Antimicrobial resistant – multidrug resistant – infection in tail with distal bone exposure

Staffordshire Bull Terrier Male 6 years old

Day 0" equals the first day of MPPT application

A 6 year old Staffordshire Bull Terrier had his tail slammed in a car door. Upon inspection no trauma was identified and the dog did not seem bothered about his tail at the time. 4 days later, the dog began licking his tail and would show signs of discomfort if the tail was touched. 9 days following the accident, the dog was checked at a veterinary hospital. However, the tail was too sensitive for the dog to allow the vet to shave or examine it. He was prescribed Gabapentin and Meloxicam for pain and 5 days of systemic antibiotics Cephalexin 750 b.i.d. 2 days later, the dog was taken to the local vet. An x-ray did not reveal any bone trauma. The vet, in addition, prescribed the tail be soaked daily in a lukewarm solution of water and chlorhexidine shampoo (Chlorhexiderm) followed by application of a topical antibacterial-antifungal-corticosteroid ointment blend of nystatin, neomycin, thiostrepton, triamcinolone (Animax), a regime which was continued until the start of MPPT. The following day, the dog managed to remove the cone and lick the wounded area revealing hair loss and inflammation along the tail caused by an infection (pic 1). The infection was, ergo, resistant to the antibiotic drug provided systemically, to the two antibiotic drugs and the antifungal drugs provided topically, and to the antiseptic.

The Chlorhexidine-Animax regime was continued without much success (pic 2) until the dog chewed on the tip of the tail and was prescribed another course of systemic antibiotics, Cephalixin, this time at an increased dose, ie.1000 b.i.d., in the hope that the increase in dose would overpower the resistance to the antibiotic which had already been established during the first course of the drug. At first, this dried out the tissue but did not stop the tip of the tail from necrotizing, i.e. it failed to stop the infection. (pic 3) Instead, the nature of the infection rapidly changed from dry into wet necrosis (pic 4). As the drug was broad-spectrum, this change was presumably caused by a further change in the microbial balance and further reduction in diversity of the microbiome, inadvertently but inevitably, strengthening and intensifying the infection, and driving its spread further cranially. (Such a spread was later identified as it was halted - as exemplified in pic 8.)

The dead tip fell off overnight leaving a 5mm tip of the tail bone fully exposed, but intact (pic 5). All medication was continued until MPPT treatment was started 3 days later. There is no photo from before the application on the day MPPT was initiated, but the one taken after 24 hours treatment shows an immediate reversal of the infection (pic 6).

In the course of the 31 days that had passed since the accident, the tail had been treated with two courses of systemic antibiotics increasing dosage on the second course (Cephalexin 750 and 1000 twice daily), with daily application of two topical antibiotics (neomycin and thiostrepton), and a topical antifungal (nystatin), following daily soaking in the antiseptic, chlorhexidine, which is cytotoxic including to canine cells, and with daily application of a glucocorticoid (triamcinolone) which suppresses the immune system and boosts infections, despite reducing inflammation. Nowadays it must be assumed, that every individual carries at least one antimicrobial resistant microorganism. Consequently, this extensive use of antimicrobial components had efficiently favoured and strengthened any antimicrobial resistant infective agent and supported its further spread by killing the competition and weakening the dog's own immune defences.

These changes, i.e. this dysbiosis, had also helped mask the spread cranially of this resistant infection. The spread was detectable on the outside of the tail from the inflammation reaching 5 cm up the tail, but it was unknown how far it had advanced internally out of sight, i.e. without revealing its presence on the skin.

This questioned the effectiveness of the traditional approach of tail amputation leaving an uncertainty with regards to the location of an amputation. A further concern regarding tail amputation was the fact that the dog's own microbiome evidently contained one or more resistant species and any dysbiosis following an amputation was therefore likely to repeat the currently experienced trouble.

The infective agent was using red-pigmented toxins as one of its many weapons (virulence factors) breaking down tissue and inhibiting immune cells. Often, in addition to the toxins readily available in the soft tissue, concentrations of toxins are stored by the bacteria in small abscesses disseminated throughout the infected tissue.

MPPT enabled the immune system to collect and concentrate these microbial toxins and dispose of them on the wound surface preventing them from completing their harmful endeavour. Once reached the surface they would dry out and be removed during the daily washing of the tail. The stages are captured in pic 7, pic 10, 11, 12 and pic 15, 16).

The wound progressed well. The swelling disappeared and the intact skin started regenerating, displaying signs of skin restoration, i.e. hair follicle recovery and microscopically thin flakes (not scales) (pic 6, 7, 9, 12, 14).

