Extremity wounds present the veterinary surgeon with a range of challenges. These wounds are often caused by projectile injuries or dragging, which results in severe abrasion. There is substantial loss of skin and soft tissue with fractures and open joint luxations. Initial wound management involves debridement, lavage, and either wet to dry or negative pressure wound dressings. A second surgical debridement is often required, as additional tissue will become devitalized secondary to crushing injury. Stabilization of fractures and fracture/luxations with external fixatures or rigid splints assists wound management and facilitates granulation tissue formation. Wounds that involve skin loss of less than 30% of the limb circumference will often close by second intention healing. Larger traumatic wounds or those resulting from the removal of tumors with wide surgical margins require reconstruction. Options for reconstruction in this area include free skin grafting, the use of bipedicled skin flaps in tractable animals and, in some cases, axial pattern flaps.

An axial pattern flap (or “arterial pedicle graft”) is a flap that incorporates a direct cutaneous artery. This gives the flap an excellent blood supply and an approximately 50% greater survival area than a comparable subdermal plexus flap alone. An axial pattern flap is developed by dissecting under the panniculus muscle to ensure preservation of blood supply to the subdermal plexus from the direct cutaneous vessel. Axial pattern flaps allow the surgeon to complete a one-stage repair of defects adjacent to the donor site or at a more distant site with the use of a bridging incision or tubing of a portion of the flap. As with any method of definitive wound repair, appropriate initial wound treatment, including debridement and lavage, and a healthy bed of granulation tissue are important for success.

The reverse saphenous conduit flap is well suited for reconstructing wounds on the distal hind limb. Blood is supplied to this flap form the medial saphenous artery and drained by the medial saphenous vein. As this flap is elevated, the medial saphenous artery and vein are separated proximally from the femoral artery and vein. Arterial blood supply is maintained to the saphenous artery by perforating vessels from the perforating metatarsal artery via the medial and lateral plantar arteries at the level of the hock. Venous drainage from the medial saphenous vein is provided by connections to the lateral saphenous vein and other venous anastomoses distal to the tibiotarsal joint.

This flap can extend distally to the toes. Before creating the flap, the length of skin needed is carefully measured with a length of suture material. Some allowance should be made for flap shortening during dissection and limb motion. The skin on the medial limb is palpated and marked to ensure that adequate skin will remain for closure. The flap is outlined with a marking pen on the medial aspect of the leg. The proximal incision is made first, cranially to caudally and the saphenous artery and vein are ligated and divided. The cranial and caudal incisions are made to the level of the tibiotarsal joint. The cranial and caudal branches of the medial saphenous artery and vein are included.

The flap is elevated from proximally to distally. The peroneal (fibular) artery and vein are ligated to improve flap mobility. Part of the gastrocnemius fascia is dissected to preserve the caudal saphenous artery and medial saphenous vein. The tibial nerve can be separated from the artery and vein and preserved with careful dissection. The vein connecting the medial saphenous...
vein to the lateral saphenous vein is located on the cranial surface of the limb just proximal to the tibiotarsal joint and should be identified and preserved.

A bridging incision is made from the base of the flap to the defect and the flap rotated into place. It is important to suture the subcutaneous tissue in the proximal corner of the flap carefully as the flap will swell postoperatively, possibly leading to hair growth into the incision in this area. A light bandage is placed over the incision. Swelling is common in reverse saphenous conduit flaps as the lymphatic drainage from the flap is initially disrupted and blood must flow in the direction opposite the valves in the medial saphenous vein.

The distal anastomoses that provide this flap with its blood supply and the medial saphenous artery and vein should be carefully evaluated before performing surgery when there is moderate to severe trauma to the medial aspect of the leg and the tibiotarsal joint. Angiography has been recommended in cases with extensive trauma in the area of the tarsus. Ultrasound has been used to evaluate blood flow in several direct cutaneous vessels in dogs but its use for evaluating the potential blood supply of this flap has not been reported.

Veterinary surgeons routinely stretch skin to close wounds resulting from trauma or surgical excision of diseased or neoplastic tissue. Preoperative skin stretching has been described in dogs and cats to close wounds that would have otherwise required extensive skin undermining, skin grafts, axial pattern flaps, or a combination of these procedures. The phenomenon of skin stretching has been attributed to mechanical creep, the elongation of skin beyond its inherent extensibility under a constant load over time, and stress relaxation, the progressive reduction in force required to maintain the stretched skin at a specific length. Mechanical creep occurs when a stretching force is applied to an area of the skin and initially results from rapid alignment of collagen fibers in the dermis in the direction of the applied force. Further elongation of skin beyond this inherent extensibility is purported to result from microfragmentation of elastic fibers and displacement of water from the collagen network.

Mechanical stretching also results in cellular growth and tissue regeneration through a complex, integrated network of growth factors, cytoskeletal structures, and protein kinases. This phenomenon is sometimes referred to as “biologic creep” and is routinely seen in pregnancy, skin growth over benign tumors, and in obesity. In addition to epidermal proliferation, tensile forces stimulate vascular remodeling and increased dermal vascularity within days of application. An experimental study in mice has shown that this increased dermal vascularity is associated with expression of a number of genes associated with hypoxia. Presumably skin stretching transiently decreases blood flow in the affected area, leading to expression of hypoxia-associated genes, stimulating the generation of new blood vessels and increased blood supply.

The beneficial effects of preoperative skin stretching raises the possibility of extending the useful, viable length of axial pattern flaps for reconstruction of wounds on the distal limbs. The author has used preoperative skin stretching on a thoracodorsal axial pattern flap. This dog, a German shepherd mix, had a wound extending from the elbow to just proximal to the carpus. Two skin stretchers were placed extending from the base of the proposed flap to just across the dorsal midline. The owners tightened the skin stretchers twice daily. After 4 days, approximately 8-10 cm of additional skin was available for wound repair. The entire flap survived, which is notable given that partial flap necrosis was a frequent complication in a previously reported series of thoracodorsal flap wound reconstructions.

It is important to stress that the concept of pre-stretching axial pattern flaps to provide additional skin and improve vascularity has not been proven in a large number of clinical cases. However if the concept is validated, several flaps may become viable options for reconstruction.
of distal limb wounds. These would include the caudal superficial epigastric flap, the deep circumflex iliac flap (ventral branch), and the genicular axial pattern flap.

There are additional novel possibilities to consider in distal limb wound reconstruction. The use of a semitendinosus myocutaneous flap for reconstruction of an open tibial fracture with substantial overlying soft tissue loss has been described. The semitendinosus muscle has a proximal and distal supply and the muscle can survive on either. In this case the caudal gluteal vessel (proximal blood supply) was ligated and the myocutaneous flap was rotated distally using the distal caudal femoral artery to supply the entire flap. In this case the muscle and the overlying skin were used to cover a large soft tissue defect over a comminuted grade III open tibial fracture. The entire muscle survived but a small amount of skin distal to the muscle flap necrosed.

The flexor carpi ulnaris (humeral head) muscle flap has been described for reconstruction of reconstruction of distal forelimb injuries in two dogs. This muscle has a distal blood supply from the caudal interosseous artery that allows the muscle to be transected proximally and rotated into distal soft tissue defects. Neither of these cases had the overlying skin transferred with the flexor carpi ulnaris so it is not clear if skin would survive in such a composite flap. Instead overlying soft tissue defects were covered with free skin grafts.

References
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