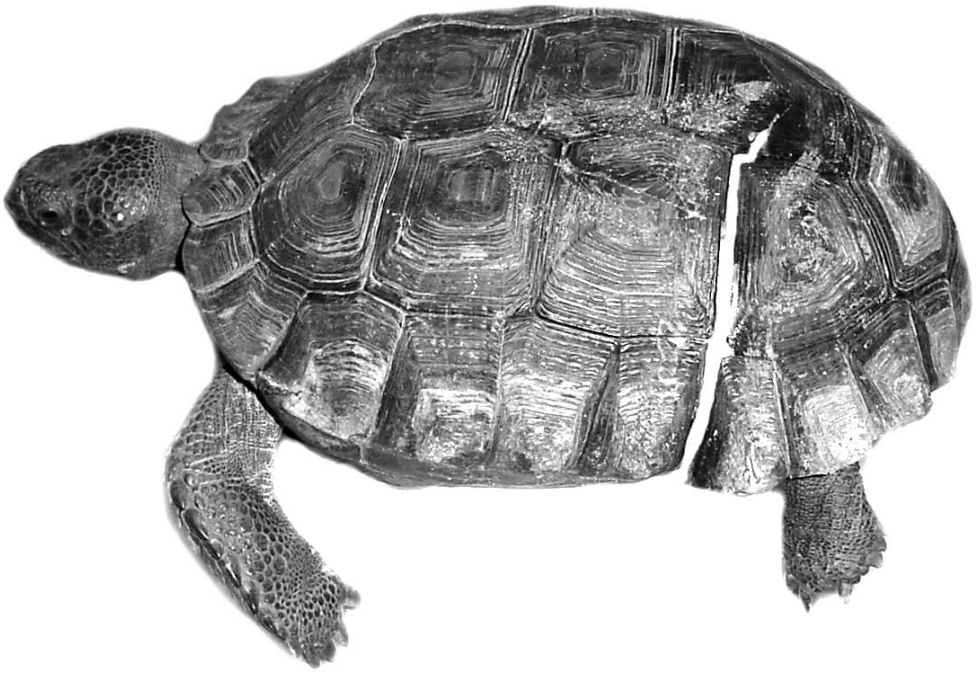
Chelonian Shell Fracture Management

FWRA Symposium 2003



Joshua Moore

Florida Wildlife Hospital
4560 North U. S. Highway 1
Melbourne, FL 32935
josh@floridawildlifehospital.org

Introduction

Chelonians comprise the group of reptiles known as turtles and tortoises. Chelonians in Florida are a very diverse group of individuals radiating from dry sandy terrains to aquatic and marine habitats. They range in size from 5cm hatchlings to 175kg sea turtles. There are many illnesses that these animals suffer from, but it is the traumatic injuries that most rehabilitators are familiar with. The turtles' shells offer some protection but are no match for cars, lawn mower blades, and even dogs. Because there is so much variability in shell fractures, rehabilitators must be creative in their management. The methods contained in this text include all methods familiar to me.

People should not think of fracture management as a carpentry project. Shell injuries involve fractured bones and open wounds. With all the various tools and materials being utilized and the lack of information on long-term fracture healing, it's easy to just throw some fiberglass over the hole and hope for the best. Now after several experiences with these animals I realize that what we really need to do is assist them by guiding the shell fragments, monitoring wound healing and recording success, and providing our patients with what they need to stay healthy. The rest is up to them.

Intake

Patients usually present with multiple shell fractures and tissue abrasions. Injuries are most often the result of traumatic events, usually hit-by-car (HBC). Initial treatment should include debridement of foreign bodies and clots. Shell fragments should be moved only to reduce pressure and occlusions. It may be necessary to sedate the patient to reduce stress when shell manipulation is required. Wounds should be well flushed using a low-pressure wash (substantial enough to wash away loose debris, but not strong enough to aggravate tissue damage) of sterile LRS, saline, or water. After the wound is well irrigated, a final rinse of 4% chlorhexidine (with water only) or 0.1-0.2% povidone is used to sterilize the wound. Before covering the wound, Silver sulfadiazine (SSD) is injected into the wound as a resilient topical antibiotic to help reduce bacterial or fungal colonization. Anti-inflammatories should be used for injuries that include the head or spine. Severely damaged patients should be started on antibiotics. Finally make sure the wound is entirely covered to prevent fly larvae, fungus, and bacteria settlement. Coverings can range from bioclusive type dressings (Tegaderm) to tapes or any type of sterile wound dressing. For plastron wounds a "shield" can be made from x-ray film to protect the bandage and wound from contamination. If the wound is confined to the dorsal surface, the animal can be placed in a container with shallow water for short periods (approximately an hour) to encourage hydration. All enclosures should be partially placed on a heating pad set on low.

