavily keratinised, acellular serrated surface (Maas, 2013). Scales originate from the underlying stratum germinativum, a basal layer of progenitor columnar epithelium, and receives nourishment from the dermis.

Growth and maintenance of normal healthy reptile skin is through a cyclic physiological process called ecdysis (Mitchell and Diaz-Figueroa, 2004), commonly known as skin shedding. This consists of renewal and resting phases. Ecdysis begins when the stratum germinativum forms new intermediate and stratum corneum layers under the old skin. Enzymes dissolve the connection between the new and old intermediate zones and the space fills with lymph, resulting in shedding of old skin. During times of growth and regeneration the resting phase time decreases and reptiles shed more frequently.

Reptile wound healing

Although the stages of mammalian and reptile wound healing are similar, reptile skin has been reported to heal more slowly (Mickelson et al, 2016). Following damage there is an initial vascular 'coagulation' phase, in which vasoconstriction occurs and a fibrin clot is produced through platelet-mediated activation of the intrinsic clotting cascade. Damaged tissue produces proinflammatory cytokines, which attract polymorphonuclear leukocytes, endothelial cells and fibroblasts to the wound in preparation for the 'inflammatory and debridement' phase. This second phase is characterised by increased blood flow and migration of white blood cells into the wound to remove debris, foreign material and infecting microorganisms, ready for repair, and may persist for weeks in poor wound environments.

In the third, 'proliferative', phase there is re-epithelisation, granulation, angiogenesis, fibroplasia, and subsequent repair and restoration of dermal integrity. In contrast to mammals, fibroblastic response originates in the dermis adjacent to the defect rather than from the ventral subcutaneous tissues, and lizards do not form a significant epithelial scab (Maderson and Roth, 1972). The final 'remodelling' phase may persist for weeks to months; it involves restoration and maturation of epidermis and dermis through collagen and extracellular matrix organisation, wound contraction and scar maturation.

Factors affecting wound healing

Reptiles are ectothermic and rely on varying their environment to regulate core body temperature and subsequently all physiological processes including immune system function and wound healing (Mickelson et al, 2016). Reptiles not exposed to optimal temperature, light and humidity gradients, nor given sufficient privacy, may experience delayed wound healing, therefore a thorough history should be obtained. An environmental history should include photographs of the reptile's enclosure and records of environmental temperatures. Individuals receiving suboptimal nutrition, suffering concurrent disease or suffering secondary bacterial and fungal infections may experience extended wound healing or non-healing wounds.

Approach to a reptile fight wound case

The approach to wound management should consider species behaviour, temperament, anatomy and size, and possible secondary stress- related complications. Subsequent to obtaining the patient's history, a full clinical examination should be undertaken. Fractious animals and those in pain should be examined under general anaesthesia. Manipulating dermatological injuries can be painful, therefore appropriate species-specific multi-modal analgesia should be provided. This may include non-steroidal anti-inflammatory drugs (NSAIDs), opioids and local anaesthetics.

The field of reptile analgesia is rapidly evolving (Sladky and Mans, 2014; Sladky, 2019). Reptiles are adept at hiding pain, so its recognition requires knowledge of the species and individual concerned. In summary, there is currently no efficacy data for NSAIDs in lizards, therefore dose and frequency are extrapolated from mammalian medicine. Similar deleterious side effects are assumed to apply, so assessment of suitability for use should be made for each individual patient. While opioid receptors are expressed in reptiles, further studies are required to understand the efficacy of commonly used opioid dugs in these species (Sladky and Mans, 2014). The current literature suggests that the optimum analgesia for lizards is obtained using μ-receptor opioids. However, respiratory depression may occur with these; this effect is less pronounced with tramadol. Topical administration of local anaesthetic drugs is commonly used before and after wound debridement.

Reptiles with large surface area defects can suffer loss of essential electrolytes and fluids, therefore fluid replacement therapy should be undertaken as required. Fluids replacement may use the oral, subcutaneous, intravenous, intraosseous or intracoelomic routes. Oral rehydration and nutritional support with a reptile-specific product such as Critical Care Formula (Vetark, Winchester) or a species-appropriate Emeraid® Intensive Care Product (Lafeber, Swindon) with the patient at optimal body temperature is ideal providing a functional gastrointestinal tract. Individuals in a catabolic state will have higher calorific requirements.

Radiographs and blood samples for biochemistry and haematology should be taken if concurrent disease is suspected. Microbiologic samples for bacterial or fungal culture should be submitted as appropriate.

