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Getting it Together - Wound Management and Closure in Dogs and Cats Mini Series

Session 2: Surgical Wound Closure - Making the Most of Available Skin

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Surgical Wound Closure: *First principles*

Closure of a wound using a surgical technique is usually the quickest and often the most cost effective method in achieving resolution of an open wound for our patients. Reconstruction of large skin and deeper tissue deficits is obviously a key skill in surgical oncology. In these situations having a choice of a number of options of closure and utilising multiple techniques with confidence is essential in achieving successful results.

For all surgical techniques, but in particular in relation to closure of skin wounds, an appropriate surgical technique is essential. The basic principles of surgery were summed up by Halsted in the 19th century.

Halsted's Principles of Surgery

Strict asepsis

Gentle tissue handling

Accurate hemostasis

Maintenance of adequate blood supply

Careful approximation of tissues

Avoidance of tension in tissues

Obliteration of dead space

Tissue handling and instrumentation:

Avoid the use of large rat-toothed forceps as these can cause considerable trauma to wound edges, especially if repeatedly used for assessing wound approximation. I prefer use of either an Adson or Adson-Brown thumb forceps or a Debakey forceps. Better still, if repeated manipulation of a skin flap will be required use either a pointed reduction forceps or place stay sutures. Correct application of the scalpel blade in a perpendicular manner to the skin surface is important to avoid partial thickness ragged incisions which will promote more inflammation. Careful blunt dissection with a blunt tipped Metzenbaum scissors or Mosquito haemostats is used to undermine skin or dissect between fascial layers.

Other equipment required are a marker pen and ruler to measure margins. Intermittent lavage of large flaps or placing saline soaked sponges over them is necessary to prevent dessication. Copious lavage of the wound site prior to closure is also advised to remove any residual debris. Electrosurgical coagulation is very useful for larger procedures to speed up operating time and prevent haematoma formation. It is important to avoid excessive use especially in areas that may be under tension or with reduced vascularity as it will cause considerably more inflammation.

Suture material

As previously discussed the initial strength of a wound is due to the fibrin clot and therefore minimal. Until days 7-14 when collagen is deposited into the wound, the sutures must support the wound. Therefore correct suture selection and avoiding prolongation of the inflammatory phase so that wound healing occurs rapidly is critical.

All suture materials act as a foreign body within the wound, which will therefore tend to slow wound healing. Therefore use of a suture material must be advantageous to the wound and exceed any deleterious side effects associated with it. There is now no place for the older natural suture materials such as catgut that elicit a strong inflammatory reaction within the wound. These suture materials breakdown due to this inflammatory reaction which makes them also unreliable within the wound. The modern absorbable synthetic suture materials are absorbable by hydrolysis and elicit a minimal inflammatory reaction within the wound. The degree of suture reaction elicited is proportional to the amount of suture within the wound. The amount of suture depends on the diameter of the suture and the suture pattern used with much more suture present for interrupted compared to continuous techniques.

Suture selection is generally based on surgeon preference and experience. However use of monofilament sutures is advisable for most wounds as there is less tissue drag (and therefore less trauma) and allow less bacterial adherence. This later point is especially important in contaminated wounds. I prefer not to use multifilament suture material for skin suturing as it generally elicits much more inflammation. For skin suturing I prefer to use either monofilament nylon or polypropylene, generally size 2 to 3 metric (3/0 – 2/0 USP). I use the larger size for only large/giant dogs.

For the subcutaneous tissues, sutures need to be absorbable and either monofilament or multifilament synthetic absorbable sutures can be used, although multifilament is avoided with any contamination. My preference is for a monofilament in all cases and I generally use either polydioxanone (PDS, Ethilon) or glycomer 631 (Biosyn, Covidien), although if there will be minimal tension present and rapid healing anticipated then poligecaprone (Monocryl, Ethilon) or Caprosyn (Covidien) are alternatives. These can be especially useful in cats as they subjectively appear to cause less reaction. For most fascial planes my suture preference is for one of the longer acting absorbable monofilaments, such as polydioxanone (PDS, Ethilon) or polyglyconate (Maxon, Covidien). The size of suture depends on the tissue but is generally 2metric (3/0 USP) for the subcutaneous tissue and size 2 to 3.5 metric (3/0 – 0 USP) for the fascia depending on the tension and size of animal.

Suture handling

- Handle the suture carefully
- Never clamp the suture material with the instrument as this significantly weakens it
- Be sure to place square knots with appropriate numbers of throws for the tissue involved
- Poorly placed knots are one of the most frequent causes of suture slippage
- Place the suture an adequate distance from the wound edge – for traumatised skin the 5mm skin margin will have increased collagenase activity and subsequently can lead to suture pull out
- Try to ensure that the tension of the wound is taken by the deeper subcutaneous tissues and not by the skin to reduce the risk of dehiscence
- Swaged needles create less trauma and are easier to handle. Selecting a more curved needle for deeper layers aids closure. Straight or slightly curved needles are appropriate for the skin

Assessment and Planning

Surgical planning, whether for an open wound or for tumour removal, requires an accurate estimation of the tissue deficit that needs to be closed. Various options for closure of the wound are then assessed and ranked according to the likelihood of the most rapid closure and return to function for the patient. This is then balanced against surgeon experience, patient management and client acceptability. The closure options available will depend on the region where the wound is and the availability of local skin. It is very common to utilise a combination of techniques especially for large reconstructions. Therefore a thorough knowledge of the available closure options is essential.