Notes

Initial presentation can be gruesome and require extensive debridement and cleaning to thoroughly discover the extent of the wound.

Excessive blood loss should be considered when dosing anesthetics on initial exam.

Fluid therapy should begin immediately following exam.

Corticosteroids should be used sparingly for short periods after initial trauma. Poor metabolism of these medications can adversely affect overall healing.

Useful tools on intake include a wet-table with grated top, 30-60cc syringes for flushing, 15-20cc syringe and plastic pipette tip for injecting SSD, solid hand tools for shell manipulation, protective eye glasses, and picks for debriding.

Wound Treatment

While caring for injured tortoises, it is necessary to practice good reptilian husbandry. Maintain proper diet, thermal regulation, and U/V exposure. The wound should always remain covered to prevent airborne invaders and should be flushed regularly depending on the amount of

debris within the injury. Wounds that are oozing continuously will need to be flushed more regularly to keep the area clean. If the injury contains large amounts of debris, it may be necessary to use a variable intensity flushing apparatus capable of delivering a forceful stream. A good tool for this function is a *Water Pik* or 30-60cc syringe fitted with a 20guage needle (fig. 6). It is important to remove necrotic tissue and foreign debris, but take care not to cause any unnecessary tissue damage with too much stream pressure. A soft-bristled brush can be used to help lift away debris. After flushing, wash the area with a sterilizing solution. Using a hair dryer, the area can be rapidly heat dried, reducing air exposure time. The wound should be filled with a resilient antibacterial ointment and covered quickly. Flushing should be a regular treatment until oozing has ceased. Wound treatment can be continued, less frequently, if you decide to treat the wound throughout the entire healing process.

Notes

Healing can take many months to complete. If necessary alter sterilizing solutions every 3-4 washes to prevent bacteria resistance.

Fracture Realignment Materials

There are many mechanisms available for repairing shell fractures. Before considering which device to use for repair, the wound should be stabilized and the patient determined to be releasable. Sometimes it is necessary to realign select fragments earlier to stabilize the injury and make wound care possible. When doing this, it is important to choose a device that will secure the fragment quickly and not add damage to the injury.

In the past U/V cure epoxies have been quite useful for temporary suturing. However, now, I DO NOT recommend using polyester epoxy resins with fiberglass material. This combination is too messy and cumbersome. For quick fixes there are other methods and materials available that outperform fiberglass, and are much cleaner to use (see below).

Whenever using adhesives on the shell, it is imperative to properly prepare the surface using some kind of etching tool (sandpaper or *Dremel*). The surface should be etched in a light criss-cross pattern. Etching increases the surface complexity, giving the epoxy a greater adhesive ability.

New materials are available with beginnings similar to poly-epoxies, in that they are developed for other industries (usually marine repair) and adapted for use in the medical field. Two products we at Florida Wildlife Hospital (FWH) are using frequently with great success are *Marine Tex (MT)* and recently *BondTech (BT)*. MT comes in a 1:5 (slow cure) or 1:1 (rapid cure) two part package. It has a viscosity and workability like putty and hardens like steel. After hardening, it can be sanded like wood. BT can be used as one part liquid or combined with an accelerator to decrease curing time. With these products and others like it, the application is much different than that of epoxy/fiberglass techniques.

We use these products almost exclusively for fracture repair including bracket adhesion, bridging, and patching. The properties of these materials allow the rehabilitator to apply them more accurately, reducing the chance of them invading the wound or making a mess otherwise. When dry, they adhere to the shell securely until the scute sloughs off. Minimal amounts can be used, reducing actual shell contact. MT, slow cure, can take 4-7 hours to cure completely or, fast cure, 30 minutes. My experience with these products has shown the fast cure difficult to work with and not as adhesive. I prefer the slow cure when possible. BT is a new product that is still being investigated by FWH with great success. When used with the accelerator, it cures in seconds with incredible adhesive strength. During recent trials, realignment was completed in less than 20 minutes prep-to-finish on a large Gopher tortoise fracture.

