More Soft Tissue Surgery Case Challenges for Advanced Practitioners Mini Series

Session 3: Wounds and Reconstructive Surgery

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Wound classification

There are several different ways of classifying wounds, which can help with wound management decision making, specifically whether to close wounds or whether to employ some open wound management techniques. The previously described 'golden period' of 6 hours since wounding to decide whether a wound can be closed is no longer used, as it is the degree of contamination and the cause of the wound that are more important in determining the risk of developing infection.

- Degree/type of contamination (bacterial & gross). Clean surgical wounds can be closed primarily with a low risk of infection. The risk increases with contaminated and infected wounds. Unless a wound can be converted to a clean-contaminated wound with lavage and debridement techniques it should be left open, at least for a few days. The 6-hour 'golden period' is no longer used as a criterion for wound closure, as it is the degree of contamination rather than the time since injury that is important in developing infection. Some wounds are associated with increased tissue trauma, especially crushing (e.g. bite) and burns. These cases may benefit from a period of open wound management to assess the degree of local tissue ischaemia before wound closure. In some cases ischaemia will lead to tissue necrosis after several days.
- Degree of tissue ischaemia – be aware that ischaemia can turn a closed wound into an open wound
- Concurrent injury or disease. Superficial wounds may have to be left untreated if the animal has other life-threatening injuries. The presence of fractures underlying skin wounds may influence treatment options.
- Species or breed – determines how much tissue is available for primary closure of flaps. Cats are known to have poorer healing abilities than dogs. Some breeds of dog, such as Greyhounds, Yorkshire terriers etc., have less available skin and poorer skin elasticity than other breeds, making wound closure more difficult.
- Tension on a proposed wound closure. Wounds under tension will dehisce; tension relieving techniques, flaps or graft are needed to overcome tension
- Blood supply – local blood supply to a wound may be affected by local trauma or damage to local vasculature, and further tissue loss may occur, usually over 2-3 days. Consider the location of direct cutaneous blood vessels supplying axial pattern flaps. These arteries supply an 'angiosome' or territory of skin and muscle. They should not be sacrificed during wound closure, as they may be required later for an axial pattern flap if wound healing fails.
- Proximity of local structures. Wounds adjacent to body openings e.g. the eye may require a different closure plan to avoid damage or distortion.
- Previous attempts at closure
- Which is the easiest option available or the options least likely to fail?

Case 1 – Delayed Primary Wound Closure

An otherwise healthy dog had just been presented for vaccinations. He developed an abscess over the scapula and shoulder within a week of vaccination, although a link cannot be conclusively made between the two. Appropriate treatment of the abscess, including surgical lavage and antibiotic therapy, was instituted by the referring vet. Antibiotic therapy was continued based on the bacterial culture and sensitivity of the sample taken at diagnosis. The skin overlying the abscess became necrotic and was surgically debrided.

Routine wound management was undertaken. Other webinars are available discussing management of wounds including dressings (Degloving Injury, nurses' club webinar, September 2015).

Antibiotic Use

Antibiotic therapy was continued until healthy granulation tissue had formed in the wound. A broad-spectrum bactericidal drug given orally is sufficient; there is no need to use multiple classes of drugs. There is also no need to keep culturing a wound that has healthy skin edges and where granulation tissue is forming, as this type of wound has no evidence of active infection. Infected wounds have red swollen skin edges, ongoing necrosis and no evidence of granulation tissue, which will only form when bacterial load and inflammatory mediators have reduced. Similarly it is important not to culture just because there is a lot of fluid on each dressing change – it is normal for granulation tissue to produce a lot of fluid that may be sticky and have a mild odour. The discharge seen with infection looks different, and can be assessed cytologically if necessary, and is associated with tissues looking clinically infected. The rationale for not performing repeated cultures is that the results are difficult to interpret. A granulation tissue bed will contain bacteria, in the same way that the mouth, vagina, axillae etc. contain bacteria, but they are acting as commensal bacteria. Many of them will be hospital acquired bacteria and may be multi-drug resistant, and repeated cultures and changing antibiotics is just likely to promote antibiotic resistance, both within the population of bacteria within a wound and the wider population. Therefore a healthy wound is just assessed visually if it is forming a bed of granulation tissue.

