WOUND CLOSURE TECHNIQUES FOR THE FRONT LIMB, NECK AND TRUNK AND HIND LIMB

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Anatomy

The companion animal skin consists of two main layers. The general composition of the outer layer, the epidermis, is of avascular keratinised stratified squamous epithelium. The thicker vascular dermis lies underneath the epidermis and consists of tough fibroelastic tissue with a supportive and nourishing function. The dermis rests on a layer of loose connective tissue known as the subcutis or hypodermis, composed of adipose tissue, the cutaneous trunci muscle (where present) and direct cutaneous arteries and veins. This layer is particularly abundant in most dogs and cats, but the quantity and elasticity of skin differs from breed to breed and on the physical condition of the animal. Variations in structure are present at different sites of the body surface. For instance the nose and footpads have a thick protective keratin layer while the skin between the hind legs is fairly thin and sparsely haired. In addition, in most skin areas specialized epithelial appendages exist such as hair follicles and sebaceous glands.

Blood supply

In dogs and cats, direct cutaneous arteries are responsible for supplying large areas of skin. They run parallel to the skin in the hypodermis and arise from perforator arteries. Musculocutaneous arteries branch off the perforator arteries and supply small portions of the skin and run perpendicular to the surface of the skin.

The subdermal plexus in dogs and cats is of major importance in companion animal reconstructive skin surgery and should always be preserved when undermining skin for local flaps, especially when no direct superficial arteries can be incorporated in the proposed flap. Axial pattern flaps are flaps based on such direct cutaneous arteries and veins that supply a specific region of dermal tissue. Since the terminal braches of these vessels supply the subdermal plexus, axial pattern flaps have better perfusion than local flaps and are widely used in veterinary reconstructive surgery.

Skin tension

Tension on the wound edges is the most common reason for skin reconstructions to fail and occurs when insufficient skin is available to close the initial defect. Closing wounds under tension, particularly on extremities, may create vascular and lymphatic compromise to distal areas or reduce perfusion to wound edges causing delayed healing or wound dehiscence. The elasticity of the canine and feline skin is primarily the result of the lack of firm attachment of the subcutis to the bone, muscle and fascia. The skin is loose and abundant on most parts of the body, particularly on the neck and trunk, but is less pliable on the limbs, tail and head, especially around the bridge of the nose, nasal planum and medial canthi. This is the result of linear alignment of fibrous tissues within the skin in this area. The skin tension lines have fixed directions on the topographical anatomy of the dog. In breeds with abundant skin, like the Shar Pei, tension lines are of less importance when dealing with reconstructive surgery.

The tension lines of the head and neck region resemble the orientation of the underlying muscles. The tension lines of the trunk are perpendicular to the body

axis and the tension lines of the dorsal thoraco-abdominal region are parallel to the body axis. The tension lines of the limbs are generally parallel to the long axis of the limb on the cranial surface, but perpendicular to the long axis of the limb on the lateral and caudal surfaces.
Generally speaking, incisions should always be made parallel to tension lines to minimize wound tension during closure. Incisions that are made in an angle or perpendicular to these lines may result in wound deformation, wound dehiscence and necrosis. If this is impossible, methods to reduce skin tension should be employed upon closure. These include, from simple to more advanced, undermining the wound edges, selecting tension-relieving suture patterns, using tension-releasing incisions or skin stretching and tissue expansion techniques. If these methods do not allow primary closure of the wound, secondary intention healing or reconstruction with skin flaps or grafts have to be considered.

Reconstruction of the neck and trunk
Reconstruction of skin defects in the neck or trunk area is usually relatively easy in dogs and cats, because of their considerable amount of loose skin in this area. In most cases defects can be closed using local skin flaps. However, after radical resection of tumors, for closure of large traumatic wounds, or for reconstruction in areas with compromised blood supply, other techniques have to be used. In addition, reconstruction of the caudal part of the trunk and in particular of the perineal area, is more challenging because of less available skin.
The axial pattern flaps that can be used for the reconstruction of large defects in the neck or trunk area are the omocervical, thoracodorsal, and the cranial and caudal superficial epigastric flaps.
The muscle and myocutanous flaps that can be used for reconstruction of the neck and trunk in dogs and cats include the external abdominal oblique and tensor fascia lata muscle flaps and the cutaneous trunci and latissimus dorsi myocutaneous flaps.
Reconstruction of surgical wounds in the perineal region is challenging, since local skin is not applicable for local flaps because of a high risk of necrosis. However, an axial pattern tail flap, based on the lateral caudal arteries can be used to close rather large caudodorsal trunk and perineal defects. The scrotum flap, used as a subdermal plexus flap, can also be used to close defects in the perineal area. Finally, excessive skin folds around the vulva require episioplasty or vulvoplasty in case of perivulvular dermatitis, but excessive skin here can also be used to close adjacent defects.

