Treatment of large distal extremity skin wounds with autogenous full-thickness mesh skin grafts in 5 cats

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Summary

Five cats with large, distal extremity abrasion wounds were treated with an autogenous, full-thickness, mesh skin graft. Survival of the mesh grafts in all five cats was considered between 90 and 100%. Successful grafting requires asepsis, an adequately prepared recipient bed consisting of healthy granulation tissue, proper harvesting and preparation of the graft, meticulous surgical technique and strict postoperative care. Factors that are essential for the survival of skin grafts include good contact between the graft and the recipient bed, normal tension on the sutured graft, strict immobilization after grafting and prevention of accumulation of blood or serum under the graft. Meshing the graft provides more graft flexibility over uneven surfaces and allows adequate drainage. In contrast to previous proposals, the authors recommend no bandage change before the fourth day after grafting. Full-thickness mesh skin grafting can be used to successfully treat large distal skin wounds in cats.

Key words: soft tissue surgery, skin transplantation, skin mesh graft, abrasion wound, cat

Behandlung von grossflächigen Hautwunden der distalen Extremität mittels autogenen, genetzten Vollhauttransplantaten bei 5 Katzen

Fünf Katzen mit Abrasionswunden an den distalen Extremitäten wurden mit autogenen Vollhauttransplantaten behandelt. Eine erfolgreiche Hauttransplantation erfordert ein gut vorbereitetes, aus gesundem Granulationsgewebe bestehendes Wundbett, korrektes Entnehmen und Verarbeiten des Transplantates, sorgfältiges chirurgisches Arbeiten und eine intensive postoperative Nachsorge. Faktoren, die für das Überleben und Anwachsen des Transplantates essentiell sind, sind eine gute Kontaktfläche zwischen dem Wundbett und dem Transplantat, ein nicht zu starker Zug auf das Transplantat durch die chirurgische Naht, striktes Immobilisieren der Gliedmasse nach der Transplantation und Verhindern von Flüssigkeitsansammlung unter dem Transplantat. Das netzartige Einschneiden des Transplantats erlaubt es, das Transplantat auf eine unebene Fläche anzupassen und fördert gleichzeitig eine gute Drainage. Im Gegensatz zu den Angaben in der Literatur empfehlen wir, den ersten Verbandwechsel nicht vor dem vierten Tag postoperativ durchzuführen. Bei allen fünf Katzen ist eine Fläche von 90–100% des Transplantats angewachsen. Der Einsatz von Vollhauttransplantaten zur Behandlung grossflächiger Hautwunden an der distalen Extremität von Katzen wird empfohlen.

Schlüsselwörter: Weichteilchirurgie, Hauttransplantation, freies Hauttransplantat, Wundbehandlung, Katze

Introduction

Mesh skin grafts are full-thickness or split-thickness sheets of skin, which are incised (meshed) in parallel rows. The incisions permit an expansion of the graft and confer the graft with enhanced flexibility to conform to uneven surfaces. Meshing also provides a route through which wound fluid might escape. This prevents the accumulation of fluid between the graft and the recipient bed, which can lead to the loss of a graft by impeding revascularisation. The successful use of meshed skin grafts has previously been described in the horse, the dog and the cat (Hanselka et al., 1976; Jensen, 1959; Swaim, 1980). The purpose of this report is to describe the technique and outcome of full-thickness autogenous meshed skin grafts in five cats with large distal extremity skin wounds.

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Animals, Materials and Methods

Animals

Five client-owned domestic short-hair cats that were presented to the Department of Clinical Veterinary Medicine, Division of Small Animal Surgery, University of Bern, in 2002 and 2003, were treated with meshed skin grafts. All cats weighed between 3 and 4 kg and were between 7 months and 14 years of age. Four cats were spayed females and one was an intact male.

Four cats suffered from a road traffic accident and were presented with large, and in one case circular, abrasion wounds and de-gloving injuries to the distal extremities. Two of the skin wounds were freshly contaminated and two were infected at the time of presentation. In three of four cats, the skin wounds were located between the distal tibia and the paws and included the tarsal joint, and in one cat the wound extended from the carpus to the distal phalanges. Exposure of the bone was evident in all four cases. In addition to the skin wounds, fractures and abrasions of metatarsal or metacarpal bones or the phalanges were present in two cats. One cat was presented for the excision of a subcutaneous 2×3 cm leiomyoma over the proximodorsal aspect of the carpal joint. Following tumour excision, the resulting wound was too large for primary skin closure.