Fight wound preparation

Similarly to mammals, the initial goal of wound care is to prevent further contamination and convert contaminated or dirty wounds into clean wounds suitable for immediate or delayed surgical closure, or healing by secondary intention. Large open wounds should be assessed and debrided under species-appropriate anaesthesia and analgesia. Initially wounds should be lavaged with copious volumes of warmed, physiologically balanced fluids to assist removal of foreign material and aid determination of the gross demarcation between viable and nonviable necrotic tissues. Nonviable tissues should be debrided using sharp excision, while taking care to preserve subdermal vascular supply. The wounds should then be flushed again.

Aggressive debridement can facilitate regeneration of epithelium; however, in small patients with large wounds, particular care should be taken not to remove viable tissue. Nonviable tissue may appear necrotic, shrivelled and dark or there may be a slough of devitalised tissue, white blood cells and wound debris. This slough may appear soft or leathery and be yellow-white or discoloured yellow-brown (Nichols, 2015). Tissue of questionable viability can be left in situ and reassessed 24–48 hours later, when the extent of tissue necrosis is more apparent, and repeat debridement performed as required.

Surgical wound closure

Following irrigation and debridement, wounds can be assessed for suitability for surgical closure, whereby appositional healing is achieved by suturing the edges of the wound together. Surgical closure is generally recommended when a wound is clean, with minimal trauma and contamination and less than 12 hours old. However, many injury and patient specific factors need to be considered before attempting primary wound closure of a reptile fight wound (Di Girolamo and Mans, 2016).

Wound specific factors include:

- The degree of contamination
- The age of the injury
- Extent of devitalisation of wound edges and ability to debride
- The location of wound
- The extent of soft tissue loss and extent of dead space
- The availability of adjacent tissue for wound closure or possibility of skin flaps or grafts
- The tension present on the closed wound
- The preservation of blood supply and good haemostasis.

Patients specific factors include:

- Individual health status and ability to withstand anaesthesia
- Individual capacity to tolerate open vs closed wounds
- The patient's living environment and preferred optimum temperature zone (POTZ),
- Owner compliance and ability to manage an open versus a closed wound.

Historically, monofilament suture materials that retain their tensile strength for prolonged periods have been used in the reptile integument; however, materials considered suitable for use in mammalian skin can be used and similar selection criteria can be applied. McFadden (2011) summarised the recent literature on suture material choice in reptiles. All suture materials reviewed caused a chronic inflammatory response, with monofilament absorbable suture material being the least reactive histologically. No suture material is absorbed by day 90, suggesting a prolonged absorption time in reptiles compared to mammals; suture extrusion often takes place before absorption and this should be considered when selecting suture material. Reptile skin should be closed using an everting suture pattern, such as horizontal mattress sutures, to counteract the tendency to invert after incision.

Secondary wound closure and adjuncts to healing

If a wound is unsuitable for surgical closure then secondary wound closure may be applied. This is appropriate for example in cases with large skin defects where the wound edges cannot be opposed; contaminated wounds; or extensively devitalised wounds (Mickelson et al, 2016). This process requires formation of granulation tissue matrix and wound contracture, which can take weeks to months. Secondary intention healing may result in prolonged healing times and functional deformities. Lizards maybe particularly intolerant to the latter if contractures affect mobility.

Adjuncts to wound healing

The principles of optimising secondary intention healing in lizards are similar to those for small mammals (Mitchell and Diaz-Figueroa, 2004). However, optimal temperature gradients for reptiles can result in desiccation of wounds and damage to granulating tissue if inappropriately managed. Wounds should be covered to protect against desiccation, as this may result in arrested wound healing and secondary infections. Infection stimulates an immune response characterised by invasion of inflammatory cells and release of enzymes and cytokines, which leads to indiscriminate destruction of host tissues, and subsequently prolonged wound healing. Hydrocolloids or hydrogel dressings absorb fluid from wounds and provide favourable environments for epithelisation and for angiogenesis, which promotes granulation. Topical dressings limit opportunistic infections and prevent desiccation under environmental lighting, thus facilitate reptile wound healing.