Dressings

Wet-to-dry dressings are not advocated in human wound care anymore, as they are painful to remove and may damage any granulation tissue that forms. A debriding produce that is use to clean the wound of necrotic and inflammatory tissue at dressing changes can be used as an alternative in wounds where debridement is needed (Debrisoft, http://activahealthcare.co.uk/woundcare/debrisoft).

If there is a concern for infection, a honey dressing may be of use, as honey has natural antibacterial properties, and is equally effective against antibiotic resistant bacteria. Honey must be produced from pathogen free bees to create sterile honey as normal honey may contain *Clostridial* spores. Manuka honey contains growth factors that make it more potent. The high osmotic potential debrides by drawing fluid from the wound. Honey also has anti-inflammatory properties, is anti-bacterial and promotes the formation of granulation tissue. For large wounds I find it easier to use honey impregnated dressings as the honey found in tubes is difficult to apply to large wounds and has a tendency to slide off small wounds. However I find the honey in tubes easier to use in small or awkward wounds as the honey dressings can be quite stiff – I either apply the honey into the wound directly, or onto an Allevyn dressing, which is placed onto the wound.

Decision-Making

The wound in this dog has the potential to be problematic to treat. There is no obvious axial pattern flap (APF) available to close it. The obvious APF for the thoracic limb is the thoracodorsal (TD) flap, but there is a skin wound visible over the site where the TD vessels arise from deeper muscle. The vessels can be assessed by using Doppler to listen for arterial flow in those cases where viability can't be determined. In this case, manipulation showed that the skin in the region of the TD vessels was involved in the wound, and so the vessels would have been damaged. Similarly the skin overlying the superficial cervical and lateral thoracic direct cutaneous vessels was involved in the wound and these flaps would not have been viable. Most of the axillary fold has been lost although a small portion was attached to the trunk.

Potential closure options included:

- (Delayed) primary closure of the entire wound – I did not think this was likely to be possible as manipulation of the wound suggested there would be too much tension. I will not close a wound like this unless tension can be overcome, as dehiscence is inevitable.

- (Delayed) primary closure of the cranial and caudal aspects of the wound with the centre of the wound left open initially. When the cranial and caudal aspects of the wound had healed, the centre could be closed by:
    - (Delayed) primary closure – this would be more likely to be successful if the wound is smaller as the healed part of the wound would have reduced a lot of the tension. The tension could be further reduced by undertaking skin stretching of the skin around the wound for 4-7 days prior to closure
    - A local subdermal plexus flap. Given the amount of skin loss and the location, an advancement flap is unlikely to work in this location, as a long flap is needed to close a defect by advancement given that it closes a wound by stretching the skin of the flap. An advancement flap would have to be harvested from the skin over the shoulder (given that cranial and caudal to the wound would be the skin previously closed primarily that would be scarred and non-flexible). A better technique would be a transposition flap in a location where the donor site could be closed primarily by undermining local tissues. Transposition flaps based on the subdermal plexus are generally rotated through 30-90 degrees, so the donor site is chosen by palpating local skin to find an area where skin is plentiful so that the donor sire can be closed without tension. The donor site should also be closed along lines of tension if possible and should not be affected by tension applied by movement of the thoracic limb.
    - Second intention healing +/- skin stretching
- Second intention healing remains a good option for owners where surgical closure is not an option financially. All wounds of the trunk heal eventually. Costs can be reduced by bandaging only until granulation tissue has filled the wound after which the wound can be covered in t-shirts or dog coats to prevent trauma. The granulation tissue will produce a large volume of fluid so this will be a slightly messy option that will involve lots of washing. Owners should be advised that the discharge would make a mess of carpets and furnishings. Emailed photos and wound measurements every few weeks can follow progress. Surgical intervention is required if a wound stops healing over a two-week period. It is a mistake to try to use wound dressings to encourage healing if a wound has stopped healing – no dressing product will be able to overcome the lack of skin able to stretch into a wound. This applied particularly for wounds of the limbs, especially distal limbs and joints.