Data collection and evaluation

Data collected included the time from initial clinical presentation to surgery, the time from surgery to final splint cast removal, and the duration the wounds were covered with a protective bandage after splint cast removal. Graft healing was documented with digital photographs taken before and after surgery and at every splint cast or bandage change. The final take of the graft was calculated as a percentage of the area of the preoperative skin wound covered by a healthy graft at the time of splint cast removal.

Figure 1: Healthy granulation tissue with migration of the epithelium from the wound margins. Photograph taken on the day of skin transplantation.

Any complications associated with the procedure were recorded. After complete healing, owners were questioned by telephone about the cosmetic results and were asked if they would perform this surgery again if their pet suffered similar injuries. The cosmetic results of the grafts were graded on a scale of 1 to 3, where 1 was assigned if no difference between the graft hair coat and the surrounding normal hair coat was detectable, 2 when a slight difference was noted, and 3 if a marked difference was evident.

Surgery

Wound preparation

Abrasion and de-gloving wounds were debrided, lavaged with Ringer's Solution, and bandaged with an absorbable, adherent wet-to-dry dressing. Daily debridements and bandage changes were continued until a healthy granulation tissue formed (Fig 1).

Harvesting and preparation of the skin graft

Full-thickness grafts were harvested from the lateral thoracic or abdominal wall, where abundant loose skin was available and undermining could be used to close the area. The direction of hair growth was noted and the size of the defect was estimated. A skin incision of the estimated size was performed and the graft was elevated and undermined with scissors, leaving some subcutaneous tissue. The graft was completely excised and fixed with cannulae on a sterile cardboard with the subcutaneous tissue facing upward. Before the graft was applied to the recipient site, the subcutaneous fat and vessels were completely removed from the graft with sharp scissors until the base of the hair follicles was visible (Spreull, 1968) (Fig. 2). Meshing was performed by hand, using a No. 11 scalpel blade. Incisions of approximately 1 cm in length were made in parallel rows, allowing about 5 mm distance between rows. During preparation and meshing, the grafts were kept moist by irrigation with a crystalloid solution.

Preparation of the recipient bed

Surface debris was removed with sponges and epithelial cells migrating from the wound edges were removed with sharp scissors from the granulation tissue. Any haemorrhage in the recipient bed was controlled with light finger pressure before the graft was applied. The granulation tissue, with its character-

Table 1: Summary of the results of the five cats treated with autogenous full-thickness mesh skin grafts. DSH: domestic short-hair cat.

Animal	Skin wound	Presentation to surgery	Splint cast	Protective bandage	Take	Complications
DSH, fs, 1y, 3 kg	Abrasion de-gloving injury, carpus, metacarpus	14 days	9 days	14 days	90%	10% necrosis of the graft (distal), 40 % dehiscence on donor site
DSH, fs, 5y, 4 kg	Abrasion, tarsus, metatarsus	21 days	14 days	21 days	95%	None
DSH, fs, 14y, 4 kg	Wound after tumor resection, carpus	14 days	14 days	21 days	90%	10% necrosis of the graft (distal)
DSH, fs, 1y, 4 kg	Abrasion, tarsus	15 days	21 days	7 days	100%	Slight muscle contraction and reduced range of motion (tarsus)
DSH, male, 7m, 3 kg	Abrasion, tarsus	7 days	7 days (wooden spatula cast)	14 days	95 %	None

istic smooth surface and red appearance, was kept moist while the graft was harvested and prepared.

Application of the graft

Efforts were made to match the direction of the hair growth to that of the surrounding skin and to maintain the direction of the skin incisions parallel to skin tension lines. The graft was placed such that maximal contact with the recipient bed was achieved with an equal degree of expansion of the incisions. The edges of the graft were directly sutured to the edges of the bed and the final form of the graft was prepared with scissors. The graft was sutured using a nonabsorbable, monofilament material (Prolene® 4/0 or 5/0) and an interrupted suture pattern (Fig. 3a). In some cases, additional tacking sutures were placed from the mesh incisions to the granulation tissue.

Figure 2: Harvested meshed full-thickness skin graft after removal of subcutaneous tissue, ready to apply on a wound bed.