The surrounding skin is manipulated to determine its local tension and availability. This allows assessment of whether the wound can be closed by mobilisation of the local skin or if more distant flaps will be required. This step is initially performed with the animal conscious and in various normal positions. When under anaesthesia I repeat this before the hair is clipped to assess the cosmetic effect. I then repeat it after the clip to ensure that sufficient hair has been clipped. After position in surgery I repeat the 'scrunch' to ensure the area is sufficiently draped and that the patient position is ideal. I scrunch again after I have drawn the required margin around the tumour to ensure that with this margin closure can be achieved. After tumour removal the wound edges will retract and the defect will look considerably bigger. Scrunching now may be more difficult but should be possible (manipulate the skin with stay sutures attached to the edges). If I have been satisfied up to now I can be reasonably confident that local closure will be possible.

The same process is undertaken if skin is to be taken from another site (as with transposition flaps and axial pattern flaps) to assess the ability to close this donor site can be made.

When preparing the site I will generally clip wide enough so that I have at least two options for closure possible, especially with more challenging reconstructions. As a default I will always clip and prepare more skin than obviously necessary. Obviously owners need to be warned of this prior to surgery.

Surgical Drains

Obliteration of dead space is one of the key principles of successful surgery. Dead space will inevitably fill with exudates from the wound and if this continues to collect can lead to a separation of fascial planes. Apposition of the tissue layers is prevented and this will at least delay healing but can lead to wound dehiscence. In the presence of bacterial contamination, infection of the dead space will lead to abscessation.

Most open wounds will be able to drain through the wound by gravity, although if there is a ventral pocket additional drainage may be required. For closed wounds, drains are needed to control the dead space by removing any exudates that collect in the area.

Dead space can be controlled by careful layered closure of deeper wounds with interrupted sutures or continuous suture lines. However to remove the exudate that will collect in the remaining dead space, wound drainage is required. If closure of dead space is not possible due to important local structures drainage will definitely be closed. Use of pressure bandages can also be used to close dead space/restrict movement.

Wound drains are classified as passive, active or sump.

Passive: Passive drainage is performed using radioopaque latex Penrose drains. These are available in different widths but the basic principle is that there will be gravity dependent flow of fluid over the surface of the drain. Therefore it is obvious that Penrose drains must exit at a site ventral to the area to be drained. The drain is usually anchored in a dorsal position with a single skin suture that goes through the skin, tacks the drain and exits out through the skin. There is no advantage to having a separate dorsal hole through which the drain enters. It is best not to place the drain directly below the closed wound incision. It is also very important not to exit drain through the closed wound incision as this will delay healing, but to exit it through a separate ventral exit site. At this position the drain is anchored to the skin with a single suture.

The disadvantage of Penrose drains is that they are often unable to adequately drain large areas, however in this case multiple drains may be placed with a layered closure. Passive drains are also messy and the exit site must be covered to collect the exudates and to prevent introduction of bacteria. This bandage will need to be changed regularly to assess the level and type of fluid production.

The resolution of dead space can be slow with Penrose drains and it can be difficult to decide when to remove them, as assessment of the rate of fluid production is tricky. Penrose drains are usually maintained for 3-5 days or when the production is minimal. Drains will elicit some fluid production themselves, therefore once fluid production appears to tail off and stabilise, removal should be appropriate.

Active: Active or closed suction drains have **considerable advantage** over passive drains. They rapidly eliminate dead space, leading to a good approximation of underlying tissues and thereby a quicker cessation of drainage. They are less messy as the fluid is collected in the vacuum container, which also allows calculation of fluid production. This is very useful in determining the progression of

the dead space obliteration. They do not require bulky bandaging over the wound site but instead can be secured with stockinette or ties. These drains are placed into the dead space and are then exited (usually with a swaged-on needle with commercial drains) at a site distant from the wound. They do not rely on gravity. Active suction drains are dependent on creating a vacuum within the dead space, therefore it is essential that the primary wound has been completely closed. Obviously they cannot be used in combination with passive drains and if primary wound dehiscence does occur then the drain will become ineffective. The disadvantage is that they are more expensive; although the reduced bandaging and hospitalisation required will usually offset this. Drains are produced by many companies, with my preference for the less bulky vacuum containers that can be easily removed, emptied and replaced. Homemade drains can also be made using butterfly catheters and vacutainers.

Managing Skin Tension

There are many strategies to manage skin tension that can be utilised during surgery. However the key to consistent successful management is the anticipation of tension during the initial surgical planning stages (see *scrunching* earlier). Anticipated tension can then be managed using a combination of techniques before, during and after surgery.