As planned the cranial and caudal aspects of the wound were closed. The wound edges were undermined as much as was needed to achieve wound closure without tension. A flap of skin that was part of the axillary fold was moved cranially onto the caudal aspect of the brachium, as the greatest loss of skin, with the least skin locally for closure, was the brachium. Towel clips were used for temporary closure and to facilitate trying skin in different locations to make the best use of skin, so that as much of the defect was closed as possible, without excessive tension.

When just the centre of the wound was open, it was apparent that there was enough skin dorsally to close the defect, as there was enough laxity in the skin that it could stretch into the remaining defect with undermining. It is important not to undermine too extensively as undermined skin relies on the subdermal plexus for survival and skin necrosis can occur with excessive undermining. I try to leave direct cutaneous blood vessels that are present between underlying muscle and skin as I reach the limits of undermining to preserve some of the blood supply to the subdermal plexus, but this isn't possible at the start of undermining. However, despite undermining, the tension on the wound was unacceptable and just suturing the wound edges would have led to dehiscence. In order to reduce tension, I placed progressive rows of walking sutures between the subdermal layer of the skin and the underlying granulation tissue bed so that when the skin edges were apposed there was no tension present. Tension was assessed with the limb in different positions – it is important not to have performed this surgery with the elbow bent to bring the brachium closer to the dorsal skin edge, as tension would have been overcome in surgery but not when the dog was awake.

A drain was not considered necessary, as there was not significant dead space deep to the skin repair. A wound soaker catheter could have been considered.

Healing complications

Dehiscence of the wound became apparent caudally and cranially. It is likely that it was due to tension. Despite thinking that the initial surgery had overcome sufficient tension, tension is the most likely cause of wound dehiscence when closing large wounds primarily. There was no evidence clinically that dehiscence was secondary to infection, although dehisced wounds can subsequently become infected. The caudal wound was not closed as the tension could not be overcome, and given the intact suture lines cranial and caudal to it, it was left to heal by second intention. Similarly the cranial aspect of the wound had started to dehisce where two suture lines met, a common site of weakness. This was also left to heal by second intention. Initially the wound over the brachium remained intact and so no further intervention was necessary.

When the brachial incision started to dehisce, surgical intervention was required. As soon as wound edges that are under tension start to separate, it is likely that complete dehiscence will occur as healing cannot occur when skin edges are not touching, unless there is skin contact with an underlying granulation tissue bed. In this location, the brachial skin was slightly elevated from the granulation tissue bed due to the anatomy of the limb so second intention healing would not occur. Catastrophic dehiscence would likely have occurred if the wound was left. The photos taken as the wound was prepared for surgery showed the amount of skin edge separation when loose sutures had been removed. The skin edges were resutured as the walking sutures appeared to be intact. As the skin closing the defect had been stretched for a number of days, in fact it had lengthened, so that the second surgery to close the defect actually had minimal tension on the wound edges. This phenomenon where skin stretches when tension is applied to it is the mainstay of second intention healing and is utilised during skin stretching techniques.

A small area of dehiscence again occurred in the cranial wound at the junction of two suture lines, but both this and the caudal wound healed by second intention in the time it took for the brachial wound to heal.

Case 2-5 – A series of skin grafts

In most cases a full thickness lightly meshed graft is used as it resists trauma, results in full hair coverage and has no scarring on the graft. Where large areas need to be grafted and there is insufficient skin available, a fully meshed graft is chosen. Graft survival is 90-100%. Indications include distal limb wounds or areas where contracture deformities may occur with other closure techniques. The recipient site must be healthy - drainage of fluid from an unhealthy wound bed can build up under the graft and prevent graft adherence.

Where grafts will take:

- Healthy granulation tissue
- Surgical excision sites
- Recent clean avulsion/ abrasion wounds
- Slightly contaminated wounds that can be surgically debrided to convert them into a clean wound just before placing graft

What not to graft:

- Proximal limbs - there is too much movement for the graft to take easily, and local and axial pattern flaps are available that are more suitable
- Exposed bone, cartilage, tendon, nerve without connective tissue
- Infected, severely contaminated or crushed tissue
- Chronic or hypertrophic granulation tissue

- Chronic ulcers
- Tissue with poor vascularity e.g. irradiated tissue, avascular fat

Performing a skin graft:

- Make a template of the wound
- Choose skin on the lateral thorax or abdomen that is easy to reach, check there is enough skin for closure.
- Place the template on the donor site, and make sure the hair growth on the donor site is in the same direction as hair growth should be on limbs.
- Incise the graft outline in the skin, starting on one edge
- Place stay sutures or skin hooks on the edges of wound as you go round to avoid damage from repetitive handling with thumb forceps
- Use a scalpel blade to remove a full thickness layer of skin, leaving superficial fascia and fat behind. This technique is useful as you can tent the skin up and remove the subcutaneous tissue while the skin is under tension. Alternatively remove the tissue using thumb forceps and fine scissors. The graft should look very thin and hair follicles should be easily visible.
- Use a no. 11 blade to cut rows of meshes. If covering a small area cut small holes and only spread the graft out enough to conform well and drain. If there is a large deficit to cover, make the holes closer together and open the mesh wider.
- Place the graft onto the recipient bed, with the hair in the correct orientation. Allow meshes to open up to conform to awkward contours and open enough for drainage.
- Suture the graft directly to the wound edges if you have removed the epithelium from the edge of the recipient bed, *or* suture to healthy skin 3-4mm away from the wound edge so the graft and wound edge are overlapping.
- Place some sutures between skin at the edge of a meshed slit and the underlying granulation tissue, especially where the wound is irregular, but don't fill the majority of them
- The graft should be under similar tension to that found in normal skin in that area.
- Close the donor wound
- Cover the graft with a sterile non-adherent dressing e.g. Mepotil or Jelonet and bandage.
- Immobilize the graft for 10-14 days with a dressing alone or a splint. External skeletal fixation can be used to immobilize joints especially in animal being treated for shearing injuries. Keep the animal in hospital until the graft has taken.
- Change the first dressing under heavy sedation or GA after 2 days, then every 2-3 days. Take care when removing dressings if the dressing is adhered to the graft.

Successful take:

- Graft is initially pale
- 1st 48h graft is oedematous and cyanotic (accumulation of fluid & haemoglobin)
- Colour - light red d 3-4, red d 7-8, normal colour by day 14

Graft failure:

- Stays pale - avascular necrosis
- Black - dry ischaemic necrosis

Case 2 was a wound of the medial distal brachium and proximal half of the antebrachium. Granulation was very slow to appear in this wound. It is likely due to the underlying aetiology of the wound – the histology of the ischaemic skin was consistent with a necrotizing inflammation with a marked bacterial infection. This type of wound is likely to have high numbers of bacterial toxins and inflammatory mediators, which must all be removed as part of the healing process before granulation tissue can form. Granulation tissue formation is a skin that infection and inflammation are under control. It is difficult to predict how long it will take for a wound to be ready for grafting or other closure techniques.

The location of the wound made healing options difficult. Second intention healing can occur with wounds that consist of half to a third of limb circumference, the amount reflecting the inherent skin elasticity of the individual animal. However it is slow on the limbs, may be incomplete and may cause contracture over a joint. Surgical closure, if successful, will be much quicker and have a better functional and cosmetic outcome. There is no axial pattern flap that can reach the antebrachium of dogs – the thoracodorsal flap at best reaches the elbow in dogs, although the distance it can reach to will vary depending on the length of the dog's scapula relative to the length of its brachium. In Labradors, it can typically only reach the elbow. Furthermore, increased length would be needed for this flap to reach the medial limb. Similarly the axillary fold isn't big enough to reach the antebrachium and a brachial APF would not have been long enough. A local subdermal plexus flap would be difficult to elevate into this location.

Skin grafting can be applied to any location on the limb. However the more proximal the wound, the more difficult it is to control movement of the graft on the granulation tissue bed. Movement is one of the most likely reasons for graft failure, as long as the graft has been harvested correctly. A bandage must be applied to both the limb and the trunk to try to reduce the bandage slipping at the elbow.

For surgery to the limb, where access around the limb is needed, a hanging leg preparation is required. The video shows a useful way to use a conforming dressing to make a hook to hang the leg from a drip stand. The hook can be cut after the surgeon has taken the leg and started to wrap it is a sterile cover, thus avoiding the difficulty of trying to undo a dangling piece of rope or bandage. It is easiest to clip the hair between the donor site and the wound to make draping easier. For a medial wound, the donor site will be on the contralateral body wall to make access to both possible at surgery.