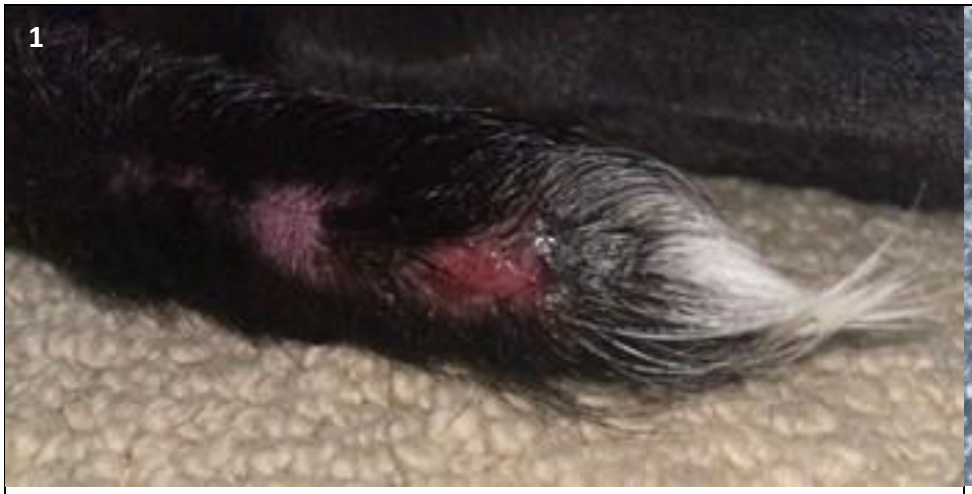
Up until the start of MPPT, the focus had exclusively been on the ventral side with the exposed bone. However, the dorsal side soon revealed signs of also being involved in combatting the internal infection which had reached further cranially than exterior signs had previously implied (pic 8). This was dealt with (pic 13) and by the end of the second week the dorsal side was smooth filling in with new hair growth all over.

The dog became less focused on his tail and seemed less uncomfortable as he would much more willingly allow the owner to handle his tail.

The abscesses containing concentrations of bacterial toxins were penetrated by the immune system one by one as the immune system regained it strength and control advancing to perform these tasks in a controlled manner. Once penetrated, the content of the abscesses had to be evacuated, whilst still contained in vesicles, and carried to the surface where it could be disposed of. This battle can cause pressure inside the tissue and twice during the healing coincided with the dog seeming uncomfortable and chasing his tail. Such expulsions can be mistaken for bleeding (pic 15). The dog consistently relaxed very soon after the expulsion of a portion of red-pigmented waste implying that such expulsions return the pressure in the tissue to base level.pic 16). The dog seemed well aware that the MPPT treatment was working and consistently lowering his pain, because he started willingly jumping in the tub and relaxing for the treatment.

The processes of infection removal and tissue recovery continued steadily (pic 17). Once the soft tissue surrounding the bone was sufficiently free of infection and the tip of the bone, that was sticking out, had been cleaned and any damage to the periosteum had been repaired, the bone was protected with granulation tissue and subsequently with epithelium (pic 18). Because the dog had had so copious systemic and topical antimicrobial treatment during the first month following the accident, the infection was deemed tenacious and MPPT treatment was continued until closure. The dog lived in a hot climate and the day following closure he was off to the beach and a longed-for swim (pic 19). This did not impact healing (pic 20).

The infected skin along the tail healed completely restoring all his original pigmentation and hair growth. The owner had always been very fond of his white-haired tail tip against his otherwise intense black fur and was delighted to see the regrowth of his hallmark white tip (pic 21, 22). Follow-up 2½ months after full closure showed a dog that had fully moved on after the accident and was not bothered by his tail at all (pic 23, 24).

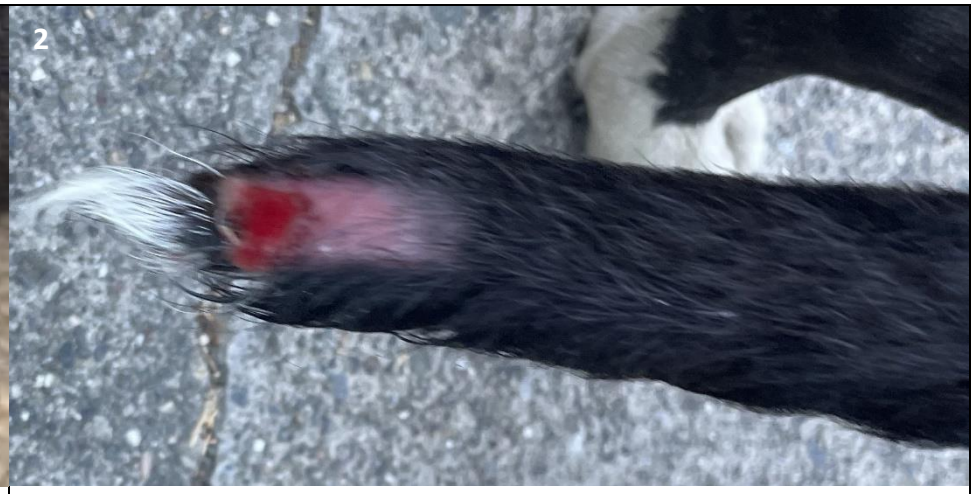


Day minus-19

3 weeks before start MPPT

12 days after the accident. Day 3 of a 5-day systemic Cephalexin antibiotic course. 1 day after starting daily chlorhexidine bathing and topical antibacterial-antifungal-corticosteroid-ointment.

Infection is spreading cranially. Hair loss and inflammation.



Day minus-12

2 weeks before start MPPT

After 8 days of Chlorhexidine bathing and topical antibacterial-antifungal-hormonal ointment.

