Negative pressure wound therapy in a slow healing distal extremity

Author : ELISA BEST

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ELISA BEST reports a case study involving a cat with a crushing injury to a hindlimb where a skin graft was successfully coupled with vacuum-assisted therapy

Summary

A distal extremity wound in a young cat, resulting from a crushing injury, failed to granulate appropriately. Negative pressure or vacuum-assisted wound therapy was used to stimulate wound granulation as well as support a free skin graft that was applied subsequently.

Key words

negative pressure wound therapy, NPWT, free skin graft, vacuum-assisted

A MALE, neutered, 30-month-old domestic shorthaired cat presented with non-weight-bearing left pelvic limb lameness.

The skin extending from the dorsal part of the distal tibia to the level of the metatarso-phalangeal joints had been avulsed from its attachment medially.

After administration of intravenous fluids and analgesia, the cat was anaesthetised, examined and radiographs of the thorax, pelvis and left hock joint acquired. Stressed view radiographs identified fracture of the styloid process of the fibula as well as loss of the medial collateral support to the

talocrural joint. A cranio-dorsal luxation of the left coxo-femoral joint was additionally present. The hip luxation was reduced in a closed fashion and the avulsed skin sutured closed. A non-adherent dressing followed by a soft padded bandage had been applied to the distal extremity.

Clinical history

On assessment 24 hours later, the distal left hind extremity felt cold, raising concerns about the viability of the tissues and blood supply to the distal limb. Doppler probe ultrasonography over the plantar metatarsal artery indicated preservation of the blood supply to the distal left extremity. Three days following the injury, a type 2b transarticular external skeletal fixator was applied across the talocrural joint to provide stability to both the talocrural joint and the soft tissue injury **(**Figure 1**)**.

The skin at the proximal margin of the wound started to show evidence of necrosis seven days post-injury. A large area of skin from the level of the talocrural joint to the mid-metatarsal region dorsally was debrided, revealing accumulation of purulent material beneath it, a sample of which was submitted for bacteriology.

Proximally there was evidence of blood supply to the skin edges, but distally, although not obviously necrotic, the remaining skin failed to show good evidence of vascular supply **(**Figure 2**)**. The pes was also swollen and felt cold to the touch. The skin wound was managed with daily flushing using sterile saline and covered with medical grade manuka honey and a sterile hydrophilic foam dressing. A pure growth of *Pseudomonas mendocina* was cultured from the wound and antibiotic treatment switched from co-amoxiclav/metronidazole to trimethoprim sulphonamide in response to culture and sensitivity results. The clinical significance of this bacteria is unknown as it is normally a soil/water isolate. However, as it was a pure growth, with visible presence of infection, treatment was considered appropriate.

The appearance of the tissues of the distal pes improved markedly, apart from the dorsal skin, which required further debridement 14 days post-injury.

The wound was then treated with regular (48-hour to 72-hour intervals) flushing and a combination of hydrophilic foam dressings with sterile manuka honey or sterile wound hydrogel. Despite this, the granulation tissue that formed was scant and both tendons and metatarsals remained exposed **(**Figure 3**)**.

The coxofemoral joint had reluxated and was explored via a craniolateral approach three weeks after the injury; as the cartilage of the medial aspect of the femoral head had avulsed, it was elected to perform a femoral head and neck excision. The wound bed of the pes was debrided simultaneously and the exposed metatarsals foraged in an attempt to stimulate healthy granulation tissue formation.

Despite this and ongoing wound management, a satisfactory granulation bed failed to form.

Routine haematology and biochemistry were performed to rule out any metabolic causes; none were apparent. At this point a negative pressure wound therapy (NPWT) unit was obtained. Three-anda- half weeks post-injury the cat was anaesthetised and the skin around the wound was surgically prepared. The granulation bed was flushed with sterile saline and the skin prepared finally with chlorhexidine gluconate two per cent in 70 per cent isopropyl alcohol.