Skin grafts must be covered with a non-adherent dressing e.g. silicone or paraffin impregnated gauze. Some authors recommend changing the dressing after a few days. In our practice we wait approximately four days as changing the dressing will apply some tension to the wound bed and may interfere with healing. There is likely to be nothing that can be done to help a failing flap if it is assessed earlier, assuming that there will be no fluid accumulation. I place mesh holes in all grafts, regardless of whether they are needed for conforming the graft to the wound bed or to allow more wound to be covered, specifically so that fluid doesn't accumulate and lift the graft from the wound.

At the first dressing change it was easy to see the graft was failing but the extent wasn't apparent. At four days, the graft shouldn't have been lifting off the wound bed as the dressing was removed, and this was an early indication that the graft would not look good. There were some areas of graft that were an acceptable colour and others that were 'melting' with necrosis. Unless a graft has completely come away in all places, it is redressed. Obviously necrotic tissue is removed and the wound lavaged to remove inflammatory mediators. It is surprising how often parts of a graft that look very unhealthy (assuming they are not obviously necrotic and not attached to the wound) can survive completely or have dermal survival so that they re-epithelialise from deeper structures. Therefore a graft is not abandoned for a few weeks. Similarly a repeat procedure is not performed until the granulation tissue bed has

been assessed to see if any islands of dermal tissue from the graft have started to produce islands of epithelium. In this case there was minimal graft survival but given that the wound was then left to heal by second intention, the islands will have helped with this process.

This case highlights the importance of warning owners that, despite the quoted 90-100% graft take in the literature, catastrophic failure can occur and the procedure may need to be performed or another option considered.

Case 3 was a similar wound, of longer length. Greyhounds and Lurchers etc. have very fine skin that is easy to harvest, but the difficultly lies in trying to close a donor site. There is very little spare skin over the body wall, and it has very little elasticity/ ability to stretch after undermining, and as the majority of the body wall in these breeds is over the ribs, trying to close a donor site is very difficult. One option is to take a long thin graft, so that there is only a narrow defect to close, and to mesh it extensively so that it can cover a larger area. In the extreme form of this technique ('pie-crusting') the skin covers a much smaller area of the wound than the area of the meshes, and the mesh holes will each heal by second intention when the graft has taken. The option I used in this dog was to take the graft from the lateral neck, as there was considerable more skin, it was less skin, and it is easier to close a defect here than over the ribs. If I had been nervous about the graft failing I could have taken a smaller graft and meshed it more extensively, thus having the option of leaving enough neck skin in case another graft was needed.

The dog's thoracic girdle and neck were raised on sand bags so that the neck did not touch the table. Trying to undermine skin that an animal is laying on is difficult, so this technique makes donor site closure easier.

At first dressing change the graft is healthy in the middle third, and this took completely. The proximal third has many red areas when the wound bed is visible, and note that this is the same location where failure occurred on the previous dog – it is likely to have been due to excessive movement of the graft against the wound bed under the dressing. As wound-healing progresses it is apparent that some of the proximal graft that seemed to have died and was not apparent initially at follow up, had in fact just had epithelial death, as an island of skin is visible in later photos. This island made second intention healing quicker.

Case 4 had suffered skin necrosis after extravasation of a chemotherapy drug. Although unproven, we have found that graft take seems to be reduced over these wounds even in the presence of a bed of granulation tissue. There was a strip of skin that I didn't remove, as every piece of skin is precious and is preserved to see if it can be used to close a wound. The wound had already had complete failure of a meshed graft I had applied. The graft had had no take at all and become completely necrotic, which is an uncommon finding, and made me concerned that the same would happen with another graft. I therefore used punch grafts, harvested from the trunk with a biopsy punch and then the subcutaneous fat was removed. This is a laborious process and for a wound this size took just as long as preparing a sheet graft, so it is not a timesaving technique. I use a smaller biopsy punch to remove pieces of granulation tissue in rows from the wound bed, and this is done prior to harvesting grafts to allow time for the granulation to stop bleeding. Failing to do so would mean that blood developing between the wound and the graft might lead to the graft either being washed out or not being able to adhere to the wound bed and undergo plasmatic imbibition etc. The advantages of this technique are that the graft sits within the granulation tissue and is less likely to move around and it can be used in difficult areas e.g. over calcaneus. I tend to use it when a mesh graft has had partial failure in an area where I don't think second intention will work, and in these dogs I will sedate them to harvest a few punch grafts, which I put in granulation tissue. In the latter, I allow animals to go home with their bandages, whereas I hospitalise animals with large punch grafts or any sheet graft.

