Turtle Shell Repair: Let's Get Crackin'

Julia Becker, DVM, MS
Associate Veterinarian, Tippecanoe Animal Hospital

Introduction:

Turtles may present to a veterinarian and/or wildlife rehabilitator for varying degrees of trauma to the shell and/or soft tissues. Most often, the patients will be native turtle species that were hit by cars or lawn mowers or chewed on by dogs or other predators. The overall condition of the patient must be thoroughly evaluated before proceeding with shell repair, as extensive injuries may preclude a successful outcome. Many good references address methods of shell repair, but comprehensive case management includes many aspects: determining the extent of injuries, addressing concurrent health concerns, providing pain management, selecting an anesthesia protocol, and choosing and implementing a method of shell repair. In addition, long term management must be taken into account in some cases.

Examination:

Correct species identification is critical to providing the proper care (terrestrial vs aquatic habitat, correct diet, etc.). Field guides usually contain color photos, drawings, and identification keys that are quite helpful.
Next, gender should be determined. Often species have some sexually dimorphic characteristics as adults: length of toenails on forelimbs, contour of plastron, size and shape of tail. Many times gravid females are hit by cars. A nesting site may be needed in captivity, and provision must be made for incubating any viable eggs. Radiographs will reveal if eggs are fully calcified and ready to lay. Even in cases when a female turtle cannot be saved, eggs may be removed, incubated, and successfully hatched.
Accurate weight at time of intake should be obtained. A healthy turtle should be heavy/solid when picked up. Obtaining a weight routinely is a valuable piece of information for monitoring the turtle patient.
Check for signs of possible infection: nasal or ocular discharge, swollen eyelids, discolored skin or shell, swelling on side of head (aural abscess).
Check for trauma/damage: A chart depicting the carapace (top) and plastron (bottom) of the turtle is useful for recording location and extent of shell fractures. Note any soft tissue damage. If the turtle is able to walk, note whether it has full use of all four limbs. Not only is adequate limb function necessary for mobility on land, aquatic species need to be able to swim, and females need to be able to dig nest sites. Some turtles also excavate hibernation sites. Pay particular attention to head trauma, including jaw fractures and eye trauma. Vision and ability to eat are critical to successful rehab and release.

Assessment/Prognosis:

1. Shell: Significant percent of damaged shell, missing large shell fragments (30%), severely depressed or unstable, non-viable shell fragments, or fractures across the midline that may affect the spine and result in paralysis are negative prognostic indicators.
2. Associated or concurrent concerns: Open coelomic cavity, grossly contaminated coelom and/or damaged internal organs, presence of maggots or fly eggs, head trauma, significant soft tissue damage, and limb fractures also carry a poorer prognosis.
3. Other considerations: species (terrestrial vs. aquatic; protected status); age (juvenile vs. adult); general health (good weight, hydration status, etc.); temperament (aggressive/dangerous); releasability; size; our ability to provide appropriate captive care, possibly long term.
4. Experience, knowledge base, and skill of veterinarian and rehabilitator. Up to date, accurate reference materials, appropriate therapeutic medications, proper shell repair equipment and appropriate captive husbandry supplies are vital to success.

After fully examining the turtle, a determination should be made whether to pursue treatment. Minor shell damage may not even require intervention. Severe injuries that are not survivable warrant humane euthanasia. If injuries would preclude successful release of a wild turtle back into its natural habitat, captive maintenance (if allowed legally) or euthanasia are options. Many turtles that have significant shell damage can recover, given enough time and optimal captive care.

Priorities:
Pain relief, hydration, wound care, temporary stabilization of any loose shell fragments, provision of proper housing, and antibiotics (if warranted) are all important initial goals. Be sure the housing you utilize will deny flies access to your patient. Fly strike can be a life-threatening complication. Radiographs are highly recommended for all fracture patients---not only to assess the extent of the damage, but to check for eggs in females.

Pain relief: Reptiles are an extremely diverse group of animals, and they have widely varying responses to many analgesic and anesthetic agents that are commonly used in dogs and cats. Assessment of pain in reptiles can also be challenging, especially when looking at behavior in stressed wild animals recently brought into captivity. Many studies use avoidance of a noxious thermal stimulus to measure analgesic effect. There is quite a bit of information on various analgesics for red-eared sliders, as they are the "turtle of choice" for many of the studies There is a good review of analgesic protocols by Sladky (1): Butorphanol and buprenorphine are commonly used opioids that have **not** been shown to be effective analgesics in several reptile species studies, but tramadol is proving effective in turtles. NSAIDS may reduce inflammation, but pain relief may not be comparable to what we have come to expect in mammalian patients. Agents such as lidocaine and bupivacaine do appear to provide local analgesia.