A polyurethane ether foam dressing was cut to 5mm greater than the diameter of the wound and placed over it. Padding (sterile sponge) was placed between the toes and between the toes and digital pad. A spray-on wound dressing/ adhesive was then applied to the skin proximally and two adhesive polyurethane drapes were placed on the plantar and dorsal aspect of the foot to include the external fixator frame **(**Figure 4**)**. Sterile cohesive bandage was placed over the clamps and pin ends to prevent them puncturing the adhesive drape. A small hole was cut in the polyurethane drape over the foam dressing and the adhesive disc and suction pipe connected to this.

On application of the vacuum, some loss of suction was noted proximally and this was repaired with a further application of spray on adhesive and polyurethane drape. This was then covered with a layer of padding and cohesive dressing. The NPWT device was set to 100mmHg and left in place for 72 hours. Although initially there were some slight issues associated with tangling in the vacuum tubing, the cat remained generally comfortable and tolerated the device well **(**Figure 5**)**.

After 72 hours the cat was anaesthetised and the dressings removed. This revealed a marked improvement; the wound was now covered in an even bed of healthy granulation tissue**(**Figure 6**)**. Despite coverage not being complete (some tendon and metatarsal exposed dorsally) it was opted to proceed with a free skin graft. The left flank was surgically prepared with chlorhexidine scrub and chlorhexidine gluconate two per cent in 70 per cent isopropyl alcohol. The skin around the recipient bed and the bed itself was prepared as previously described.

The recipient bed was measured and the correct size graft harvested (having noted and marked the direction of the hair growth). The wound was closed by an assistant using 3-0 poliglecaprone 25 simple continuous sutures and skin staples while the graft was prepared. The subdermal layer of the graft was carefully removed and the graft meshed. The graft was then placed over the granulation bed and sutured to the edges using simple interrupted 4-0 polypropylene sutures. Simple interrupted sutures were additionally placed between the graft and recipient bed **(**Figure 7**)**.

The graft was then covered with a non-adherent silicone mesh and the NPWT device reapplied in a similar manner to previously. The vacuum was set at 80mm Hg continuous suction.

The cat was hospitalised for the following seven days while the NPWT device was left in place. Analgesia was provided using sublingual buprenorphine and oral meloxicam. Antimicrobial support was maintained.

The dressings were carefully removed under sedation after seven days. This revealed a very

healthy looking graft with no areas of congestion. The granulation tissue had extruded through the mesh holes in the graft (Figure 8). The graft was then dressed in standard manner using a silicone mesh, hydrophilic foam dressing, soft conforming bandage and a cohesive outer layer. The dressings were changed approximately every 72 hours.

The external fixator frame was removed after six weeks and dressings were discontinued five days later. The graft remained healthy and showed no areas of necrosis. Complications included a small ulcer over the point of the calcaneus that resolved once the dressings were removed, as well as some skin irritation along the edges of the graft; this was managed with a topical steroid/antibiotic cream applied sparingly. Healing was otherwise uneventful and the foot showed a healthy covering of skin and hair 10 weeks post-injury (Figures 9 and 10).

Discussion

Full thickness free skin grafting is a very useful technique in the distal limb where large skin deficits are pres ent and other reconstruction techniques are not feasible. However, it has some limitations in veterinary medicine, for example, prolonged after care and the possibility of failure of the graft[1].

The process by which dermal and epidermal cells survive from the point of being harvested to becoming fully revascularised by new capillaries in the recipient site is termed “take”. This is a complex process and relies on the recipient site being capable of providing nutritional supply and vascular support to the graft. Suitable recipient beds include fresh surgical wounds and healthy granulation tissue[1]. Healthy granulation tissue normally appears in clean open wounds after three to four days. Presence of infection or necrotic tissue will slow this process.

In this particular wound, both of these may have been contributing factors causing a lack of healthy granulation tissue. Another theory is there was a disruption of blood supply caused by the crushing nature of the injury. The various techniques, such as repeat debridement and forage, usually deployed to revitalise a granulation bed, had not been successful in this case.