Reconstruction of the front limb
Reconstruction of skin defects of the front limb can be complicated because of the lack of loose skin and the fact that most axial pattern flaps will not be able to reach the distal part of the limb. In small lesions, defects can be closed using local skin flaps. However, after radical resective surgery of tumors, for closure of large traumatic wounds, or for reconstruction in areas with compromised blood supply, other techniques have to be used.
The axial pattern flaps that can be used for the reconstruction of large defects in the front limb include the omocervical, thoracodorsal, the cranial superficial epigastric, lateral thoracic and brachial axial pattern flaps. Both the peninsular and island variety of the brachial axial pattern flap can be used.
The forelimb fold transposition flap technique utilizes the thin elastic skin fold of the forelimbs and is a skin-fold advancement flap, not an axial pattern flap. Because of the sheer size of the flap, minor vessels run within the flap and even

the lateral thoracic artery might be included. It is a versatile flap than can be used for defects of the upper arm or sternal region.
From the thoracolumbar region two large myocutaneous flaps can be created to close defects of the forelimb, the cutaneous trunci and latissimus dorsi myocutaneous flaps. Both flaps, but especially the thinner more mobile cutaneous trunci flap, can be used to cover defects near the elbow joint. Since they originate from the trunk and are used to close defects of the trunk as well.
The flexor carpi ulnaris muscle flap can be used in case of chronic recurrent problems when other techniques have failed or in cases with large defects of the antebrachium where skin and subcutis are lost and bone is visible. This muscle flap is more likely to stay attached and remain in place on a bony surface than skin flaps and.
Reconstruction of defects of the underfoot are especially challenging. Many new techniques have been developed to close these defects with better outcome than the local flaps, including fusion podoplasty, segmental pad transfer and phalangeal (toe) fillet flap. The toe fillet technique is specially worth mentioning because of it versatility and excellent results. Either the digit 1 or 2 and 5 can be used for this technique. Last but not least, mesh grafting is often used for distal limb lesions, especially in cats, when no local tissue is available at all.

Reconstruction of the hind limb
Surgeons have more options for reconstruction of skin defects of the hind limb than the front limb. In small lesions, defects can be closed using local skin flaps. However, as for the front limb, for closure of large wounds, other techniques have to be used.
The axial pattern flaps that can be used for the reconstruction of large defects in the hind limb include the deep circumflex iliac axial pattern flap, caudal superficial epigastric axial pattern flap, the genicular axial pattern flap and the reversed saphenous conduit flap. The latter is unique in its kind because of the ligation of veins and arteries proximally, reversing the blood flow. An adequate blood supply is secured through anastomoses with other vessels. The hind limb (flank) fold transposition flap technique utilizes the thin elastic skin flank fold of the hind limbs similarly to the one of the front limbs. This versatile flap can be used for defects of the upper limb or inguinal region. Muscle flaps that can be used on the hind limb are the cranial and caudal sartorius flap.
Options for reconstruction of defects of the underfoot of the hind limb are similar to those of the front limb. The metatarsal pad transfer is described as a salvage procedure for extensive damage to the underfoot.

Wound closure techniques
Most plastic and reconstructive techniques used in companion animals involve the creation of new surgical wounds. The general surgical principles of using aseptical techniques, proper instruments, and delicate tissue handling while creating a surgical wound apply here as well. In addition, appropriate suture materials and suture techniques have to be used for any type of surgery, but for reconstructive surgery in particular.

Complications in performing plastic and reconstructive surgery
Complications of wound closure in plastic and reconstructive surgery are similar to those in general soft tissue surgeries and include wound dehiscence, infection, hematoma or seroma formation, and excessive scar formation. In addition, closure of wounds on the extremities under excessive tension can lead to oedema or circulatory embarrassment of the tissues distal to the wound. Most

complications can be avoided by a proper pre-operative planning and skin mobility assessment, by using a meticulous surgical technique and achieving haemostasis. Chances of flap survival will increase if the size and localisation of the wound is suitable for receiving the flap, if the wound is neither contaminated nor infected and if the wound is not older than 4-6 hours. It is also important that the recipient bed for the flap is fully prepared. Another complication that should be avoided is the development of dead space, which can lead to the formation of abscesses, seromas or hematomas. Formation of dead space can be overcome by placing drains, subcutaneous and walking sutures and bandages. The authors recommend the use of either passive or active drains whenever possible while taking care not to damage the blood supply at the base of the flap by making exit ports.

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