Traditionally, shell fractures requiring extensive realignment have been corrected using invasive orthopedic procedures. This requires the use of sterile stainless steel screws, taps, drills, and wire. Additionally it is necessary to use anesthesia and specific surgical skills.

A new technique innovated at FWH, in place of invasive methods, uses a combination of specific adhesives with orthodontic brackets (fig. 1). The technique for applying and using the brackets is simple enough to be completed by one person of most skill levels and does not usually require anesthesia (patient or physician).

Methods

The first step to any fashion of realignment is to stabilize the injury. Fixtures can be attached at any time, but the realignment should not take place until the wound has been completely debrided.

Methods of using epoxy resin/fiberglass fixatives will not be discussed here to promote the use of more appropriate and efficient means. Please pass this information on to any vets you know still using this older technique. Fiberglass patches on chelonian shell fractures are destined for failure. We have seen too many poorly applied patches over wounds infected with fly larvae and other goodies.

Covering the wound with fiberglass prevents monitoring the healing process and also prevents flushing the wound to keep it free from pathogens. Using mounting brackets or stainless steel screws along with wire allows us to monitor the wound and treat as necessary.

Invasive methods of realignment with screws should be completed only under the supervision of a trained veterinarian. DO NOT try this at home. This procedure requires the use of sterile equipment, anesthetics, and precision drilling into live material. After anesthetic induction (which can be its own problem depending on the species) the edges are scraped using a #10 or #11 scalpel blade until a fresh blood supply is present. Next predetermined sites are drilled and tapped to allow stainless steel screws to be inserted. Finally the screws are wired together until the edges are in close apposition. Following this surgery the animal should be placed on an antibiotic regime. While it is more strenuous and requires additional skills, this technique is useful and can be necessary on large animals.

Non-invasive methods are by far easier and presently offer almost all of the advantages of the above technique, while avoiding the disadvantages. I say almost, only because the overall strength limits of adhesives are not as great as screws mechanically attached to the animal. Overall strength aside, the non-invasive techniques and materials used at FWH meet and exceed the strength needs.

Attaching the brackets requires only a realignment design (fig. 4) and the hardware. When designing the placement for the brackets (fig. 2 & 4), think simple. Attach them to secure surfaces, away from suture lines and attach only what is necessary (about one pair every 1.5-2cm).

When using Marine Tex

To attach the brackets, first etch the surface at the attachment sites. Next apply a small dab of *Marine Tex.* (This should be sufficient to extend beyond the base of the bracket and slightly up the side.) Finally, using forceps, place the bracket onto the *Marine Tex*. Push the bracket down securely and try to push some of the *Marine Tex* up over the base, but do not cover the hooks you will use when wiring. A small, narrow disposable tool that is good for manipulating the material is the wooden end of a culture swab. This is very effective for applying the small dabs, and a clean one is useful for manipulating the material around the bracket. Make sure brackets are applied in the proper direction. This will have to be decided by the rehabilitator, based on necessity and bracket availability. To remove, grind the MT away from the edges and twist off with pliers. MT cure time can be decreased with an additional heat source like a heat lamp placed ~60-90cm away.

When using BondTech

Prepare the site as described for MT. Brush a small amount of accelerator on the sites. Grasp the bracket with a pair of forceps and apply a small amount of *BondTech* to the base of the bracket; press firmly on the site. After ~10 seconds the bracket will be secure enough to let go. After all the brackets are in place, apply a small amount accelerator around each one, and add a tiny drop of BT. Be careful not to use too much of either product. Too much accelerator will cause the adhesive to cure too rapidly, producing a small amount of vapor. (Do not be alarmed; the turtle is not on fire.) Too much adhesive will flood the brackets, filling in the hooks, making wiring difficult. To remove, twist off with pliers.