Preoperative techniques

Assessment of tension lines: tension lines have been mapped in the dog and cat and can be useful when planning excisions and closures. In general the length of the incision is made parallel to these lines, otherwise there is a greater tendency for the wound to widen. However there can be considerable variability between breeds and the maps are somewhat inaccurate, particularly on the limbs. This can confuse planning and closure. An easy way to assess the direction of the tension lines following a tumour excision is to examine the shape a circular wound assumes. An initial circular wound will be stretched into an elliptical shape, whose long axis is parallel to the tension lines. This ellipse can then be lengthened (to prevent dog ears) and closed.

> Always start with a CIRCULAR incision when excising skin masses (which are mostly circular) rather than an elliptical incision. Tension lines mean that most circular defects change into an elliptical shape. This means that only enough skin as necessary is removed

Presurgical skin-stretching: skin is a viscoelastic tissue and the application of a stretching force over time allows the skin to extend beyond its inherent elasticity. The most commonly used technique is **pre-suturing** of skin, a technique used exclusively in the distal limbs for smaller skin deficits. Tension vertical mattress sutures are placed across the elective surgical site to stretch the skin on opposite sides. Sutures are placed under local anaesthesia, sedation or short GA 24 hours prior to intended surgery. The bites are placed about 3-5cm from the edges of the intended excision margins. A number of sutures are placed along the length of the wound and the sutures when tied place the surrounding skin under tension. For large defects, in particular on the trunk, **skin stretchers** (as

described by Dr. Pavletic) can be utilised. These are made of adhesive Velcro® pads that are glued (with tissue glue) to the surrounding skin. Velcro tape is then attached and stretched between the pads across the elective surgical site. These can be adjusted 3-4 times a day to keep the skin under continuous tension to increase recruitment of local skin. These are kept in place for 1-4 days (with the greatest gains at 3-4 days) and may also be used postoperatively to reduce incisional tension. The disadvantage is that they may be difficult to maintain in position, especially in the boisterous animal.
These techniques can be useful to recruit some additional skin, but in my experience the amounts recruited can be disappointing. The surgeon should not over-rely on these techniques especially in areas of high tension and should consider if any alternate strategies would be better suited to straightforward closure.

Patient position: correct patient positioning is essential when planning surgery. Releasing skin that is trapped under the recumbent animal may mobilise more skin and should be routinely performed prior to the final prep and draping. Placing pads under the animal may help to mobilise skin, for example pads under the dependent scapula and pelvis for large lateral flank wounds. Positioning the limbs in normal anatomical positions is particularly important when working in the inguinal or ventral pelvic positions to aid wound closure (for example bilateral caudal mastectomies).

Operative techniques

Intraoperative skin stretching and strategic subcutaneous suture placement:

The inherent elastic recoil of the skin can be overcome intra-operatively by stretching skin towards a wound to be covered and holding it in place with tacking sutures or towel clamps. Even after only 5-10 minutes the skin will start to relax, reducing tension at the wound edge. These techniques are very useful not only to achieve some short term stretching but also can be useful in order to work out the best way to close a wound, or to make suturing easier.
Tension should be predominantly taken by the deeper subcutaneous sutures to avoid excessive amounts at the wound edge. Strategically placing interrupted deep subcut buried sutures helps to stretch skin, but is also aimed at taking and spreading tension along the wound. Ideally once the subcutaneous sutures have been placed there is minimal tension at the dermis/epidermal (skin surface) level, with the external skin sutures just placing the wound edges in gentle apposition rather than taking tension themselves. If this cannot be achieved then wound dehiscence is more likely.
Further skin stretching will also occur over the hours and days following surgery, and it is common to find that a tightly sutured wound is more relaxed by the following day. Care and experience is necessary to determine how much tension is acceptable, as excessive tension leads to skin necrosis, suture failure and/or dehiscence.

Key point:

The aim of local wound closure is to take and spread the tension in the deeper layers of the wound, so that the skin sutures just place the less robust superficial skin edges in gentle apposition. Strategic deep suture placement is necessary.

Undermining skin:

Correctly undermining skin is a useful surgical skill in releasing tension and mobilising skin. Knowledge of the vascular anatomy of the skin is essential. If present, the panniculus muscle must be preserved when undermining skin. This is because the major blood supply to the overlying skin (the deep subdermal plexus) is intimately associated with it. Where there is no panniculus muscle (middle and distal limbs), the deep subdermal plexus is associated with the subcutaneous fat on the deep face of the dermis. Skin should therefore be undermined below this layer. This may mean undermining below the outer muscle fascia if the skin is very closely associated with it.

Using an atraumatic surgical technique such as careful blunt dissection helps to minimise damage to the subdermal plexus. Knowledge of the position of the direct cutaneous vessels should avoid damage to them when dissecting. Use careful blunt dissection with a blunt tipped Metzenbaum scissors or Mosquito haemostats (preferable near vascular pedicles to avoid disastrous consequences) to undermine skin or dissect between fascial layers.