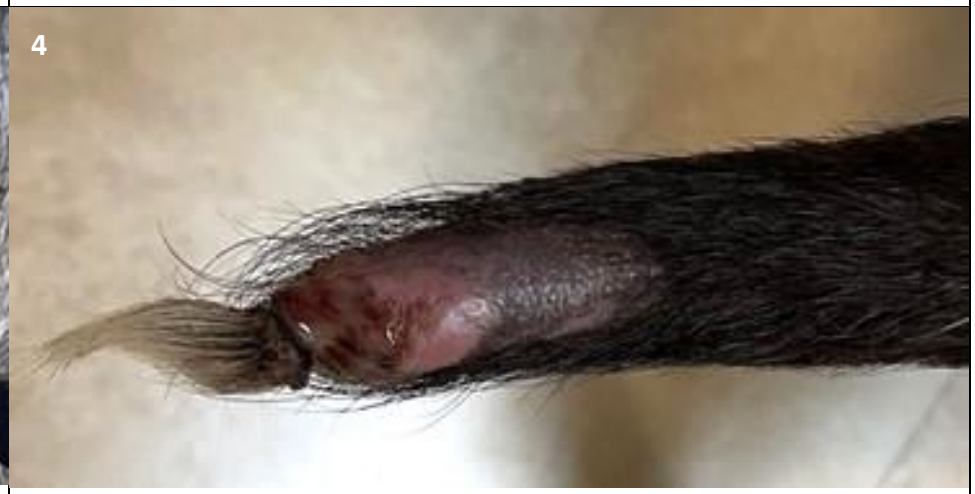
Skin loos. Further hair loss. Dull appearance lacking vitality.

Day minus-6

1 week before start MPPT

After 24 hours with second course of Cephalexin antibiotics, combined with the daily Chlorhexidine soaking and antimicrobial ointment

The white-haired tip is infected, dry and necrotic. The dry necrosis is spreading up along the tail.

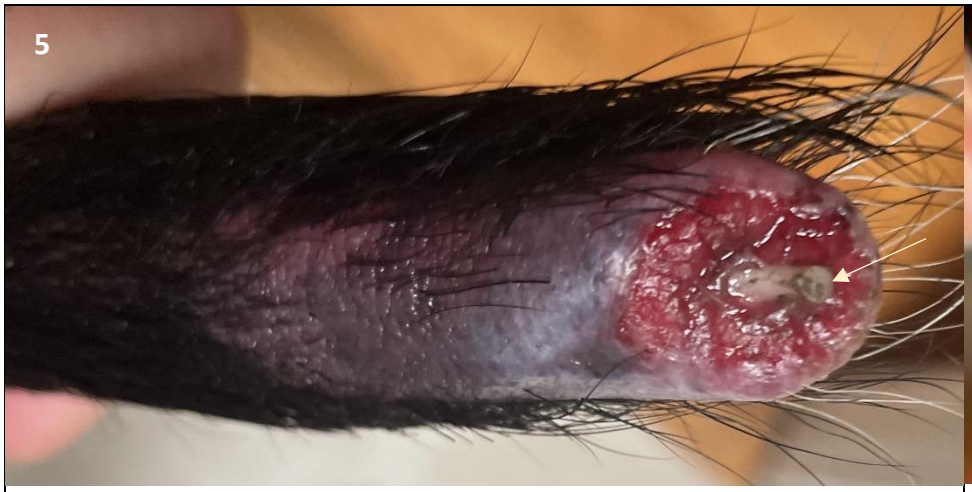


Day minus-4

½ week before start MPPT

After 72 hours with second Cephalexin antibiotics, combined with the daily Chlorhexidine soaking and the antimicrobial ointment

The infection has changed to wet necrosis. The infection is consuming the soft tissue and spreading cranially, e.g. evidence by further hair loss.



Day minus-2 - ventral

2 days before start MPPT

24 hours after the necrotic tip of the tail had fallen off by itself.

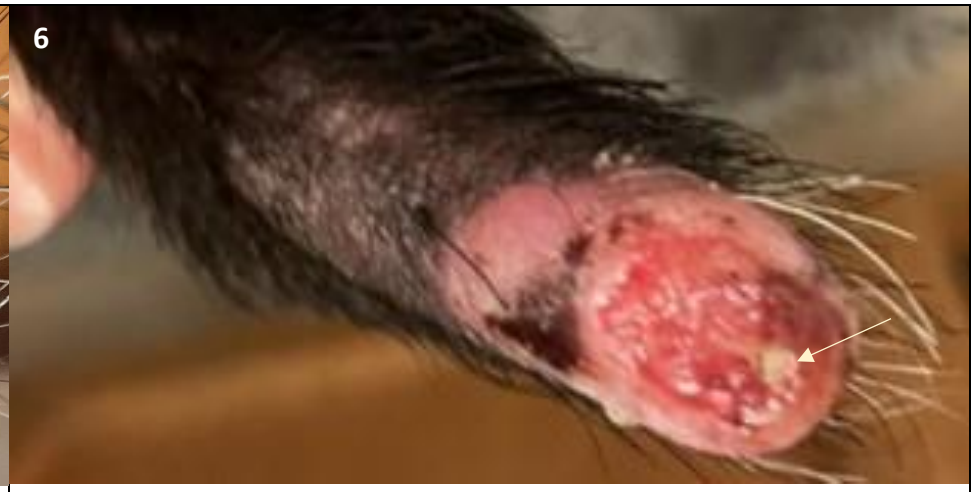
Approximately 5 mm of the tip of the bone are fully exposed and looking "dirty", but intact. Periosteum seems slightly affected but the bone is intact, and no sensitive structures inside the bone are therefore affected.