If the wound is clear of debris and swelling has subsided, the shell can be wired together (fig. 3-4) using stainless ligature (or other stainless type) wire. Wiring the shell will require hands-on experience before it becomes common practice. For long fractures, start at the distal point from the hinge and secure the shell as tightly as possible; then work towards the hinge. It will almost always be necessary to go back and redo the first ones, as subsequent ones will decrease the gap even further. As tissue swelling decreases, it may even be necessary to tighten the wiring in the days following. Wiring patterns can be done in many ways to suit your needs of strength or maneuverability. A small amount of *MT* can be placed over the fracture hinge to prevent the fracture from growing.

After the shell is wired together, you can apply more permanent bridges using *MT* and sterile dressings. Use 1.25cm steri-strips or adapted Tegaderm placed between brackets extending 3-5mm beyond the fracture line. Make sure the shell is prepped (etched and washed) beyond the strips. Using a masking tape of some kind, mask off beyond 3-5mm of the shell past the strips. After applying the *MT,* the tape can be removed. Begin by applying the *MT* to the area where the shell and steri-strips meet. Next work your way across the strip. The *MT* should be applied evenly across the bridge and not over the sides into the wound. After the bridge sutures have dried, the brackets can be removed. These bridges can be used as a semi-permanent holding mechanism during wound treatment.

Note SSD can be placed into the wound prior to the steri-strips to help prevent any of the *MT* getting into the wound.

It has been said that non-invasive adhesives can contribute to abscess formation, sepsis, and exothermic tissue damage. The methods and materials described here minimize the amount of contact between shell and adhesive. None of the adhesives produce significant exothermic reactions, and to date no adverse reactions or events have occurred in the use of these materials on more than 50 animals aquatic, marine, or terrestrial. Because of the minimal amounts used, removal also proves to be very easy without any additional disadvantages. With proper use of these materials there should be minimal risk and little chance of any wound contamination with adhesives or other materials.

The brackets can be obtained from orthodontic supply companies at about $2-4 each. A better method is to ask local dentists for spare materials, including the wire. Try to have volunteers with braces to ask their own dentist. Other reports indicate that hook-eye fasteners (used for sewing) can be substituted for the orthodontic brackets. I have tried them, but prefer and recommend the brackets because of their specific design for similar applications.

Patching

Patching can be either the partial (bridge) or complete covering of a wound using a material meant to protect or hold the wound closed. This section is meant to give helpful reminders for working with the materials used in patching shell fractures.

When working with all of the adhesives, it is important to be as precise with application as possible. Avoid using drippy resins or getting material where it doesn't need to be. Most important is

to properly prepare the shell before application. Cleanliness reduces flaking caused by debris. Etching increases the surface area for the adhesive to hold to.

The *Marine Tex* is much easier to work with than poly-resins, but don't take it lightly. When applying the *MT*, the surface must still be prepped, but not as intensely. Taping the edges of the working area will make applications neat and reduce the amount of MT adhering to the shell. If applying a patch over an area with shell missing, repeat the steps to sterilize the wound and prepare it for the *MT*. Cover the entire wound with Tegaderm, trim to within 5-10mm of the wound, and mask the area 5-10mm beyond the Tegaderm with tape (Fig. 4). Always begin by applying the *MT* around the edges first and working toward the center. The *Marine Tex* can be applied in layers so the first one only needs to be enough to cover the Tegaderm. When applying multiple layers after drying, be sure to etch the previous layer before applying more *MT*. Waxed paper can be taped over the *MT* to prevent contact with the cage or other areas of the body. The waxed paper can be easily removed after drying.

Useful tools

Dremel with a variety of bits- etching and cutting shell
Jeweler type pliers and cutters- manipulation of wire and brackets
Forceps- manipulation of brackets, removal of debris
Picks- removal of debris
30-60cc syringes- flushing wound and injecting SSD
Plastic pipettes- fitted to syringe for SSD injection
Hair dryer- rapid drying
Soft toothbrush- debriding
Marine Tex can be obtained from marine supply stores
BondTech can be obtained online at www.bondtechglue.com

Pharmaceuticals (consult with your veterinarian)

Dexamethasone- IM SID, this should be given only on intake for spinal or cranial injuries. Prolonged usage can cause accumulation and can affect healing.
Loading dose .25 mg/kg
Normal dose .15 mg/kg

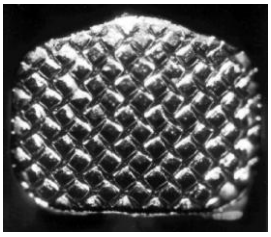
Baytril- IM 5 mg/kg
Infection present, SID daily for 10 days.
Preventative, SID for first three days, and then SID every third day.