For skin that is firmly adhered to an underlying granulation tissue bed when closing open wounds, use of a scalpel blade is best to release the edges (for the first 1-2cm). ***However*** remember that if the wound has contracted by some degree already, detachment of the skin from the granulation bed will lead to elastic recoil of the skin edges and suddenly the surgeon is faced with a much larger open wound then otherwise anticipated! Therefore for larger wounds in areas of higher tension, local closure may not be possible and consideration of an alternate strategy (local flap, axial pattern flap, graft, on-going open wound closure etc) should be strongly considered.

Wherever possible, preserve small feeder vessels encountered during dissection.

The risks in undermining are vascular compromise and creating excessive dead space.

Surgeon Beware!

Care is needed to avoid over-reliance on undermining to achieve closure and it may be better to consider alternate closure strategies if this will be the primary method of overcoming local tension. The combination of excessive undermining (having a devascularisng effect on the wound edge), increased dead space and high tension often leads to dehiscence.

Walking sutures:

These are used to move skin across a defect, to obliterate dead space and to distribute tension across a wound. The sutures are placed by taking a bite of the undermined skin followed by a bite of the underlying fascia or connective tissue but at a point 2-3 cm closer to the middle of the wound. By staggering rows of these sutures on either side of the wound, the skin is advanced towards its centre. as the sutures are tied. This technique can be used to a stage where the wound edges are near to apposition and can be closed. Absorbable sutures of 2 metric (3/0 USP) are used for these sutures and they are spaced at least 2-3 cm apart. The skin overlying these sutures is usually dimpled but this will resolve as the suture is absorbed. Placement of these sutures is commenced at the deepest portions, and it is useful to preplace all the sutures in a row before tying.

Care is needed to avoid direct cutaneous vessels. Remaining dead space will still need to be controlled using drains or bandages. A possible complication is the formation of multiple seromas that do not communicate.

Walking sutures are very useful in distributing tension across a wound surface to reduce tension on the primary suture line. They can also be used to close dead space, but do not replace the provision of adequate drainage for most cases.

Use of skin suturing tension-relieving patterns:

The ideal situation is that the skin edges are under a minimal amount of tension and that the skin sutures are only required to keep the skin edges in apposition, to allow rapid epithelialisation. Tension relieving skin suture patterns are not to be relied upon as a sole source of tension relief and for larger wounds this is a sure route to dehiscence. The skin edges are generally unable to withstand significant tension as this leads to vascular compromise and necrosis of the skin edges. However certain suture patterns can be useful in relieving minor tension or intermittent tension.

Simple interrupted sutures are easy to place and commonly used but are more time consuming to place. My personal preference for nearly all wounds is interrupted cruciate sutures using 3/0 swaged-on monofilament polypropylene or nylon (I use 2/0 for large dogs or on the thicker dorsal skin). Compared to simple interrupted they provide a stronger closure, resist tension, prevent eversion and are quicker to place. If small gaps are present or very accurate placement is required I will use occasional simple interrupted sutures. Skin staples can be very useful for rapid placement, but are only suitable if there is no tension and are placed in relatively thin skin. They can easily pull out or devitalise the skin edge if the vascularity of the skin is reduced or there is increased tension.

Vertical and horizontal mattress suture patterns are placed away from the wound edges. Stents of tubing or buttons can be used to prevent suture cut through or impairment of skin circulation. Close daily inspection for evidence of skin necrosis is necessary. The horizontal mattress suture is more likely to cause a zone of vascular compromise compared to the vertical mattress and is probably best avoided. Vertical mattress as well as far-near-near-far and far-far-near-near suture patterns are placed perpendicular to the wound and therefore cause less vascular compromise.