Case study

A 1-year-old entire female Tunisian eyed lizard presented with extensive full skin thickness fight wounds covering two-thirds of the left dorsolateral body wall 24 hours after fighting with a female cage mate. To allow thorough examination, the lizard was anaesthetised in a Stewarts® plastic induction chamber using 5% cent isoflurane (IsoFlo, Abbott, Abbott Park (IL)) in 100% oxygen. She was intubated using an 18-gauge intravenous

Figure 1. **Wound management in the first week following fight wound injury.** *The figure shows the progress of the wound in week one. (a) The degree of environmental contamination of the wound on presentation at the referring veterinary surgeon; (b) the wound after extensive lavage under anaesthetic. Some damage to underlying musculature can be seen cranially but body wall remains intact. Primary closure was possible and seen in (c); (d) day 6, 2 days before wound breakdown.*

cannula (AniCath, Millpledge, Clarborough) attached to Ayres' T-piece anaesthetic circuit with Jackson Rees' modification. She was maintained on 2% isoflurane in 100% oxygen, using positive pressure ventilation throughout the procedure. A splash block of lidocaine hydrochloride 2% (Hameln Pharmaceuticals, Gloucester) was performed before and after pressure lavage of wounds. Lavage was performed for 20 minutes with warmed lactated Ringer's solution using a 20 ml syringe with a 16-gauge hypodermic needle. Available injectable analgesics were used: 0.2 mg/kg meloxicam (Metacam, Boehringer Ingleheim, Bracknell) and 0.1 mg/kg buprenorphine (Vetegesic, Ceva, Amersham), given intramuscularly (IM) for multimodal analgesia.

Following lavage, the extent of the wound was assessed (*Figure 1*). The wound ran from ventrocaudal to the left axilla to the dorsal midline and along three-quarters of the body wall. There was some damage to the underlying musculature cranially, but the body wall was intact. Although the injury was 24 hours old, a decision to attempt primary closure was made because of the large integument defect present and concerns that secondary healing may result in excessive contracture and reduced movement under the axilla. Although the possibility of wound breakdown was significant, the potential benefits of primary closure were considered to be higher than the risks; should the wound break down the underlying musculature would still benefit from being covered by the integument for the interim time period and the skin would act as a temporary 'biological bandage'. Therefore, leaving the wound to heal by secondary intention was not chosen at this time.

Surgical debridement was carried out and the wound closed with horizontal mattress sutures using 5.0 polydioxanone (PDS, Ethicon, USA). To minimise tension, three relief incisions were made dorsally in the skin, parallel to the suture line, between scales. Surgical recovery was uneventful. The patient was hospitalised for 24 hours for assisted tube feeding with a critical care nutrition product (Emeraid® Carnivore, Lafeber, Swindon) until normal eating resumed. The lizard was discharged on meloxicam (Metacam, Boehringer Ingleheim, Bracknell) (0.2 mg/kg PO SID), tramadol (MercuryPharma, London) (10 mg/kg PO BID) and ceftazidime (Ceftazidime, Frescenius Kabi, Runcorn) 20 mg/kg every 72 hours by IM injection. The high frequency of tramadol dosing was determined by subjectively monitoring of this individual patient for behavioural indicators of pain such as inappetence, activity levels and ease of mobility. Relief incisions were protected from desiccation using Intrasite® Gel Applipak® (Smith and Nephew, Hull) daily. These were not covered. The lizard was kept isolated from the group, on paper substrate. She remained bright and very active, so close observation for wound breakdown was undertaken.

After 8 days the wound broke down cranially and under the axilla (*Figure 2a*). Because of extensive tissue devitalisation and