Amikacin- IM every 72 Hours
Loading dose 5mg/kg
Subsequent doses 2.5 mg/kg

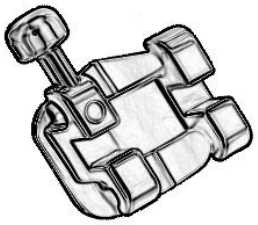
Ketamine- IM, 22-44 mg/kg, 10-30 minute induction
Larger reptiles require lower per-kilogram doses.
Can be tricky when using on aquatic turtles.

Lidocaine 2%- SC or topical, applied to area for local anesthetic

Fig. 1 Bracket Examples



Bottom



Top

Bottom

Fig. 2 Bracket placement

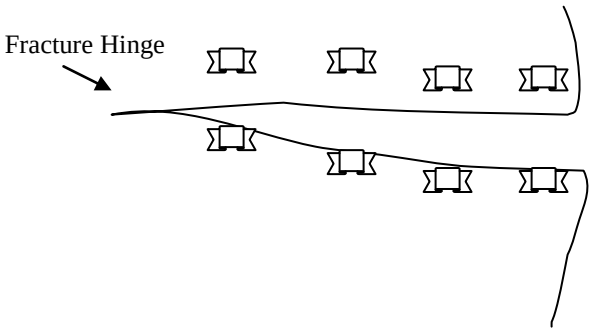


Fig. 3 Wiring Pattern

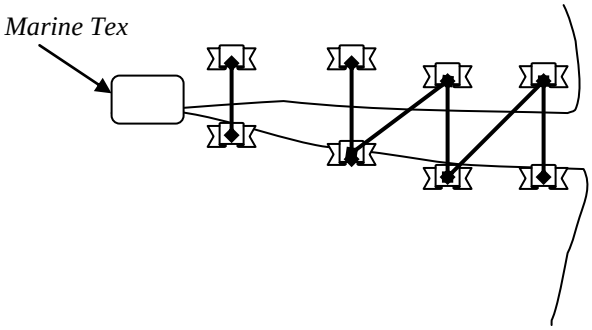


Fig. 4 Wiring Examples

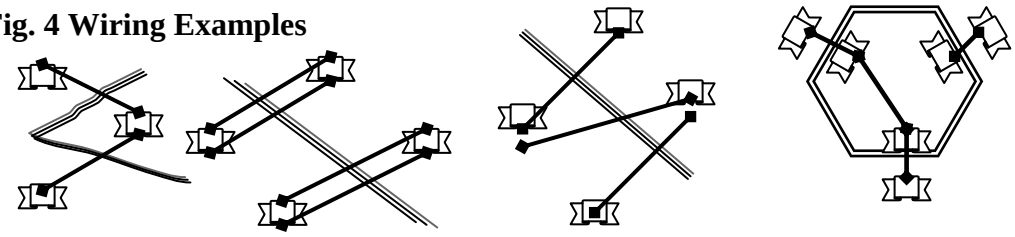


Fig. 5 Patch Example

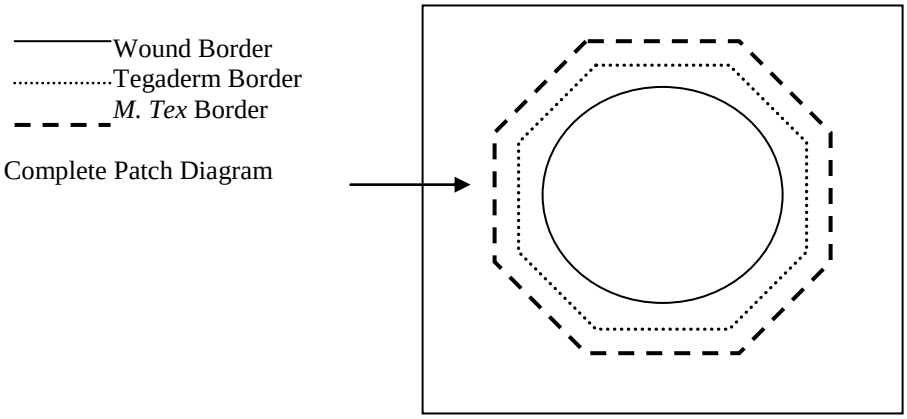
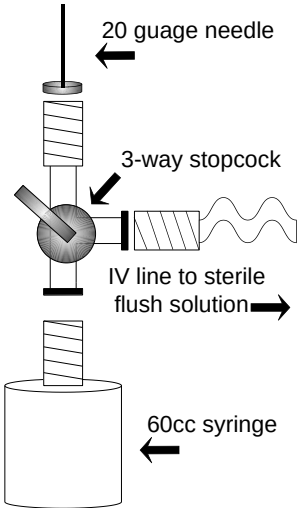