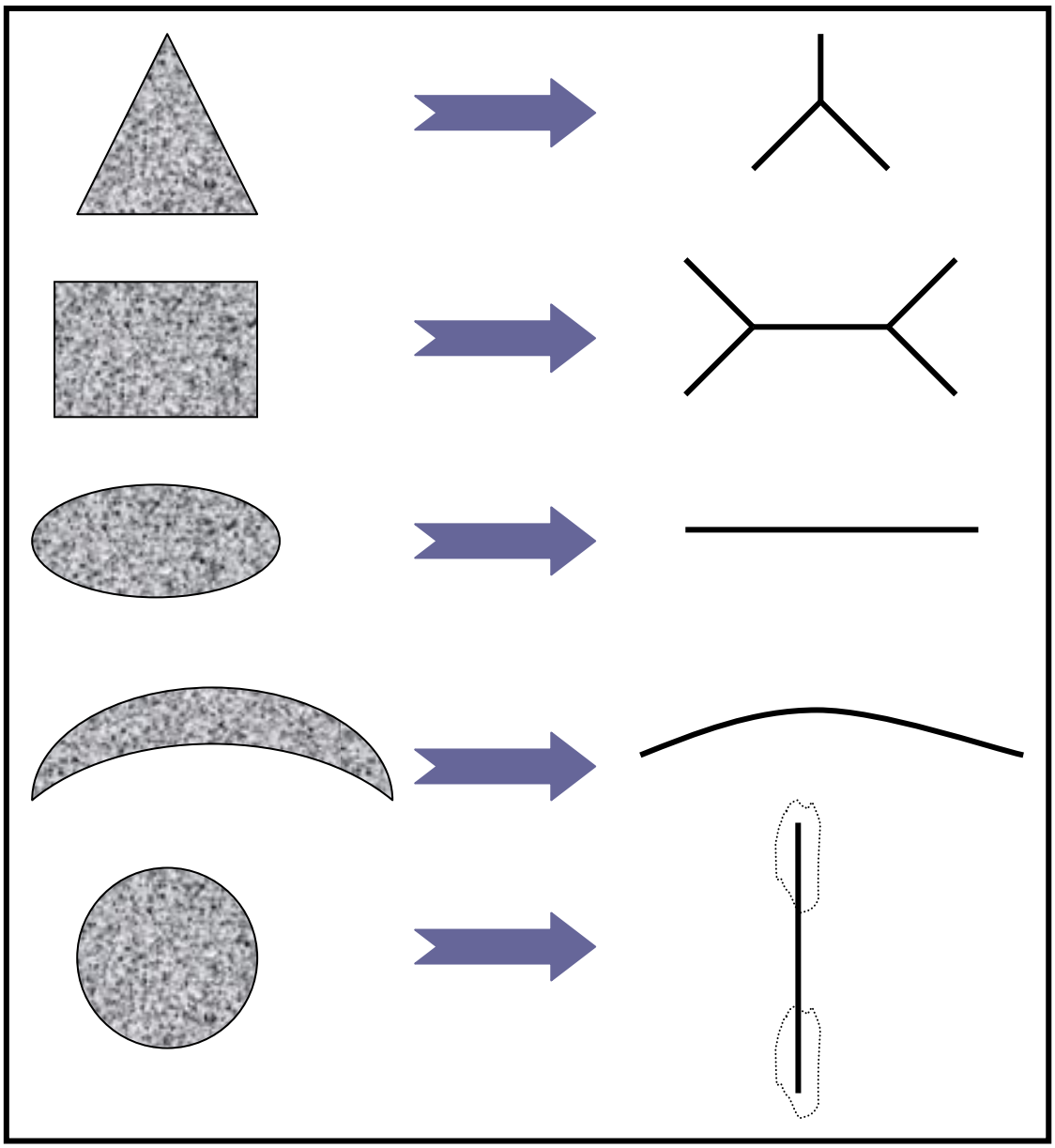
Intradermal suture patterns allow excellent apposition and cosmesis, but are not advisable if there is considerable tension as they will increase the vascular compromise at the skin edge.

Geometric patterns for closure:

Particular geometric patterns can be utilised to close certain wounds shapes. These closure patterns can be useful in areas where there is limited local skin, however as they rely on the elasticity of local skin there can be considerable tension, particularly at points of intersection of multiple suture lines (with X and Y configurations). These are common points of wound dehiscence. It is generally preferable to close wounds in a linear or curvilinear fashion when possible. With circular and elliptical defects, sutures are placed to halve the defect to achieve good apposition along the length of the incision. Dog ears can occur at the incision ends of circular and elliptical defects, but careful suturing

or excision of small amounts of skin will achieve a cosmetic closure. A length to width ratio of 4:1 has been advised to avoid dog ears at the ends of incisions, but this leads to excessive skin excision, especially for excision of skin tumours, and is rarely necessary.

See the following diagrams for examples.

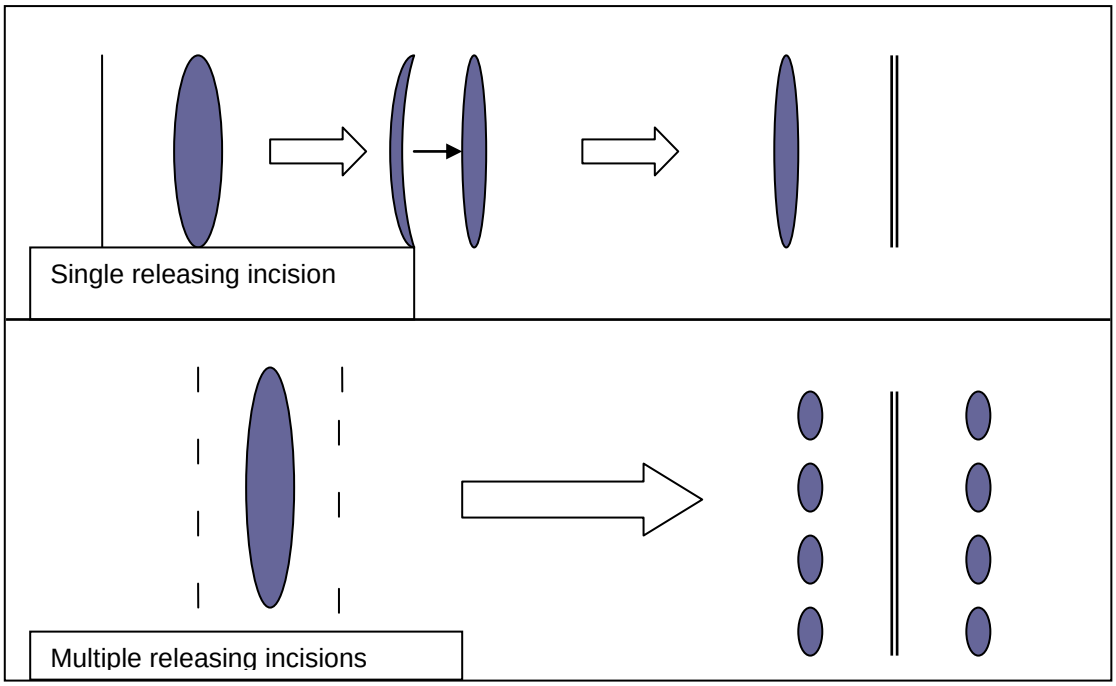


Releasing incisions:

Single – *by* making an incision parallel to the wound on one side, the intervening skin can be undermined and slid across to close the primary incision. This technique is useful in areas where the original wound is over key structures such as tendons, nerves, vessels or bone (especially used following plating of the distal limb), whereas the releasing incision in a less critical position. A single releasing incision is made approximately 3 to 10cm from the wound depending on the size of the wound, intended position of the releasing incision and the regional skin laxity. Blood supply to the intervening skin is from either end (this is also called a bipedicle flap). The releasing incision is left to

heal by second intention (this will probably take 4-6 weeks) or can be closed primarily if there is sufficient adjacent skin.

Multiple – rows of multiple incisions can be made on either side of a wound (in particular when reconstructing defects on the distal limb) to aid closure. The incisions are at least 1cm from the wounds, are approximately 1cm long and at least 1cm apart. A further row of incisions can be made 1-2 cm from the initial row. Only enough incisions are made to release the tension on wound, which is usually held near to apposition when making the incisions. If this technique is used for defects of 25% of the circumference of the limb then, the cosmetic appearance is good whereas if the defect is 33% then cosmesis is poor. The main concern with this technique is that there can be some significant compromise to the vascularity of the skin, especially if this is an area under tension. A long single releasing incision should provide better tension relief compared to multiple rows of small incisions, although the surgeon should consider alternate strategies for closure prior to embarking on this closure option.



V-Y plasty: this technique is simple to execute and can be used to relieve minor tension in certain areas such as the eyelids. Closing the distal portion of the V as the Y, pushes a small triangle of skin forward along the line of the Y.

Local flaps

(Sub-dermal plexus flaps)

Pedicle grafts are partially detached segments of skin and subcutaneous tissue that receives its vascular supply from the pedicle (base) of the flap. If this type of flap is elevated adjacent to the wound then it is termed a local flap. These are also termed deep subdermal plexus flaps as they depend on an intact deep subdermal plexus entering the flap for survival. These flaps can be developed if a wound is located adjacent to an area of loose elastic skin that can be mobilised. It is important to remember that this may lead to a deficit at the donor site that needs to be closed. As these flaps are dependent on the subdermal plexus, they are generally not applicable to very large deficits. With all these flaps great care is needed in handling to minimise damage to the vascular supply. If the flap is adjacent to direct cutaneous vessels, they can be include in the base of the flap or alternatively an axial pattern flap can be utilised.

Gentle tissue handling, careful undermining and management of tension are essential to maximise the success of local flaps

Advancement flaps

- These are local flaps that are elevated and advanced forwards over the defect.
- They are developed parallel to lines of least resistance – assessment and scrunching around the circumference of the wound identifies the best orientation of the flap.
- The flap width is determined by the width of the defect. The flap is developed using two diverging incisions.
- The flap is undermined and advanced into the defect.
- There are no rules regarding appropriate width:length ratios as regional vascularity varies. However it is advisable to have a flap with a base slightly wider than its body.

Surgeon Beware!

Although easy to create, advancement flaps have significant limitations as they rely on **stretching** the skin to close the defect. The wound closure will therefore have some tension due to the elastic retractive force of the stretched flap. This increases the risk of wound dehiscence of the distant suture line.

When planning any advancement of skin into a flap it is important to think carefully about where the tension-free or loose skin around a wound lies. Always identify this clearly first and then think about how this can be mobilised into position, possibly using local flap technique. Think about the wound requirements rather than trying to make the wound fit the planned flap.

- Avoid long narrow flaps as the end is more likely to undergo ischaemic necrosis.
- The sutures along the sides of the advancement flap should therefore be placed first with the aim of taking most of the tension off the distant suture line.

- Instead of a single large advancement flap, develop advancement flaps on either side of a wound and close in a H formation.

Rotation flaps

- This is a semicircular flap that rotates into the adjacent wound. Again this flap relies on stretching of the undermined skin but in a semicircular manner.
- Traditionally this flap has been described with an arc of rotation four times the length required to rotate the flap into the defect. This however would be rarely unnecessary in dogs and cats and the flap is developed in a stepwise manner until it can close the wound.
- In my experience these flaps are infrequently indicated in their full extent, but limited incisions to rotate skin in to close defects especially in areas adjacent to loose skin such as around the face or inguinal skin fold can be useful.