Hydration: Aquatic species can absorb fluid across the cloaca, so soaking is a way to combat mild dehydration, assuming the injuries are not such that soaking is contraindicated. Fluids are commonly administered subcutaneously or intracoelomically, at a rate of approximately 10-25ml/kg/day.

Wound Care: All wounds should be flushed of gross debris, taking care not to flush debris into the coelomic cavity if it is compromised. Remove any fly eggs. Capstar can be used to kill fly larvae. Dilute povidone-iodine or dilute (2%) chlorhexidine solution can be used to flush wounds, and silver sulfadiazine cream can be applied. Cover wounds to prevent fly strike. Temporarily stabilize any unstable shell fragments using masking tape or VetWrap (or similar cohesive bandage). Do not restrict movement of both forelimbs as their movement aids in normal respiration.

Captive housing and husbandry: Be prepared to provide an escape-proof enclosure, full spectrum lighting, supplemental heat source(s), retreat/hide box for terrestrial species, water and safe substrate. Calcium and vitamin/mineral supplements will be necessary if captive care lasts very long. Proper diet will depend on species, but all native species are carnivorous or omnivorous. Most aquatic turtles will only eat in water, which can complicate wound management and post-op care. Species-specific care sheets are readily available online from many sources.

Antibiotics: Ceftazidime is one of the most commonly used and recommended empiric antibiotic choices, as it provides a good spectrum of coverage in a relatively low volume injection. Baytril has been widely used, but does not have a good anaerobic spectrum, and can be irritating/painful when injected. Metronidazole is useful for anaerobes and protozoa. Silver sulfadiazine is a useful topical antimicrobial.

Anesthesia:
Proper local and/or general anesthesia is a crucial part of shell repair. The level of anesthesia needed depends on the degree of shell trauma, and the invasiveness of the repair technique. The effectiveness of anesthetic drugs can be significantly influenced by temperature, due to its effect on metabolism in reptiles. Use of dexmedetomidine, ketamine, midazolam and an opioid (morphine or hydromorphone) in various combinations is common. See the anesthesia chapter in Current Therapy in Reptile Medicine and Surgery for a nice list of sedation and anesthesia protocol options for various species (2). Propofol is a useful induction agent, but IV access is difficult in many cases due to patient size. Alfaxalone is a newer drug which is labeled for IV (intravenous) use, but has been shown to be an effective anesthetic IM (intramuscular) in red-eared sliders (3). However, it is costly, does not provide analgesia, and does not have a long-lasting effect. Its best use may be as an induction agent (alone or in combination with injectable sedation) prior to intubation and inhalation anesthesia or as an agent to use in combination with local anesthetics.

Repair Techniques:
All techniques require that the shell and associated soft tissues involved in the repair are clean/uncontaminated prior to closing defects. It may take several days or even much longer before closure is attempted--we do not want to seal any infection inside the shell. A broken shell in a turtle is essentially equivalent to an open rib fracture in a mammal. Any technique requiring adhesive applied to the shell requires a clean, dry shell where the material is applied.

1. For fractures that are stable and minimally displaced, especially small cracks in marginal scutes, no repair may be necessary. Cleaning of the shell edges, topical and/or systemic antibiotic therapy, and maintaining in captivity short-term should be adequate.
− Pros: no sedation required, simple, no special equipment needed

2. For fractures that are easily reduced into relatively correct alignment, any of the non-invasive techniques should be appropriate. Hook and eye closures, cable ties (+/-) saddles, orthodontic brackets…any of these firmly secured to the shell with epoxy will provide stabilization. For these techniques, super glue may be used to initially position the hardware on the shell. Be sure shell is clean and dry. Lightly "scuffing" it with fine sandpaper may help adhesion. Once hardware is glued in position on opposite sides of the shell defect, apply epoxy and allow to dry up to 24 hours. Applying too much tension too soon can cause the hardware to pop off the shell. For orthodontic brackets or hooks, use cerclage wire or stainless steel suture between them to apply tension across the defect. The cable tie saddles allow you to tighten a cable tie between the saddles to provide tension to stabilize shell fragments.
− Pros: inexpensive materials, readily available, simple, can access fracture lines for care and monitoring, may not require anesthesia or sedation, or may only need local (e.g., bupivacaine), should come off shell on its own
− Cons: cannot allow epoxy to get in wound/cracks and impede healing, must get hardware properly positioned when gluing in place to achieve proper alignment of shell pieces, can stick up above shell (bulky)--best on carapace only, not plastron