NPWT or vacuum-assisted closure involves the application of sub-atmospheric pressure to a wound and was initially described in human medicine in 1997[2].

Several mechanisms of action have been investigated. The application of controlled vacuum results in the removal of excess interstitial fluid, thereby decreasing interstitial pressure and wound oedema. When interstitial pressure drops lower than capillary pressure, the capillaries reopen and blood flow to the wound increases. Furthermore, the fluid collected by the NPWT system has been found to contain high levels of proteolytic enzymes that, if left in the wound, are likely to result in a non-healing wound environment[2],[3],[4]. Both these factors are likely to have played a role in the dramatic improvement seen in this wound within a relatively short time.

Although originally described for chronic wounds in people, a wide variety of surgical applications

are now reported. These include large abdominal and thoracic wall defects, to improve drainage in skin flaps as well as free skin grafts.

As well as an adequate recipient bed, factors that improve survival of free skin grafts include adequate immobilisation of the graft as well as prevention of fluid accumulation beneath the graft. Both can prevent the formation of a fibrin seal between the graft and recipient bed and subsequently in-growth of capillaries.

NPWT not only maintains good apposition between the graft and wound bed (even if the recipient bed is irregular), but also provides active drainage of the site. In this case, application of an external fixator frame improved stability of the site dramatically, especially since the area involved a joint surface, but would not have achieved the degree of graft apposition over an irregular surface.

It is interesting to note granulation tissue will appear through the mesh incisions in the graft after application of the NPWT device **(**Figure 8**)**, in effect providing an anchor for the graft.

There are few articles in the veterinary literature describing NPWT in skin grafting and, therefore, few recommendations on the length of time the vacuum should be applied. One article suggests 72 hours[3] while another recommends four to five days[5]. A seven-day interval was used in this case following verbal advice[6] and would, in theory, give time for new capillary in-growth.

The earlier the graft is disturbed, the greater chance of disruption of this process. It is vitally important a non-adherent contact layer is placed between the graft and the foam dressings or adherence to, and loss of, the graft is likely to occur when the NPWT dressing is removed **(**Figure 11**)**.

There were few complications associated with the use of the NPWT device in this case. The small ulcer that developed over the point of the hock could potentially have been avoided by excluding it from the polyurethane dressing, although this would probably have affected the seal. These types of sores occur commonly when one is unable to adequately protect bony prominences under dressings. There was also some loss of vacuum when the polyurethane dressings were first applied; the pes is a particularly challenging area for creating a vacuum and the use of stoma paste has been advocated to act as a filler between toes and the pads. It was not used in this case because of the proximity to the wound.

The most serious complication likely in such a case would have been loss of vacuum due to a punctured seal, although these devices will alarm should this occur. If the seal is lost or worse still the device inadvertently switched off, the occlusive nature of the dressings will cause the graft to macerate resulting in complete graft failure.

In conclusion, it would seem in this case NPWT had a beneficial effect not only in producing healthy granulation tissue, but also in supporting the skin graft and ensuring a rapid and complete take.

References

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Figure 1. Radiograph showing application of a Type 2b transarticular fixator to the limb.

Image: M OWEN/OSSICLE.