The tail is inflamed and swollen. The skin approximately 5 cm up the tail has lost its structure and is suffering hair loss involving the hair follicles.

The soft tissue is dark red and not granulating.

The wound edges are retreating.

Cream arrow: Bone extremity.



Day 1 - ventral

After 24 hours with MPPT

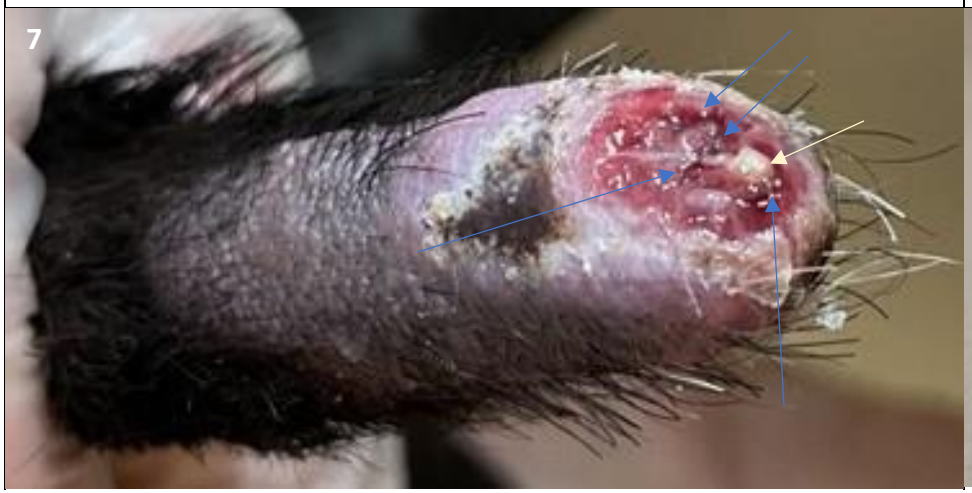
After 24 hours with MPPT.

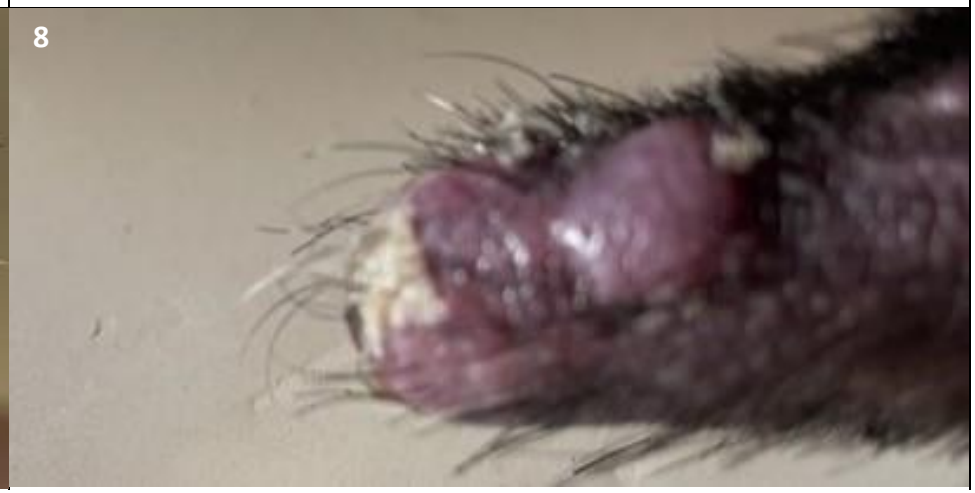
The swelling and inflammation are reducing. The affected skin is regaining its structure. The most affected part of the skin (distal-most) is epithelializing.

Pink granulation tissue is rebuilding the soft tissue around the bone, i.e. the part sticking out it considerably shorter.

The wound edges are actively epithelializing.

Cream arrow: Bone extremity.





Day 2 - ventral

Skin structure and hair follicles are recovering.

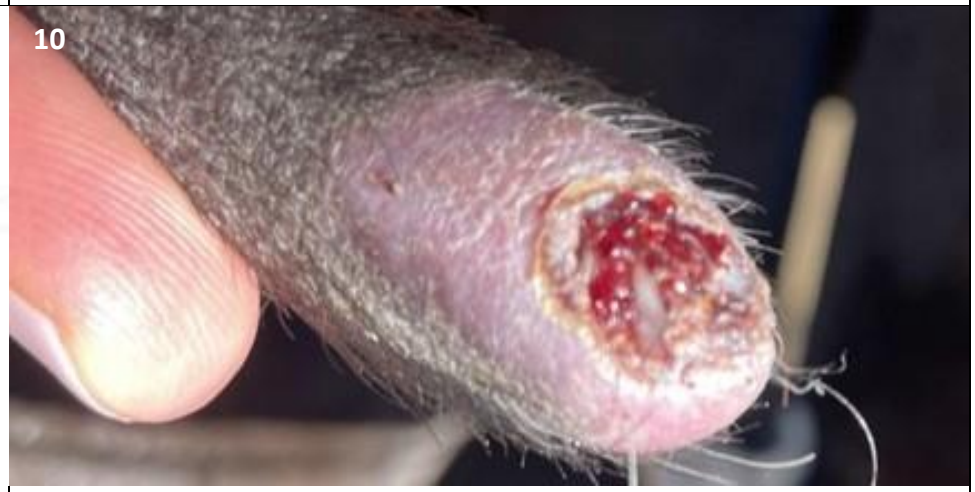
The wound is regenerating missing tissue and the size of the open wound is reducing.