Transposition flaps

- These are very useful local flaps as they supply additional new loose skin into the wound. They do require more detailed planning and assessment prior to use and a donor wound is created that needs to be closed.
- These flaps are developed from loose skin that is within 45 to 90 degrees of the wound deficit. The long axis of the flap is developed parallel to tension lines, as this makes closure of the donor wound more straightforward
- The width of the flap corresponds to the width of the defect adjacent to the proposed flap. The pivot point of the flap is identified and a measurement is made from this point to the farthest position of the defect. This distance will be equal to the distance from the pivot point to the farthest point of the flap. Once elevated the flap will be rotated through an arc into the defect.
- As the arc of rotation of the flap increases the length of the transposition flap decreases and a dog ear can develop at the base – this does not need to be corrected but will usually settle with time.
- This is a very versatile flap that can be used in numerous locations on the body. On the distal limb the flap is created parallel to the long axis of the limb.

Principles of Surgical Oncology

Treatment of the cancer patient requires an informed decision on the part of the owner and the veterinarian. Questions that may be helpful include identity of the cancer, expected biological behaviour of the tumour (benign vs malignant, local invasion vs metastass and expected sites of metastasis), options for treatment (surgical vs medical), welfare of the patient before, during and after treatment, prognosis with, and without, treatments and cost of treatment.

Assessing the mass

The following observations should be recorded about a mass:

- Location – ideally use a body map to record the location
- Description of the mass – appearance, attachment to skin, muscle etc. diffuse vs circumscribed
- Size of the mass – measure with callipers

The identity of the mass should then be elucidated.

All suspicious dermal and subcutaneous masses identified at routine examination (e.g. routine health check) should ideally be subjected to a fine needle aspiration

Cytologic evaluation of the mass

Cells can be collected from tumours by a variety of techniques:

- *Fine needle aspiration (FNA)*
    - Diagnostic cytology is easy, quick and cheap and can be used to obtain information about a wide variety of masses and body fluids. Superficial masses can be easily immobilised and are readily sampled. Deeper masses within the body cavity may be aspirated under ultrasound guidance.
    - Multiple samples are taken from the mass at different sites if possible. In larger masses try to avoid sampling only the centre of the mass as the centre is often necrotic and therefore not representative of the mass.
- *Impression smears from surface of tumour*
- *Tissue scrapings from surface of tumour*

Biopsy

Cytology does not reveal architectural information about a tissue. In addition, certain neoplasms may not exfoliate sufficient cells for a cytologic diagnosis or cytologic examination may provide insufficient information to make an accurate diagnosis. Histopathologic examination is necessary for assessment of tissue architecture and may be used to establish the tumour grade (eg for mast cell tumours) which may affect prognosis and, consequently, the treatment.

There are a variety of techniques for collection of tumour samples for histopathology:

- Needle biopsy (e.g. Tru-cut and Jamshidi)
- Biopsy forceps used for sampling tumours during endoscopy
- Incisional biopsy (including skin-punch biopsy)
- Excisional biopsy

Needle biopsy is a very commonly used biopsy technique, which is especially useful for biopsy of abdominal organs (liver, spleen and kidney) with ultrasound guidance. It is a straight-forward and quick method of getting a sample, but has the disadvantage that the sample size is small. This can be

a problem if the sample collected is not representative of the tumour (for example, an area of haemorrhage or necrosis) and is non-diagnostic.
Biopsy forceps are crocodile jaw type 'grab' forceps that are used to take samples from the mucosal surface of the respiratory, gastrointestinal and urinary tracts generally using endoscopy for guidance.

Incisional biopsy is generally applied to tumours which can be approached for direct visualisation but which are too large to be easily or completely removed, particularly where the histopathology may alter the treatment plan, for example tumours on distal limbs.
A wedge or a core is taken from the tumour in an area that could later be completely excised. The section should be large enough and deep enough to obtain a representative sample and ideally should contain a junction between normal and abnormal tissue. Avoid biopsy of an area that contains only ulcerated or inflamed tissue as this may provide a non-representative sample. Incisional biopsy is usually easily performed under sedation/local or short GA.

Incisional biopsy is an oft neglected technique but is very useful with tumours that might require major surgical intervention. The information provided may strongly influence the planned surgery, especially as the 'the first time to cut is the best time to cure'. Newer histopathological techniques and grading systems of certain tumours are starting to significantly affect the approach to surgical management as we start to understand better the biological behaviour of certain tumours

Excisional biopsy is suitable for small or easily removed tumours (for example dermal tumours on the trunk). Diagnosis and treatment are therefore performed concurrently. Preoperative assessment of the tumour via cytology is preferable to ensure adequate margins are obtained to maximise probability of a cure. As the subsequent scar may be larger than the original mass, it is important that consideration is given to the complexity involved if subsequent scar excision if tumour remains is then necessary.

Surgical Treatment of Cancer

Despite the advances in chemotherapy and other treatment modalities, surgery continues to be the most effective option for the management of cancer. Clinical cures are more commonly attained by surgical extirpation of localised disease than with any other treatment modality, however ***'the first time to cut is the best time to cure'*** and subsequent surgeries following an incomplete resection are more likely to be associated with tumour recurrence. However, this needs to be balanced by the principle of ***"first do no harm"*** as excessive morbidity or complications of surgery could adversely affect the welfare and quality of life of the patient. Every patient and their tumour therefore needs to carefully assessed and treated individually.
Before the tumour is removed, the surgeon must consider the 'dose' of surgical intervention required, i.e. is local excision sufficient or is enbloc or compartmental excision necessary.