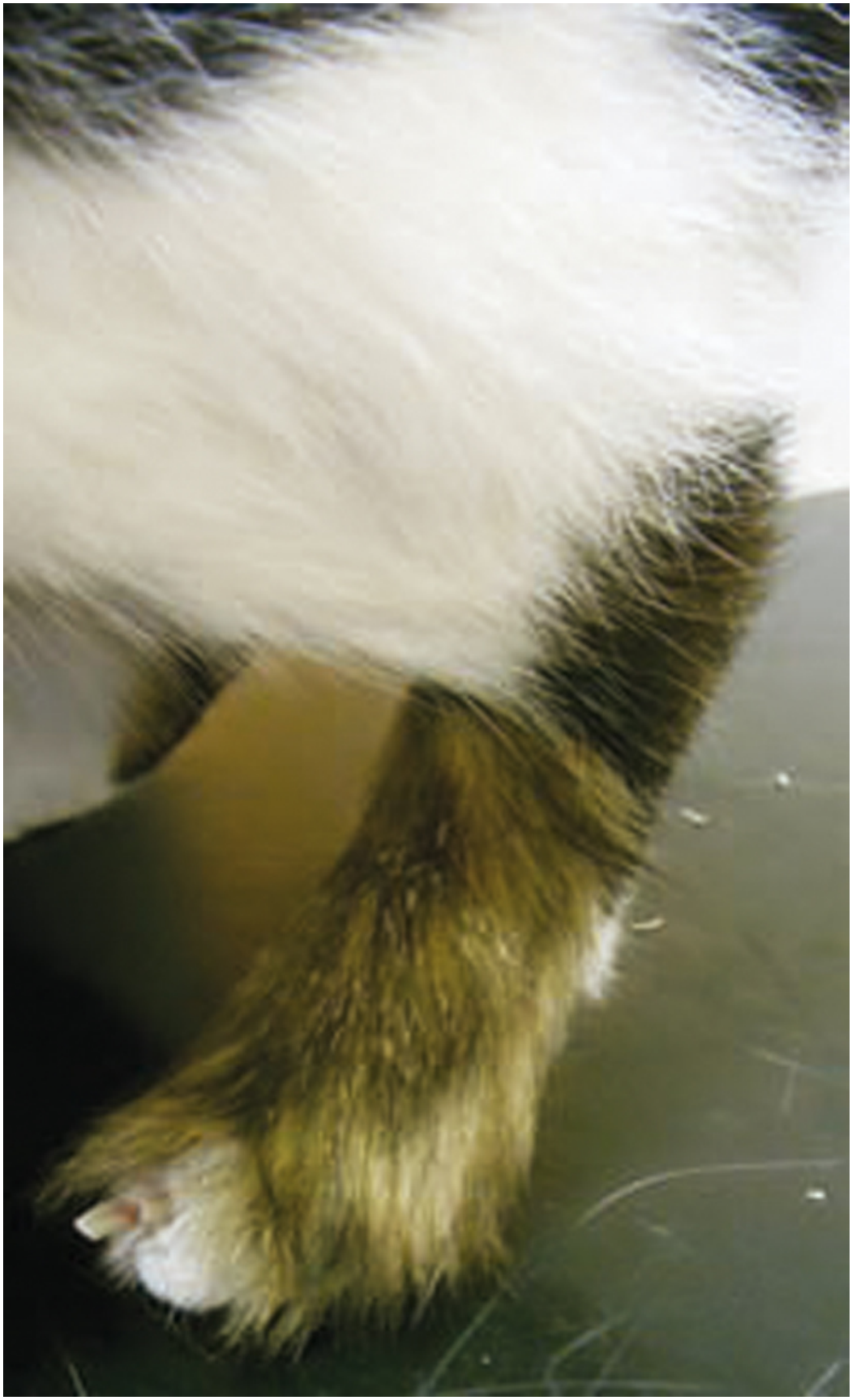

Figure 10. Final appearance of the limb.

Figure 11. It is vital a non-adherent dressing (silicone in this case) is applied between the graft and the NPWT foam dressing.

Figure 2. Appearance of the limb seven days post-injury; at this point the viability of the tissues distally was still questionable.