3. For marginal shell fractures, surgical wire works well. Requires a wire driver, orthopedic drill, Dremel or standard drill with very small bit and pliers to twist wire and wire cutters. Drill holes in shell ½" from edges of fracture and shell edge. Thread wire through the holes and twist to align shell pieces.
− Pros: fast, simple, equipment readily available, can allow for access to fracture/wound
− Cons: wire must be removed, potential for damaging shell, material from environment may accumulate on protruding wire ends, may be difficult to evenly tension the wire, requires analgesia and sedation/anesthesia

4. For carapace fractures that will have significant tension on them to get pieces aligned, or for multiple pieces, screws and wire provide the best chance of getting good alignment of fragments. Requires a Dremel or drill with small bit, small stainless steel screws, cerclage wire, pliers to twist wire, wire cutters, saline to cool drill bit. Mark the drill bit (tape) to avoid penetrating deeply into the coelomic cavity and damaging internal organs. Once screws are placed, hand tighten wire. Attempt to achieve even tension across the wires. Overtightening can cause pressure necrosis on tissue margins. Can cover wire knots with epoxy putty to keep them from snagging on objects.
− Pros: uses relatively inexpensive materials, provides excellent stabilization
− Cons: can damage organs with overzealous drilling, can cause heat necrosis by drilling, hardware must be removed and the resulting holes in shell must then heal, somewhat bulky, requires analgesia and anesthesia

5. Fractures of the plastron may be managed with bone plate or wire strips (metal bridges). Requires sheet metal, tin snips, epoxy, super glue. Cut sheet metal to size, allowing ½" from shell margins, then bend to conform to shape of plastron. Position with super glue, then attach with epoxy.
− Pros: relatively simple, good for difficult shaped parts of shell (plastron, bridge)
− Cons: may pop off, otherwise must be removed

6. Open wound management may be required when shell pieces are missing. Irrigate initially with dilute chlorhexidine solution (2%), then sterile saline. Treat daily at first, then less frequently, using saline. Daily wet-to-dry bandage changes may be needed for a week or more. Cover the wound with gauze and tape in place. Silver sulfadiazine may be applied topically.

Granulation bed will look dark, thick and "leathery." Wounds require management and bandaging up to 2 months. Aquatic turtles that are "dry docked" due to wounds will require fluids. Ilex ointment can be applied to wounds to seal them and keep water out.

Conclusion:

Many techniques and variations on those techniques have been used to repair turtle shells. They all have advantages and disadvantages, and sometimes more than one technique may be needed in a single animal to achieve the best outcome. More and more information is becoming available on analgesia and anesthesia in reptiles, and we should incorporate that into our shell repair protocols.

Veterinary Textbooks:

- Current Therapy in Reptile Medicine and Surgery by Douglas R. Mader and Stephen J. Divers, 2014.
- Medicine and Surgery of Tortoises and Turtles by Stuart McArthur, Roger Wilkerson and Jean Meyer, 2004.
- Exotic Animal Formulary, 5th ed. by James Carpenter, 2017.
- **Field Guides**:
- Peterson Field Guide to Reptiles and Amphibians of Eastern/Central North America by Roger Conant and Joseph T. Collins, 1991.
- Amphibians and Reptiles of Indiana by Sherman A. Minton, Jr., 2001.
- Turtles of the World by Carl H. Ernst and Roger W. Barbour, 1989.

References:

1. Sladky, Kurt K., Analgesia. In: Current Therapy in Reptile Medicine and Surgery, Douglas Mader and Stephen Divers, eds. Elsevier Saunders, 2014; 217-228.
2. Schumacher, Juergen and Christoph Mans, Anesthesia. In: Current Therapy in Reptile Medicine and Surgery, Douglas Mader and Stephen Divers, eds. Elsevier Saunders, 2014; 134-153.
3. Kischinovsky M, Duse A. et al. Intramuscular administration of alfaxalone in red-eared sliders (Trachemys scripta elegans)--effects of dose and body temperature. Vet Anaesth Analg. 2013; 40(1):13-20.