Preoperative assessment must include assessment of the patient for concurrent disease. Some tumours can cause specific clinical disease (paraneoplastic disease) that can complicate case management. If the tumour is considered malignant, accurate staging of the tumour is essential to provide an accurate prognosis. This requires examination of local and regional lymph nodes and determination of distant metastasis via a combination of imaging modalities.

Surgical management of cancer should ideally be performed with curative intent.
Important features of oncologic surgery include:

- Minimal and gentle handling of neoplastic tissue to avoid exfoliation of tumour cells during the surgery
- Irrigate the wound with sterile saline following extirpation to remove any exfoliated cells
- If the tumour has been biopsied remove the biopsy tract
- Handle and cut through normal tissue not the tumour.
- Ligate the venous drainage for large encapsulated tumours early in the procedure to avoid haematogenous spread of large tumour emboli.
    - *This is open to question as it this will lead to a blood engorged mass until the arterial supply is ligated. The risk of embolisation with initial arterial ligation is probably small as once ligated, the venous system rapidly collapses. It is more important to handle a very vascular encapsulated tumour carefully to reduce the risk of embolisation.*
- Be careful with closure techniques and drain placements to reduce the possibility of spreading tumour cells to more distant locations or complicating repeat surgery or adjunctive treatment (such as radiotherapy).
- Submit the excised tissue for histopathological confirmation and margin assessment. This is very important as histopathology of excised tumours may identify differences compared to preoperative biopsies. Speak to your histopatholgists to determine how best to submit samples for this assessment or to help better identification of margins (such as dyeing wound edges).

Local excision

The surgical dissection plane is directly onto the tumour capsule and the mass is ‘shelled out’ from the surrounding tissue. This is the least invasive and easiest method, however as microscopic disease will remain within the tumour bed, local excision must be confined to beingn tumours with negligible risk of recurrence and is **contraindicated *in all malignant and invasive benign tumours***. Tumours amenable to local excision include lipoma, histiocytoma and certain adenomas, for example perianal adenoma.

Wide, local excision

For benign tumours that do not have a distinct capsule, excision of the tumour together with a margin of tissue is indicated. Gross tumour should not be observed within the dissection plane at any time. The margin of normal tissue required varies with the tumour type, grade and local invasiveness. A margin of 2 cm is often quoted, but a wider margin may be required with high grade malignancies to

ensure the removal of all microscopic disease and similarly a smaller margin may be appropriate depending on the tumour location – individual assessment is required. ***The tissue margin must extend in three dimensions all around the mass***. Often the deep margin is neglected. As tumours rarely cross fascial planes, the deep dissection can terminate one fascial plane beyond the tumour.

Adipose tissue is not considered a fascial plane.

For dermal tumours, the panniculus muscle provides an effective fascial plane in most instances; for subcutaneous tumours excision of aponeurosis, fascia or deeper muscle may be required

Compartmental resection

Tumours with aggressive invasion into local tissue or that have arisen from anatomical structures (such as muscle) may require resection of the complete anatomical structure. This requires careful preoperative planning with advanced imaging (CT or MRI) to determine the extent of the tumour and subsequent excision required as well as ensuring that reconstruction of the resulting deficit can be achieved

Cytoreductive surgery

If surgical resection alone is unable to achieve complete removal of the tumour burden, cancer therapy can be achieved with surgery in combination with radiotherapy and / or chemotherapy. This situation may occur where the tumour location precludes compartmental resection without compromise of essential organs, or where the tumour is aggressive with extensive local invasion and / or distant metastasis.

Radiotherapy is excellent for treating microscopic disease within the tumour bed, such as neoplastic cells remaining following local excision of a pseudocapsule.

Chemotherapy is usually given systemically and is directed at metastatic and residual disease, however some intralesional treatments have been used to provide local control of disease. Chemotherapy and radiotherapy provide superior results to surgical treatment alone only in cases where microscopic disease remains. Consideration of the use of combined radiotherapy / chemotherapy with surgery should be made either preoperatively or in the immediate post-operative period – eg following incomplete margins reported histopathologically. If treatment is delayed until the onset of macroscopic disease then the window of opportunity for treatment has been lost.

Palliative Surgery

In tumours with a hopeless prognosis, usually because of a tendency to metastasise early in their clinical course, aggressive management of the primary tumour is pointless as the animal will ultimately die from diffuse neoplasia.

Palliative removal of the tumour burden can be considered where this will restore or maintain quality of life for the animal until euthanasia becomes inevitable. Examples of this include amputation of a primary bone tumour which is causing pain or lameness, removal of a large ulcerated mammary carcinoma causing systemic illness, hemi-mandibulectomy for an aggressive oral tumour, splenectomy for a haemorrhaging haemangiosarcoma and partial pancreatectomy for an insulinoma.