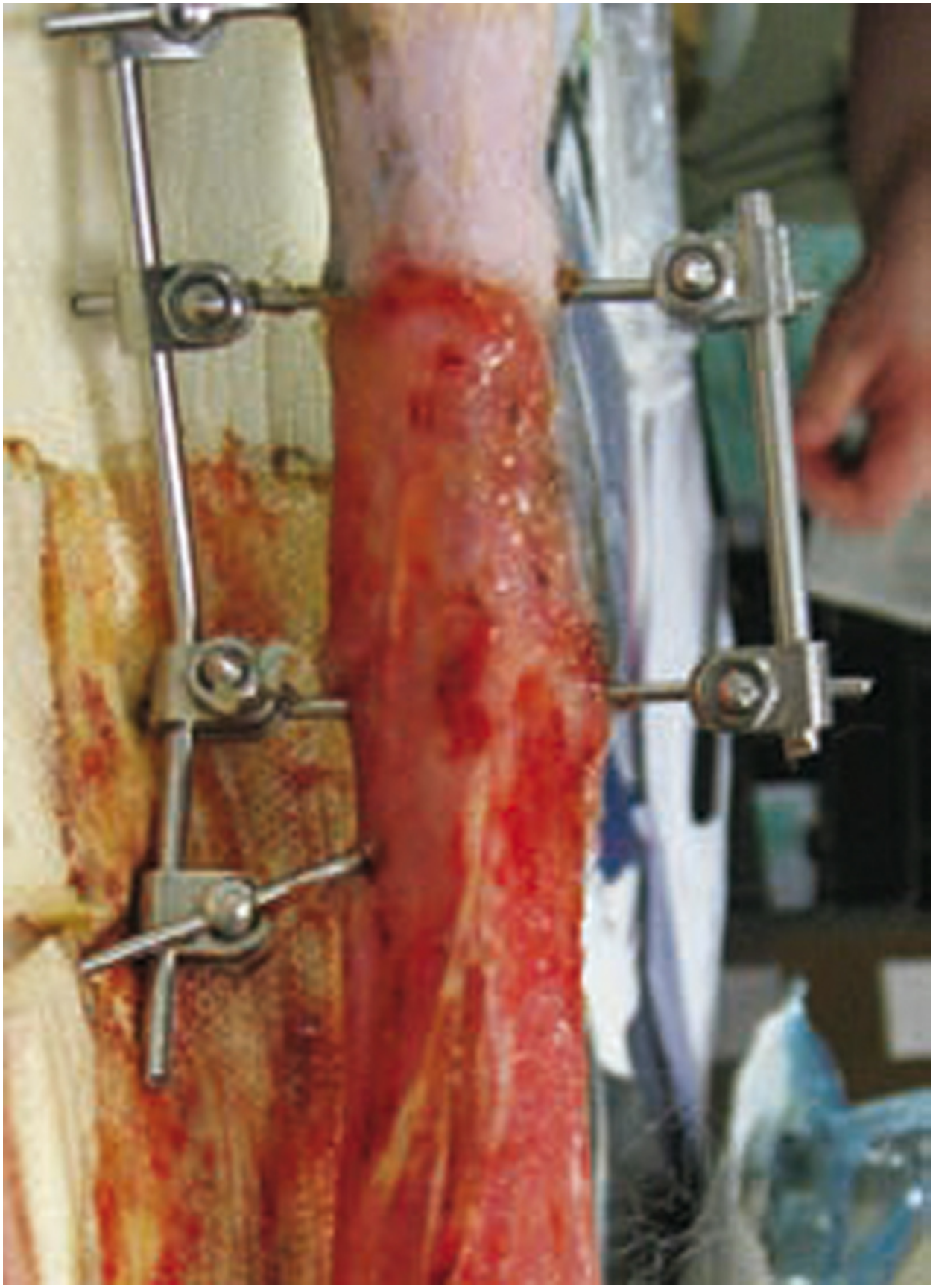

Figure 3. Appearance of wound prior to application of NPWT; granulation tissue is scant and of poor quality.

Figure 4. Application of NPWT device; note the raisin-like appearance of the foam, indicating a good seal has formed.

Figure 5. The patient shows good tolerance of the device.