Case 5 shows that antebrachial wounds will close by second intention. In this case, there was clearly not enough skin for primary closure but the skin can stretch to close a wound. I was not certain that the dog would have enough skin elasticity for complete closure, but punch grafts would have been a viable alternative for any residual deficit. Second intention healing in this scenario is performed when an owner cant afford grafting or is not prepared to consent to a procure that is not guaranteed.

Case 6 – A Chronic Pad Wound

This dog had cut his pad on a walk. Initial wound management revealed stones within the wound. Despite suturing on several occasions, and numerous bandages, the wound dehisced. Despite almost healing by second intention on one occasion, the wound recurred. Whilst pad wounds can be difficult to heal, a simple laceration should heal after suturing or by second intention as long as the dog is well rested.

Differentials I considered were:

- Foreign body
- If sutured - excessive tension on wound closure
- Weight bearing pressure
- Infection – bacterial, fungal
- Neoplasia

This dog was bandaged well and there was good owner compliance, and the wound had not been under tension when sutured. Given that there had been stones present at the time of the wound, this was the most likely differential. Fortunately it was a simple diagnosis as stones show up on radiography and this would have been a useful technique to employ at the time of initial presentation. CT is used commonly now for foreign bodies of the distal limb, but is most useful when wounds are swollen or actively discharging, as changes are more likely to be apparent than when a wound is quiescent. However, as with radiography, it is almost impossible to identify small organic foreign material with CT. The presence of fluid around a foreign body makes it easier to spot on ultrasound, which is the modality I am more likely to use if I think a foreign body is present in the foot, although I will often combine it with CT which can help in working out where the pocket of fluid sits in relation to other tissues. If I can't find a foreign body seen on ultrasound, which may occur with small thorns etc., intraoperative ultrasound (with the ultrasound in a sterile probe) can be useful to help locate it.

Given how long the dog had had a pad wound, I placed the foot in a carpal flexion bandage to prevent walking on the repair.

Skin Flaps

Understanding how to calculate the size of a flap for a given defect can be difficult. The BSAVA manual has some step-by-step drawings to illustrate the principles. However, skin elasticity will also be important as a given flap in a basset will stretch further than in a greyhound. It is also important to check that the donor site will close, as APFs based on the guidelines in textbooks will not close in all breeds e.g. the TD APF in a greyhound. Similarly a flap will be shorter in some breeds based on their anatomy and may not reach the donor site even if the textbook suggests it will work.

Case 7 - Local Subdermal Plexus Flap

The subdermal plexus is the deepest part of the cutaneous vascular system, and supplies the skin over it by dividing into the middle and superficial plexuses. It is supplied by direct cutaneous arteries e.g. thoracodorsal artery. All vessels approach and travel parallel to skin. The subdermal plexus lies in the panniculus muscle where it is present i.e. cutaneous trunci in trunk, platysma in neck and must be preserved when creating flaps. There is no panniculus muscle in the limbs. Undermining should occur in the fascial layer under the panniculus muscle or if there is no panniculus muscle then undermine below the dermis or fascia. Poor surgical technique may cause necrosis due to loss of the blood supply.

This dog had a low-grade soft tissue sarcoma. Initial case management had included biopsy for grading, thoracic CT for staging and head CT for surgical planning. Given it was a low-grade sarcoma, where recurrence after marginal excision occurs in 10-30% cases, the

original surgery was a marginal excision to avoid resection of the eye/part of the skull. Adjunctive metronomic chemotherapy was given. The mass was slow to recur, the dog remained well, and no evidence of metastasis was seen. Whilst doubtful that radiation could be offered after another marginal resection, due to proximity of the eye, it is important to seek advice from a radiation oncologist. It is difficult to see scars from previous surgery, and they must be included in a radiation field, so I often draw them on when sending a photo for advice, so that it can be seen clearly. Similarly it is useful to draw round a mass, as the extent can be hard to appreciate in photos. The location precluded radiation therapy, and the radiation oncologist did not want to irradiate after a flap, so the only treatment available was wide surgical resection. Adjunctive metronomic chemotherapy was stopped, as it had not been effective at preventing recurrence.