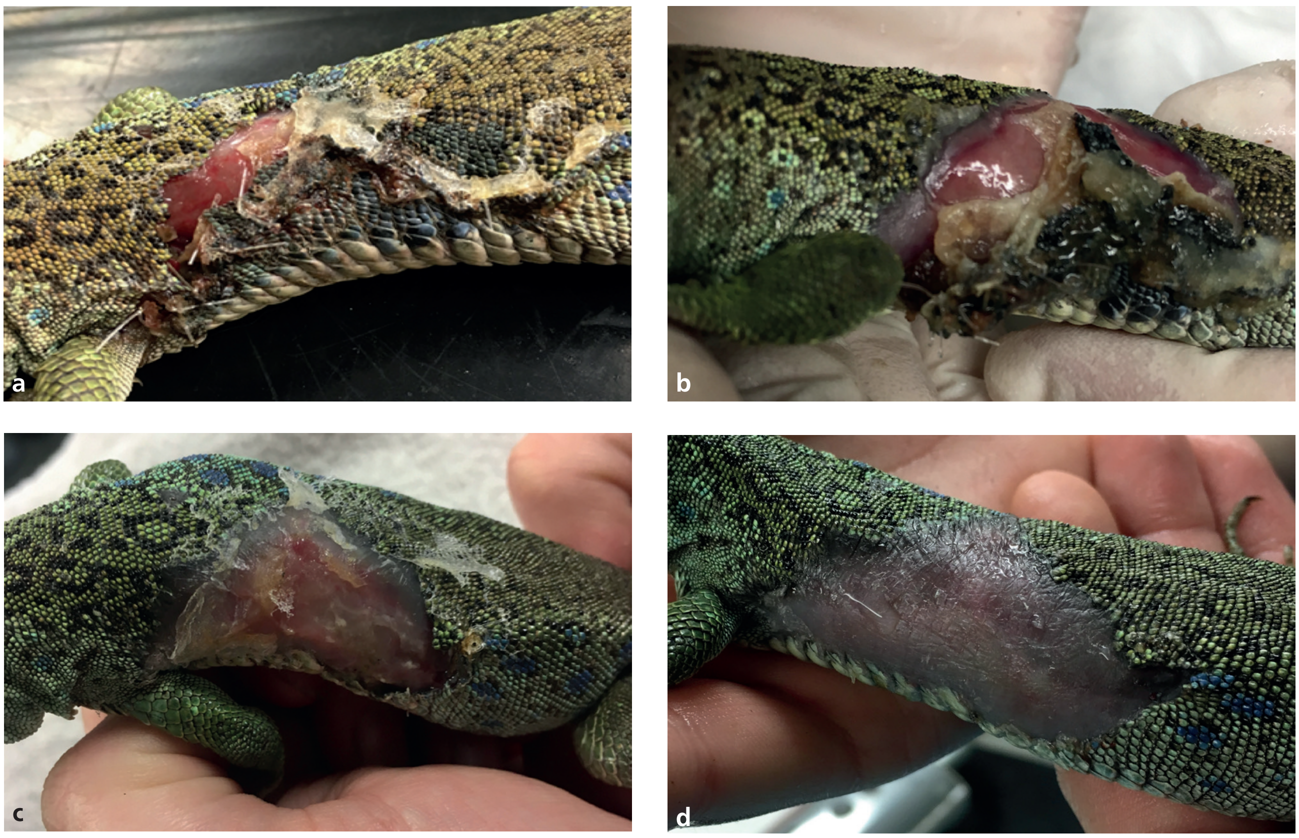

Figure 2. Progress of the fight wound after the failure of primary wound closure a week after surgery. (a) Day 8: necrosis of the skin is present cranially and under the axilla. The tissue underneath appears healthy; (b) devitalised tissue can be seen sloughing in this photograph taken on day 20 and the edges of the wound are already beginning to granulate; (c) on day 27 all the devitalised skin tissue has been sloughed and the wound is granulating; (d) epithelisation of the wound on day 40.

Figure 3. Using a dressing to protect the fight wound from the environment and to aid secondary intention healing. The optimal temperature gradients for reptiles can result in desiccation of the wound and damage to the granulation bed if the wound is not appropriately managed.

inability for the resulting defect to be closed, management by secondary intention healing was opted for. Deep to the necrotic skin a healthy granulation bed was noted.

A microbiological swab was taken for culture and sensitivity; a heavy growth of *Klebsiella pneumoniae* was cultured and found resistant to the initial antibiotic selected. The antibiotic was changed to amikacin (Amikin, 100 mg/2mL, Bristol-Myers Squibb Pharmaceuticals, Uxbridge) (initially 5 mg/kg IM, then 2.5 mg/kg every 72 hours).

The necrotic contaminated wound was prepared for secondary healing by flushing with warmed lactated Ringer's solution. An amorphous hydrogel wound dressing (Intrasite, Smith and Nephew, Hull), was applied to aid autolytic debridement of necrotic tissue and promote secondary wound healing by maintaining an optimal moist environment. This hydrogel was non-adherent and did not harm viable tissue or surrounding skin. Weekly cleaning and dressing changes were performed with the lizard conscious. The wound was covered with a modified Primapore™ 10 cm×8 cm dressing (Smith and Nephew, Hull) (*Figure 3*).

The wound progressed from necrotic to epithelised in approximately one month (*Figure 2*). Following wound breakdown, healthy granulation tissue was already apparent beneath devitalised tissue. Non-viable tissue was sloughing by day 20 and the fibroblastic response in the injured integument could be seen originating lateral to the adjacent dermis; this contrasts to mammals where it originates from the ventral subcutaneous tissues (*Figure 2b*). All devitalised skin tissue had sloughed and wound was granulating well by day 27 (*Figure 2c*). The wound had fully epithelised by day 40 (*Figure 2d*). The dressing was removed and all medication stopped on day 48, after which a staged reintroduction to an all-male group was undertaken successfully. The aggression perpetrator, another female previously included in the group, was rehomed.