Blue arrows: clusters or “vesicles” of toxins collected in the deeper tissue layers and transported to the surface of the wound waiting for the final push onto the granulating wound surface from where it can be removed.

Cream arrow: Bone extremity.

Day 2 - dorsal

The dorsal side has caught attention because it is showing a salient nodule a couple of cm further cranially from the tip than where the infection had been identified on the skin, i.e. from the outside. Such a nodule is a sign of an ongoing fight against a severe infection It implies that the infection has been spreading relatively undetected inside the soft tissue.



Day 4 - ventral

No more swelling. Hair is growing back on the intact skin that had lost the hair. The novel epithelium is maturing and gaining strength. Only the very tip of the bone is still visible. The rest is covered in new granulation tissue which again is being covered with epithelium. The thin blown film along the wound edges is protecting the epithelialisation taking place underneath it. It moves forward and leaves new epithelium in is wake ready to mature under the exposure to air.

Blue arrow: Mixture of an epithelializing brown film and a dried cluster of expelled toxins

Cream arrow: Bone extremity.

Day 5 - ventral - early in the day well before wash

Droplets of bacterial toxins being pushed through the cap of already dried out toxins and emerging on the outside where they also dry out. This is a sign that the current covering of the wound is not a healthy scab and that it needs to be removed. If the droplets are not removed, they would dry out and add thickness to the cap.

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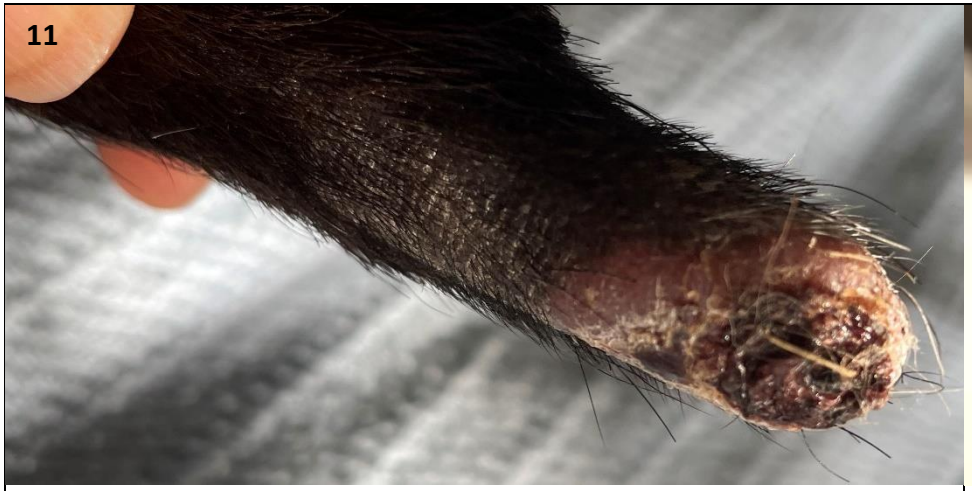

Day 5 - ventral - late in the day just before wash

Dried out toxins and other debris that has been expelled from the infected tissue onto the wound surface and has dried out forming a cap over the wound bed. This could be regarded as an “unhealthy” scab consisting of, e.g. toxins, dead tissue cells, dead immune cells and other debris. It is regarded as “unhealthy” because it covers a wound that still harbours infection and it therefore needs to be removed to make way for more debris yet to be expelled during the infection removal process.

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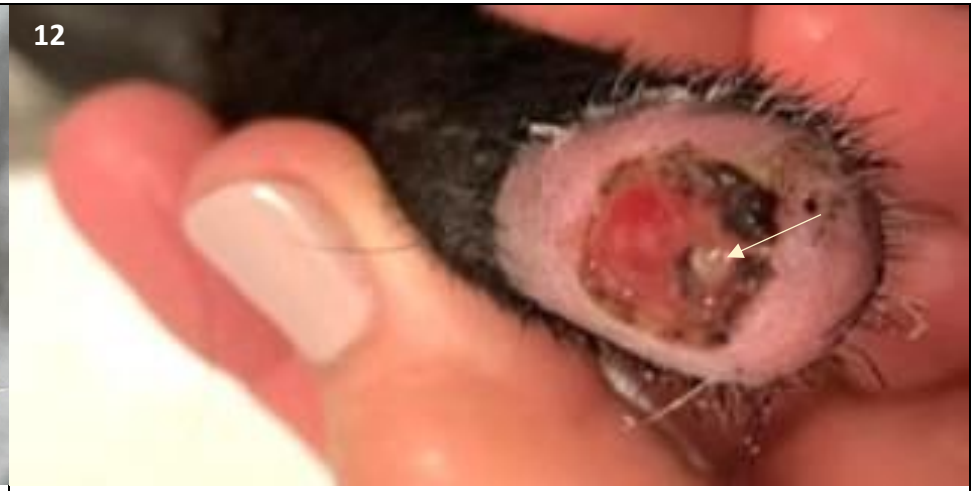

Day 5 - ventral - after wash

Scab along all edges. The epithelialisation occurs protected by this brown relatively soft film. In this case it also holds dried toxins and other types of debris. Despite this, it should not be physically removed if it does not fall off during the very thorough showering. It is important not to harm the thin brown film along the edges. At the next shower, the retained debris will have loosened enough to come off without using additional force. However, by then, new more recently pushed out debris may be stuck to the wound surface looking similar to the present situation.