Postoperative Care

The wound was covered with a non-adherent wound dressing. A secondary absorptive dressing of sponges was applied and the bandage was completed with a dressing of Rolta®[1] and Coban®[2]. A half-splint cast (3M Scotchcast®[3]) was included in the bandage in four of five cats until the graft had taken to insure strict immobilization of the graft area. In the cat that was only 7 month old, a wooden spatula was used instead of a half-splint cast in order to avert the possibility of articular cartilage damage with an overly rigid cast. The splint cast bandage was visually monitored twice daily and the cats were monitored for signs of bandage-associated discomfort.

The first bandage change was performed on the fourth day following surgery under sedation and aseptic conditions. The dressings were moistened and carefully pealed away in order to avert interfering with the healing of the graft. Further bandage chances were performed twice weekly. Splinting was discontinued and a protective bandage was applied as soon as the graft was considered to have healed by visual and digital assessment of the wound. The protective bandage was changed every 3 to 5 days until the graft was considered to have fully taken.

Results

The time from initial presentation to surgery was between 7 and 21 days. The duration of postoperative immobilisation of the joint over the graft with a half-splint cast ranged from 7 to 21 days. Following cast removal, a protective bandage was applied for an additional 7 to 21 days. The entire duration of treatment

[1] Rolta, Hartmann, Germany
[2] Coban, 3M, Health Care, Germany
[3] ScotchCast, Laboratories 3M Santé, France

from presentation to the time at which the graft was considered healed ranged from 21 to 35 days (Tab. 1). The calculated area of the initial wound covered by a healthy skin graft was between 90% and 100%. The take was 90% in two cats, 95% in two cats and 100% in one cat. In both cats with 90% graft take, only the distal 10% of the graft did not take and healed by second intention (Fig. 3b). At the time of take evaluation, all incisions due to meshing were completely epithelialized.

Only minor complications, which had no negative effect on clinical outcome, were observed (Tab. 1). In one cat, partial dehiscence (40% of the length of the suture line) at the donor site on the thoracic wound was observed 10 days postoperatively, following suture removal. Skin staples were applied to this wound, which subsequently healed uneventfully seven days later. One cat managed to remove the splint cast one day after surgery even though the bandage was sutured to the skin and the cat was wearing an Elizabethan collar. No damage to the graft was observed in this case. Finally, in one cat, mild muscle contractions and a decreased range of motion in the tarsal joint were noted after removal of the splint cast, 21 days following surgery. In two of five cats, the new hair coat resulted in darker and longer hairs compared to the surrounding healthy skin, the owners of these two cats considered the cosmetic outcome as grade 2. The three other cat owners were very pleased about the cosmetic outcome of surgery and were unable to detect any difference between the hair condition of the graft and surrounding skin (Fig. 3c). Four of five cat owners stated that they would consider performing this surgery again. The owner that was unwilling to subject their pet to this surgery again was opposed to the procedure purely for financial reasons.

Figure 3a: Graft immediately after surgery.

Figure 3b: Graft 14 days after surgery. The take was calculated as 90% of the surface area of the initial wound. A small distal region with graft necrosis was previously debrided and has healed by second intention.

Figure 3c: Graft 30 days after surgery and depicting new hair growth with an acceptable cosmetic and functional outcome.

Discussion

Large skin defects on the distal extremities of cats are challenging and time-consuming injuries to treat. Traumatic abrasions, de-gloving injuries, burn wounds and surgical resections of large tumours are the most frequent causes of large skin wounds in cats. These wounds are often unsuitable for primary skin closure, and wound healing by second intention is a long procedure that requires intensive nursing and often leads to a poor cosmetic outcome. In addition, the skin of wounds healed by second intention is often thin and easily traumatized.

Other treatment options include skin flaps, bipedicle flaps and skin grafts. Mobilization of skin flaps to treat large skin defects requires surgical skill and may require multiple procedures or microvascular surgical equipment (Pope, 1990). Distant bipedicle direct flaps, involving the fixation of a limb with the wound under the skin of the thoracic or abdominal wall, are poorly tolerated by cats. However, skin grafting is a viable option in the treatment of many large skin defects, especially in the distal part of the limb, where the local transfer of skin to cover a wound can be impossible.

In human medicine, the split-thickness skin graft technique is used more often than the full-thickness technique. Split-thickness grafting has also been described in veterinary medicine (Bauer and Pope, 1986; Swaim, 1982; Pope, 1990; Swaim, 2002; McKeever and Barden, 1978; Fox and Probst, 1982; Probst et al., 1983). With this technique, the skin is cut with a dermatome and meshed with a mesher. The donor site may be allowed to heal as an open wound by epithelialization but often heals with little or no hair growth. (Mc Keever and Barden, 1978). The advantage of split-thickness grafts is a greater viability due to a smaller amount of tissue that is more easily revascularized than in the case of full-thickness grafts. However, this technique results in poor hair regrowth and a thinner, more vulnerable skin with a scaly appearance and lack of sebaceous secretions (Swaim, 1982; Probst et al., 1983).