Fig. 6 Quick Refill Flushing Tool



Flushing apparatus using 60cc syringe, 20-gauge needle, 3-way stopcock, and IV line hooked to sterile flushing solution

Realignment Outline

1) Stabilize the animal by debriding the wound (under anesthesia if necessary to reduce stress to the animal) of shell fragments and foreign matter. During this process, we also try to reduce any pressure caused by broken shell against soft tissue. If necessary, shell can be shaved using a *Dremel* tool, with a cutting bit and irrigation, to help realign the shell.
2) The shell is flushed thoroughly using sterile wash to remove sediment and blood clots.
3) SSD is applied using a 12cc syringe fitted with an extension to help inject the SSD into the wound. The SSD will prevent infection as well as tissue and bone necroses. We have recently begun using homeopathic treatments to stop bleeding (*Calendula)* and reduce inflammation (*Arnica)*. If the *Arnica* isn't used, then Dexamethasone is given until swelling subsides. Cover the wound with Tegaderm.
4) Begin subcutaneous fluid therapy and shallow soaks, depending on the wound site, avoiding contamination.
5) The turtle/tortoise is observed and wound care is continued until stabilized.
6) Depending on activity level and current wound coverage status, the animal is allowed to graze outside. Usually they feed very poorly inside, but often do very well outside.
7) Once the wound is free of weeping, debris, and infection, we begin the closing process.
8) The wound is flushed thoroughly one last time with a sterilizing wash and then hot air dried.
9) For hinged shell repairs, orthodontic braces are used. The application sites are scored using a *Dremel* tool. *Marine Tex* (MT) is mixed up at 1:5 ratio to allow it to begin curing or *BondTech* is readied. After scoring, a small dab of MT is applied to the site and the bracket is placed on firmly but not too deep, making sure not to restrict the hooks. *BondTech* only requires pre-treating the sites with a small amount of accelerator and a small drop of adhesive that is placed on the bracket base.
10) Allow the MT to dry thoroughly before wiring the brackets. Once secure, the brackets are wired by wrapping the first end in a figure eight and then pulling the shell tight while wrapping the other end in overwraps. The remaining brackets can be attached in single strands or a continuous strand. The end of each strand can then be secured with a drop of super glue to prevent it from unwrapping, but it can still be removed with a little force.
11) After the wiring, flush the wound weekly and apply minimal SSD to prevent infection.
12) Depression fractures are treated for the wound and then the pieces are elevated. The brackets can be used to align the fragments.
13) If it is decided to close the wound because of extensive shell loss, then the MT can be used to create a prosthetic shell.
14) Whenever applying the MT, it is necessary to score the shell to increase surface complexity for attachment. (Take care to cover the wound when using the *Dremel* to prevent dust from getting into the wound.) The wound should be flushed and sterilized thoroughly prior to closing. Tegaderm is used to cover the wound and trimmed to within 5-10mm of the edge of the wound. The MT can be pasted over the Tegaderm extending 5-10mm past the edge. It may be necessary to apply a second layer to provide a thick enough structure.

References

Anderson, Debbie, D.V.M., Brevard Zoo, FWRA President. Personal communications.

Carpenter, James, M.S., D.V.M., Ted Y. Mashima, D.V.M., and David J. Rupiper, D.V.M. Exotic Animal Formulary. W. B. Saunders Company, Second Edition, 2001.

Grigsby, Stephen, D.V.M., Harbor City Animal Hospital, Melbourne FL. Personal communications.

Mader, Douglas R., M.S., D.V.M. Reptile Medicine and Surgery. W. B. Saunders Company, 1996.