Pink granulation in the wound bed. Bone still visible.

Cream arrow: Bone extremity.

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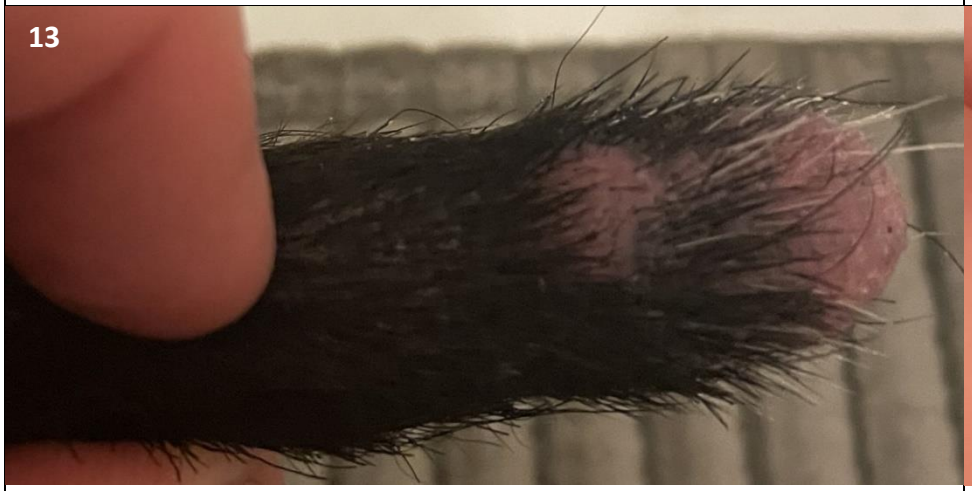

Day 8 - dorsal

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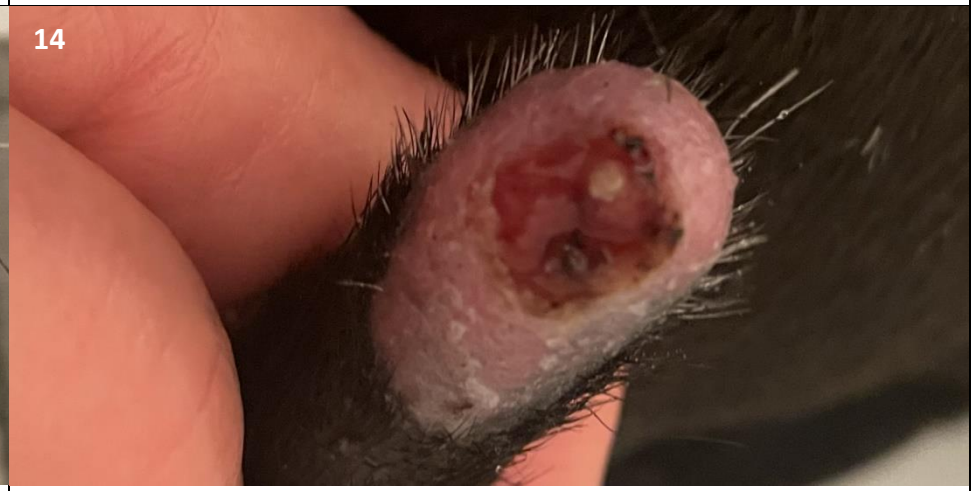
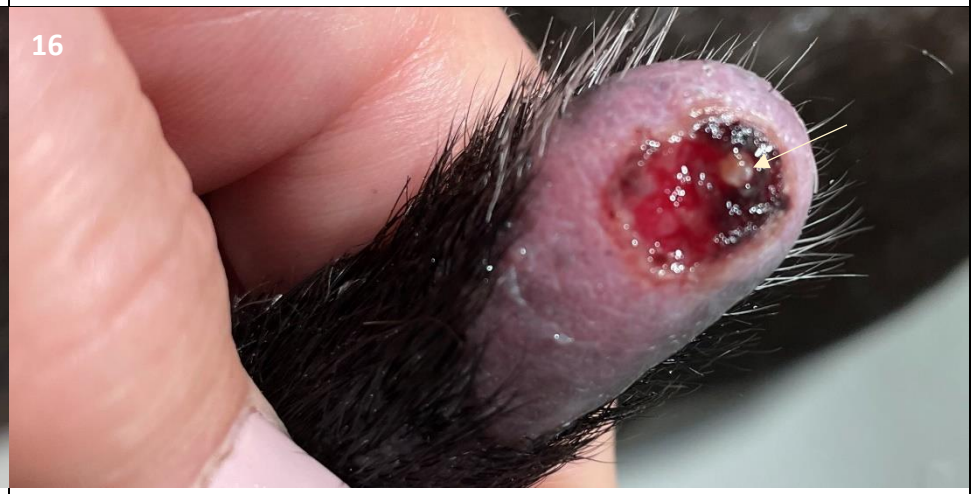


Day 8 - ventral

Please compare to pic 8. The nodule revealing dorsally the presence of the internal infection is rapidly reducing, the intact but affected skin is recovering and new hair is moving in.