Given that graft thickness is decisive in the extent of hair regrowth, full-thickness grafts have more hair growth than split-thickness grafts (McKeever and Barden, 1978). Because of the special and sometimes expensive equipment necessary to produce split-thickness grafts, the relatively thin skin of cats compared to humans and dogs, and the better cosmetic and functional outcome of thicker grafts, full-thickness skin grafts represent a better treatment option in cats.

Meshing of a graft has many advantages over unmeshed grafts. The mesh increases the size of the graft such that a recipient site area larger than the donor site area can be covered. The expansion of the mesh is dependent on the size and the number of incisions made in the graft. Because maximum expansion in the width of the graft results in some shortening of the length, a longer graft should be harvested to allow complete coverage of defects (Pope, 1988). In addition, meshing increases the number of cut edges from which the healing can occur (Swaim, 1982). The flexibility of mesh grafts allows coverage of uneven, convex and concave surfaces as well as surfaces that are difficult to immobilize. Meshing also facilitates drainage of blood and serum or exudates from under the graft. This reduces the risk of graft failure due to fluid accumulation under the graft (Zuilen and Kirpensteijn, 1995).

The time from initial presentation to grafting surgery in the cases presented in this report was between 7 and 21 days. This wide variation in time was partly due to slower granulation of wounds that were either infected or in which extensive bone exposure was present. Granulation tissue should be smooth and appear healthy if a graft is to be applied. Healthy granulation tissue is firm, flat and red (Swaim, 1980). The migration of the epithelium from the margins of the wound is an indication of a healthy granulation tissue (Pope, 1988; Swaim, 1986; Probst et al., 1983). If there is doubt as to contamination, infection or the possibility of excess fluid production, the mesh should be applied in an expanded manner to provide a maximum of drainage function. If the skin graft can be applied with minimal expansion, healing time is reduced and the graft will be thicker and more durable with better cosmetic results (Swaim, 1984).

Pope (1984) described the normal healing process of a skin graft. The take of the graft can be defined as success when revascularization occurs. Initially, the graft is nourished by absorption of plasma-like fluid, known as plasmatic imbibation. During the first 24 hours, the graft vessels gradually become dilated and filled with static blood. Revascularization of the skin grafts occurs by direct connection of graft and host vessels and by ingrowth of new vessels along preexisting graft vessels (Probst et al., 1983; Pope, 1988). Two or three days after grafting, the new blood flow from the granulation bed into the graft is established. A graft that is applied on a healthy granulation tissue is generally revascularized within 48 to 72 hours (Pope, 1988) and the rate of ingrowth of new capillaries has been reported to be approximately 0.5 mm/day (Eriksson and Zarem, 1977). In previous publications, many authors have recommended daily bandage changes for the first week following grafting (Swaim, 2002; Hedlund, 2002; Swaim, 1990; Swaim, 1986; Probst et al., 1983). However, in the present report, bandage changes were not undertaken until the fourth day after grafting in order to minimise interfering with the revascularization process. Complete contact between the dermal surface and the graft bed is necessary for ingrowth of capillaries from the granulation tissue. Where there is no contact or constant movement between the graft and the recipient, the graft will not take. Immobilization for the first days following surgery is therefore essential. Treatment of cats in this report included immobilization of the joint by applying a splint for 7 to 21 days. The larger grafts, which covered the entire joint surface, were generally immobilized for longer periods than grafts covering only the distal or the proximal part of a joint.

The authors recommend hospitalization during the postoperative period. During the initial take of the graft, some animals mutilate the graft by licking and biting the graft area. This may be due to temporary loss of sensation or ongoing pain associated with underlying structures. Skin grafts become re-innervated by ingress of nerves from underlining and peripheral tissues. The recovery of sensation in split-thickness grafts is poorer than in full-thickness grafts and is usually incomplete. The recovery of sensation usually begins between the third and ninth week after grafting (Probst et al., 1983). The application of a bandage