I sedated the dog in order to plan options for resection and closure. There are no clear guidelines for the amount of tissue to resect, as different sarcomas need different margins to achieve cure, and nobody has found a way to determine this prior to surgery. I did not consider a 1-cm margin to be sufficient given that a large surgery would be undertaken for a relatively small margin, and I felt the risk of recurrence would be too high to justify the morbidity. A 3-cm margin would have reduced the risk of recurrence but the morbidity would have been much higher, with loss of the other eye. Therefore I selected a 2cm margin. This was drawn on the dog (using a white board marked as it can be washed off with spirit afterwards) along with bony landmarks on the contralateral side of the dog, to determine the extent of bony resection needed. The dog's previous CT was used to guide decision-making as I could see where his bony structures were in relation to his mass.

My options for closure were:

- Caudal auricular APF. This flap has been successfully used in dogs for wounds of this location (see BSAVA manual). Measurement of the flap based on the bony landmarks and measurement of the base of the flap to the tip of the defect suggested it would be long enough, but it didn't leave much redundancy for turning the flap through 180 degrees. Failure of this flap would have precluded use of a transposition flap if it had failed, as a bridging incision would be needed across a potential transposition flap site. The length of flap needed would have used the full length of flap described and as the distal half of the flap relies on retrograde flow through the superficial cervical vessels, I had some concerns about failure. Furthermore the flap width would have been hard to close.
- Transposition flap from the lateral neck. The advantage over the caudal auricular APF was that this could be raised locally so the donor defect would have been smaller, and there was more available skin on the caudal head/cranial neck for wound closure. To raise a flap of sufficient length would have led to the flap being on the ventral neck.
- Both of these options were viable and would have been useful if a large defect had been left laterally, but I anticipated that resection of the lateral scar would leave a defect small enough to be closed primarily. Therefore a smaller defect would be needed and a better option might exist to close it (see advancement flap, below). Furthermore, using either of the two lateral flaps would have meant raising large flaps for the size of the defect, as a large area would have to be bridge before the main defect was reached.
- Advancement flap from the neck. There is usually such an abundance of skin on the neck, which is also usually thick and robust, that it is my primary option for closing defects of the dorsal head, forehead or eye area. It would have been difficult to use though if the lateral part of the wound had not been closed.

As with the skin graft case, the dog's trunk and head are elevated on sand bags to allow skin to be moved round. The dog was prepared for surgery of the face as well as preparing skin dorsally and laterally for any of the three closure options to be used depending on intraoperative measurements taken and the size of the defect. The mass, scar and margins were drawn with a ruler, as skin recoils when incised, leading to inaccuracy of measurements if performed after surgery starts. The ear canal and caudal auricular blood vessels were also marked on the skin prior to surgery, in case skin moved from over bony landmarks.

The mass was removed without deviating from the 2cm margins, and the deep margin included the eye and the bone of the frontal sinus and caudal nasal cavity. This was removed with an oscillating saw deep to the skin margin.

The lateral wound closed easily with undermining so an advancement flap was used. It is apparent from the photos that there was more than enough skin available to stretch into the defect. Diverging incisions were made caudally, deep to the panniculus muscle, until the wound could be closed without tension. Unusually there was little dead space under the flap so I didn't use an active suction drain as I normally do. However I placed a wound soaker catheter for local anaesthetic administration.

Despite the rather gruesome appearance, dogs will be comfortable after surgery if appropriate analgesia is given. It is useful to show owners photos of other dogs before they have surgery so they know what to expect, as the clipping and long suture lines can be traumatic to owners. A photo shown to them before they see the dog can be helpful, and is especially useful to email to owners with children, so they are not traumatised by what they see. It is useful to ask owners to send photos in every few days to assess healing – it takes much less time than regular checks and is less stressful for all concerned, and it will make it more likely that early problems will be identified. Obviously a few check-ups in person in the healing process are still required.