The size is of the wound is reducing. The wound bed is granulating and filling in missing tissue leaving the pearly bone extremity only just visible. The wound edges are epithelializing, whilst the new skin (pink) is maturing and the damaged but intact skin is recovering (greyish).



Day 10 - ventral - after wash

red pigmented toxins looking similar to blood coming out during washing

The washing of the tail coincided in time with the definitive expulsion of red bacterial toxins from soft tissue vesicles. The toxins are moved to the wound surface in vesicle-like structures. Once there, the vesicles burst, releasing the toxins outside of the soft tissue The toxins were removed by the water looking similar to a bleeding. The release of toxins had not finished by the end of the shower, and the picture is taken directly after washing and enables the recognition of dark nodes just under the surface between the granulation tissue. The situation is similar to picture 7, but in the present picture the expulsion is actively ongoing (the vesicles have burst) whilst in pic 7 the toxins are still contained inside vesicles, probably still waiting for the final push to reach the surface and ensure their content is spilled outside the soft tissue, once they burst.

Blue arrow: Red pigmented vesicles containing the red pigmented toxins from the abscesses scattered in the soft tissue after being transported by the immune system and readied for expulsion onto the granulating wound surface.

Cream arrow: Bone extremity.

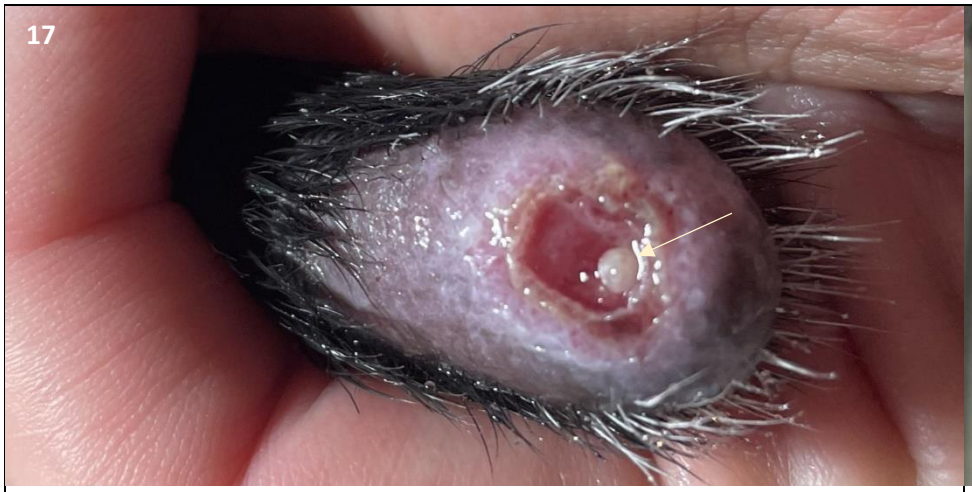
Day 11 - ventral - after wash

The expulsion from the previous day has finished, the granulation is healthy pink with no dark nodes. Brown epithelialisation protective film is present along all wound edges. Some debris containing red toxins remains attached to the wound surface and the brown scab-film distally.

The bone is pearly.

The wound size has reduced and epithelialisation is strong.

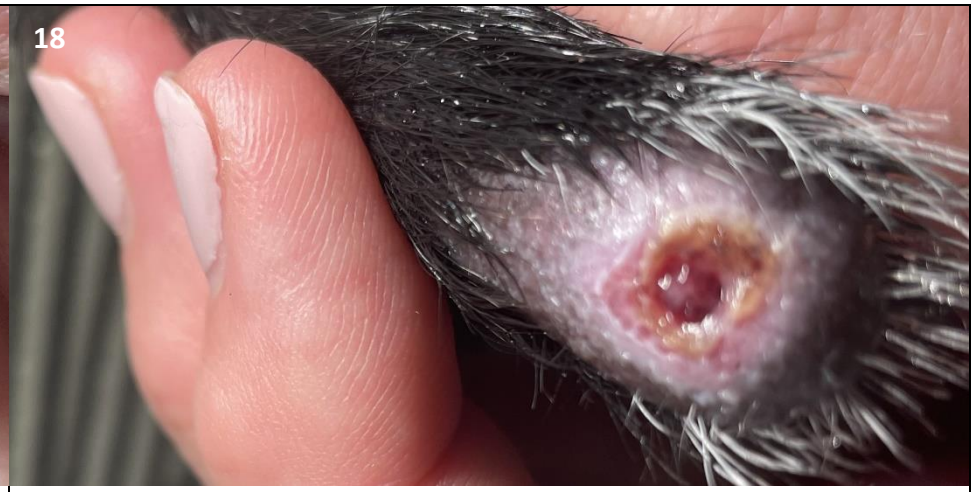
Cream arrow: Bone extremity.