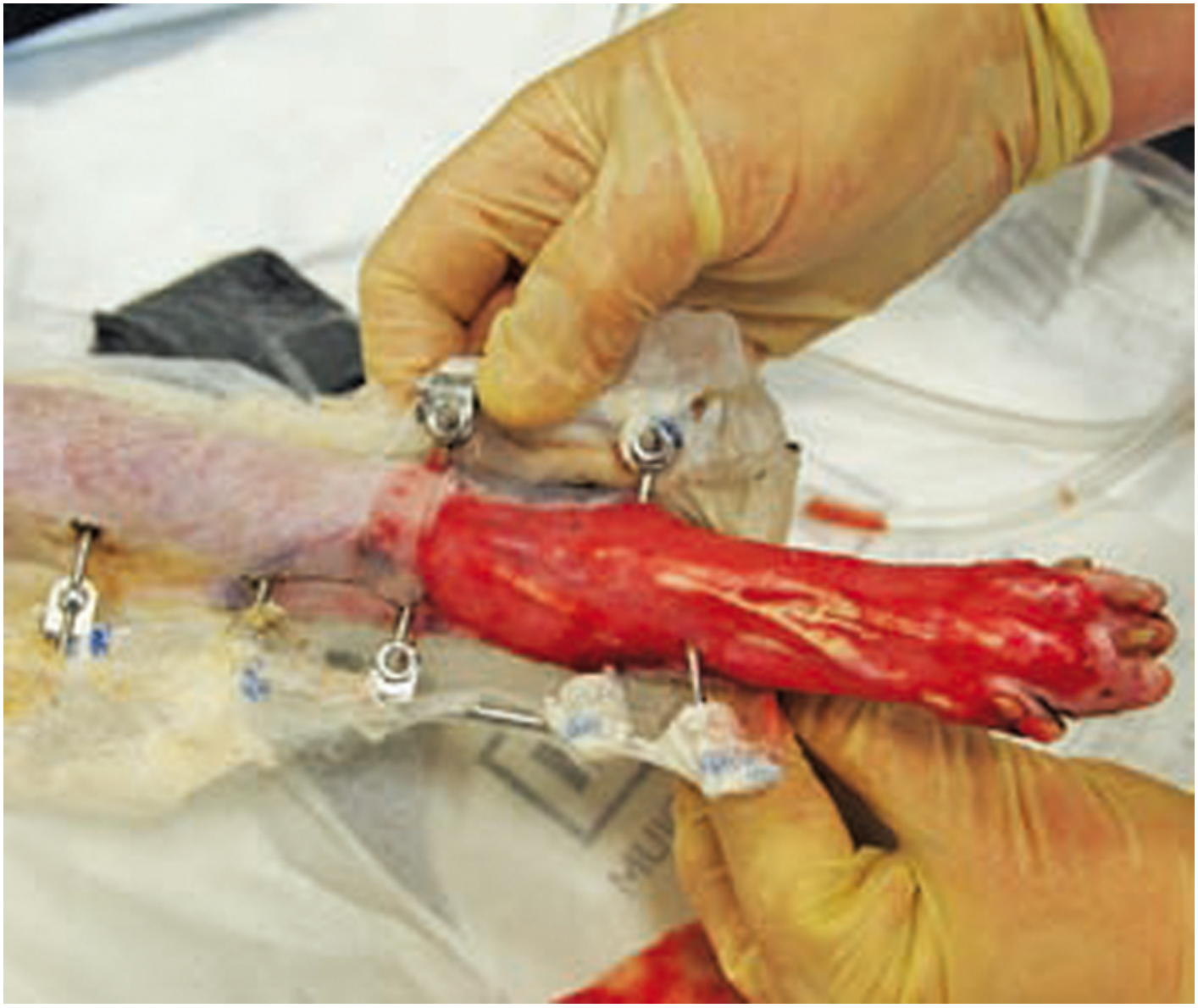

Figure 6. Appearance of the wound after 72 hours of NPWT showing a healthy even covering of granulation tissue.

Figure 7. Application of the free skin graft.

Figure 8. Appearance of the skin graft after seven days of NPWT; good evidence of take throughout and granulation tissue has extruded through the mesh incisions in the graft.

Figure 9. Appearance of the limb 10 weeks post-injury.