Discussion

This case demonstrates the amazing capacity that reptile skin has for healing and re-epithelisation. Two disadvantages of secondary intention wound closure reported are increased healing time and formation of a fragile epithelial scar. However, with supportive care this wound reached full epithelisation in one month. The time required for primary oppositional wound healing in reptiles has been estimated to be 8–10 weeks, therefore no increase in healing time occurred in this case. *Figure 4* illustrates the progression

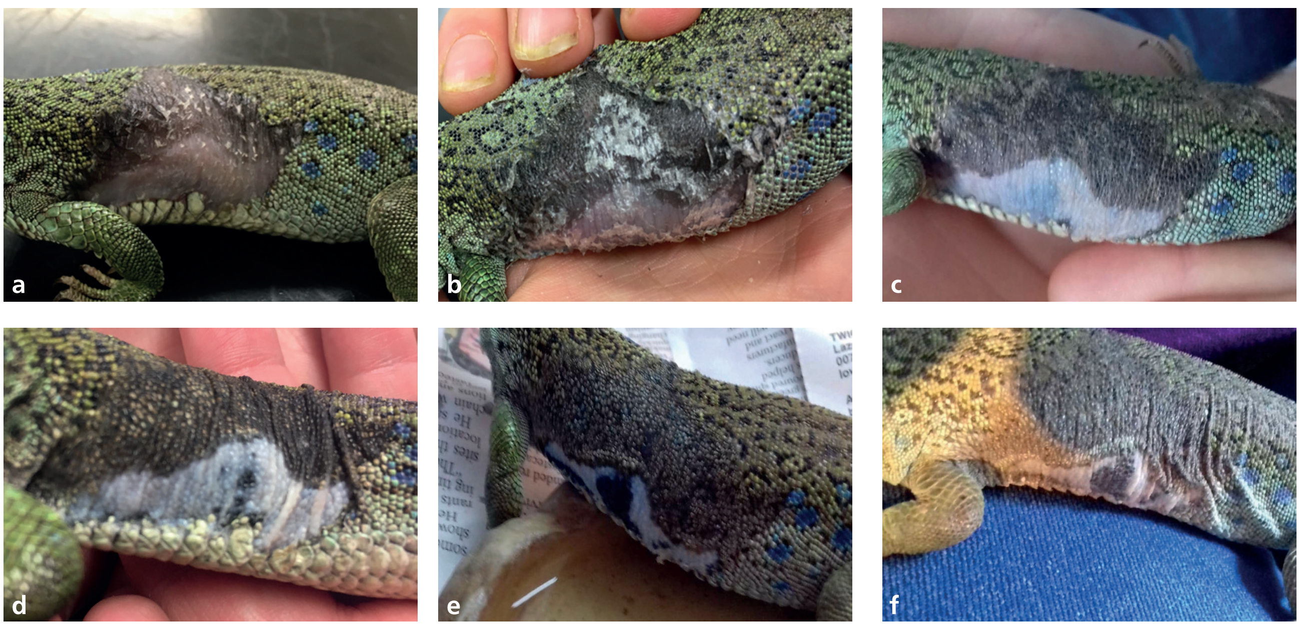

Figure 4. **(a–f)** *The progression of wound healing following epithelisation from day 50 until day 300. (b) At day 60 shows the healing area undergoing ecdysis (shedding). Progression is then shown at day 112, 156 and 210 (c–e). In (f) return of most of the pattern, pigmentation and scaling of the integument can be seen*

KEY POINTS

- Consideration should be given to husbandry and social structure of reptiles housed together; individuals should be separated should aggression occur.
- Reptile skin has an amazing regenerative capacity when managed appropriately within a Preferred Optimum Temperature Zone.
- Appropriate species-specific pain relief, and antibiosis based on culture and sensitivity should be instigated.
- Large wounds of the integument can successfully be managed for secondary intention healing in a similar time frame to wounds undergoing primary closure in reptiles.

of wound healing following epithelisation from Day 50 until Day 300. The final photograph shows return of most of the pattern, pigmentation and scaling of the integument, rather than formation of fragile scar tissue.

In mammals, use of pain management to facilitate wound healing, reduce morbidity and mortality and contribute to rapid return to normal behaviour is well documented. However, pain assessment and pain relief protocols are still in relative infancy in reptiles, therefore understanding of the normal behaviour of a given species is particularly important. The patient remained bright and active throughout treatment, making the timing of withdrawal of pain relief an anthropomorphic decision. Once tramadol was withdrawn at day 48 the patient was even more lively, which may suggest a sedating effect of the opioid.

Conclusions

Treatment protocols for wounds in mammals can be adapted for use in reptiles. Large wounds of the integument can heal successfully by secondary intention without prolonged healing times if managed appropriately, within a POTZ, and with species-appropriate pain relief and effective antibiosis based on culture and sensitivity. CA

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