Day 15 - ventral

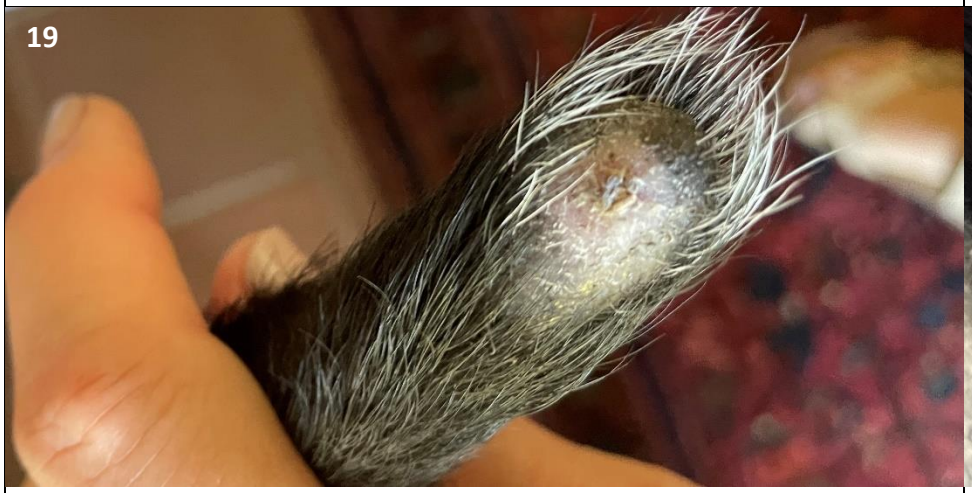
Healthy granulation and strong epithelialisation under the brownish film along the entire edge. Skin pigmentation is being restored. Pearly looking bone extremity in the final stages of repair of its periosteum.

Cream arrow: Bone extremity.



Day 19 - ventral

The wound is now free from infection and reduced to the size of the circumference of the extremity of the bone. The bone is covered with granulation tissue and readying for epithelisation. Hair growth is being restored.

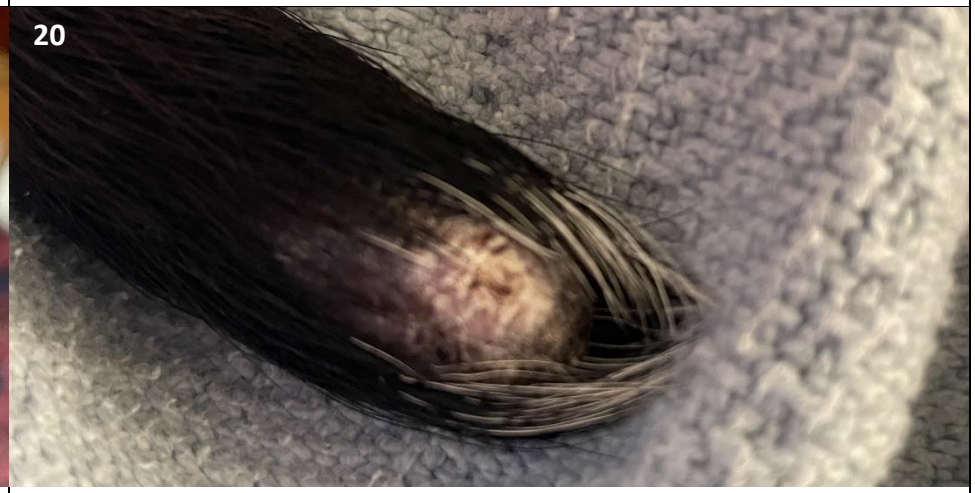


Day 28 - ventral

4 weeks after starting MPPT

Closed

Wound has been closed for 24 hours and the dog is taken to the beach for a swim.



Day 36 - ventral

The scar is 3 x ¼ mm. A 5x5 mm area of new skin around the scar is still undergoing the last phases of maturation. Such remodelling will typically continue to add strength and resilience to the tissue for months or even years.

Day 65 - ventral

Follow-up

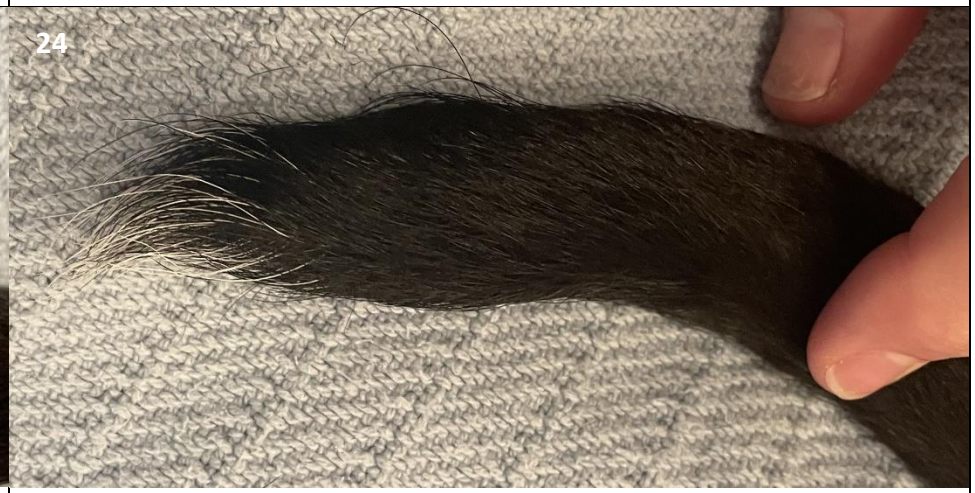
White hair on tail tip is back. Pigmentation has been re-established.

Day 65 - dorsal

Follow-up

Day 109 - ventral

Follow-up 2½ months after closure



Day 108 - dorsal

Follow-up 2½ months after closure

Fully stable closure. No concerns. Dog shows no interest in his tail and leads a life identical to before the accident.