following splint removal to protect the graft is therefore advocated.
The calculated take of the graft in the five cats in this report was between 90 and 100%, which corresponds to previously reports of veterinary graft survival (Hedlund, 2002). In the two cats with only 90% take, necrosis occurred in the distal 10% of graft. The necrotic region of the grafts appeared darker, stiff and cold compared to the rest of the graft. Partial graft necrosis was only seen over the most mobile area of the graft due to carpal or tarsal joint movement. In both cats this little area healed uneventfully by second intention following debridement.
The chances of an early and successful take of a graft is somewhat better in cats than in dogs because the feline skin is thinner (Swaim, 1986). Assessment of graft viability was done by visual inspection and palpation of the graft. Other methods to assess tissue viability, including tissue oxygenation measurements or Doppler blood-flow analysis were not performed in the cats reported in this study.
Complications seen in the cats treated in this report were partial wound dehiscence after suture removal on the donor site, premature bandage removal by one cat, slight muscle contraction, and darker and longer hair regrowth. In one cat the splinted scotch cast had to be applied for three weeks. This long duration of joint immobilization may have contributed to muscle contraction and a reduced range of motion in this case. The complications were considered minor and had no influence on the graft survival or the functional outcome of the skin transplants. However, owners should be warned that the colour and length of the hair may be altered, especially in breeds in which hair colour is controlled by a temperature-dependent enzyme (Swaim, 1980).
All owners were pleased with the outcome and all except one would consider performing this surgery again in their pets. Client-education regarding the advantages, disadvantages, alternatives and cost of this surgery is mandatory for good owner compliance and surgical outcome.

Conclusion

Five cats with large distal extremity skin wounds were successfully treated with an autogenous, full-thickness mesh skin graft. The mesh incisions allow the graft to be expanded and cover large uneven surfaces consisting of a healthy granulation tissue. Meshing allows drainage of serum and blood from under the graft. With meticulous surgical technique and postoperative care, a graft take of 90 to 100% can be expected. Full-thickness mesh skin graft is a viable option for the treatment of large distal extremity skin wounds in cats.

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Traitement de blessures cutanées étendues au niveau distal des extrémités chez 5 chats au moyen de greffes cutanées autogènes

Cinq chats présentant des blessures par abrasion au niveau distal des extrémités ont été traités par transplantation autogène de peau. Une transplantation cutanée réussie nécessite la présence d'un lit de tissu de granulation sain et bien préparé, le prélèvement et la manipulation correcte du transplant, un travail chirurgical soigneux et des soins post-opératoires intensifs. Les facteurs essentiels pour la survie et la reprise des transplants sont le bon contact entre le lit de la plaie et le transplant, une traction modérée des sutures sur le transplant, une immobilisation stricte du membre après la transplantation et l'absence d'accumulation de liquide sous le transplant.
Le découpage en filet du transplant permet de l'adapter à une surface irrégulière et favorise parallèlement un bon drainage. Contrairement aux données provenant de la littérature, on conseille de

Trattamento di ferite cutanee di grosse dimensioni dell'estremità distale tramite trapianto autogeno e reticolare di tutta la pelle in 5 gatti

Cinque gatti con ferite per abrasione alle estremità distali sono stati curat tramite trapianti di tutta la pelle. Per ottenere un trapianto della pelle riuscito si esige un letto delle ferita esistente ben preparato da un tessuto di granulazione sano, un prelievo e una preparazione corretti degli espianti, un lavoro chirurgico accurato e una cura intensiva postopertoria. I fattori che sono essenziali per la sopravvivenza e l'accrescimento dell'espianto, sono una buona superficie di contatto tra il letto della ferita e la parte trapiantata, una tensione non forte sulla parte trapiantata tramite cuciture chirurgiche, un'immobilizzazione assoluta dell'arto dopo il trapianto e l'impedimento di raccolta di essudato sotto la parte trapiantata. L'incisione reticolare della parte trapiantata permette che quest'ultima si adatti ad una superficie non piana e favorisce contemporanea-

ne pas effectuer le premier changement du pansement avant le 4e jour post-opératoire.
Chez les 5 chats une surface du 90 à 100% du transplant a repris. L'utilisation de greffe cutanée pour le traitement de blessure de peau de grande surface au niveau des extrémités distales des chats est recommandée.

mente un buon drenaggio. Al contrario delle indicazione proposte nella letteratura noi consigliamo di effettuare il primo cambio di bendaggio non prima del quarto giorno postoperatorio. In tutti e 5 i gatti la superficie accresciuta è del 90–100% dell'espianto. Consigliamo pertanto l'espianto di tutta la pelle per il trattamento di grandi superfici di ferite cutanee della estremità distale nei gatti.

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