Comparison of outcomes for single-session and delayed full-thickness applications of meshed skin grafts used to close skin defects after excision of tumors on the distal aspects of the limbs in dogs

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OBJECTIVE
To compare outcomes after application of full-thickness, meshed free-skin grafts in single-session versus delayed (staged) procedures after tumor excision from the distal aspects of the limbs in dogs.

ANIMALS
52 client-owned dogs.

PROCEDURES
Medical records were retrospectively reviewed to identify dogs that received full-thickness, meshed free-skin grafts after tumor excision from the distal aspects of the limbs between 2013 and 2018. Signalment; diagnostic test results; comorbidities; procedure type (single session or staged); tumor characteristics; donor site, recipient site, and size of grafts; concurrent procedures; surgeon; antimicrobial administration; external coaptation type; number of bandage applications; percentage graft survival; graft outcome; postoperative complications; and time to complete healing were recorded. Graft outcome was deemed successful if there was full-thickness graft viability over ≥ 75% of the original graft area. Variables were compared between dogs grouped by procedure type.

RESULTS
The number of bandage applications was significantly greater for dogs that had staged versus single-session procedures. Twenty-seven of 30 (90%) and 18 of 22 (82%) skin grafts placed in single-session and staged procedures, respectively, were successful. Percentage graft survival, graft outcome, and complication rate did not differ between groups. All complications were minor. Time to complete healing was significantly longer after staged procedures (median, 51 days) than after single-session procedures (29.5 days).

CONCLUSIONS AND CLINICAL RELEVANCE
Results suggested both procedure types are appropriate for skin graft placement. The shorter healing time and fewer bandage changes associated with single-session skin graft placement may be beneficial after tumor excision. Prospective studies are needed to confirm these findings. (*J Am Vet Med Assoc* 2021;258:387–394)

Management of skin defects involving the distal aspects of the extremities can be challenging owing to the lack of skin available for primary closure and the fact that these defects are typically beyond the reach of available local axial pattern flaps.[1–5] Various techniques have been described to cover these skin defects, including distant pedicle flaps, tube flaps, microvascular free tissue transfer, and second-intention healing.[5–9] Most authors recommend the use of second-intention healing only if the wound involves < 30% of the circumference of the limb to prevent complications such as wound contracture, joint dysfunction, delayed healing, and incomplete epithelialization.[5] Thus, skin grafts are commonly used to address large skin defects at the distal aspects of limbs.[1,2,4,8,10,11]

The principles and techniques of skin grafting in dogs and cats have been well described. Skin grafts can be full thickness or split thickness, depending on whether the entire dermis is incorporated.[10,12–15] Studies[2,13,16] have shown that full-thickness skin grafts have a high percentage of graft survival, with retained viability of the original graft reported to be as high as 90% to 100% when prepared correctly. To maximize the likelihood of a successful outcome, free-skin grafts may be meshed and expanded before grafting, increasing coverage area by 3 to 9 times, improving graft flexibility to allow placement onto irregular surfaces and facilitating drainage of graft-bed exudate.[4,10,11,17–19]

Unlike flaps, free grafts rely entirely on the development of new arterial and venous connections with the recipient bed. Free grafts, therefore, require a vascularized wound bed for successful grafting, such as a fresh wound or, more commonly, healthy granulation tissue.[2,8,10,20] Historically, defects created by tumor excision have initially been managed as open wounds to allow for granulation tissue formation prior to skin graft placement. Granulation tissue functions as a protective barrier for underlying tissue and provides nourishment to the applied skin graft.[11] A delay between initial tumor excision and graft placement also allows time for histologic examination results to be obtained prior to graft application, providing an opportunity for surgical revision if inadequate margins are found. Alternatively, free grafting has been used to reliably reconstruct the skin over extensive surgical wounds without the need for a delay to allow granulation tissue to form.[1] However, to the authors' knowledge, there are no reports directly comparing the outcome of free-skin graft application between fresh wound beds and beds of granulation tissue.

The purpose of the study reported here was to compare the percentage of graft survival, graft outcomes, and complication rates between dogs that received full-thickness, meshed free-skin grafts following tumor excision on the distal aspects of the limbs by 2 methods: grafting onto the fresh wound bed immediately after tumor excision (ie, a single-session procedure) and grafting after granulation tissue was allowed to form in the wound bed (ie, a staged procedure). We hypothesized that the final outcome of graft placement would not differ between treatment groups.

Materials and Methods

Case selection

Dogs were eligible for study inclusion if they had a full-thickness, meshed free-skin graft applied to the distal aspect of a limb after tumor excision. Dogs were grouped according to the graft technique, with those that had the graft applied to the wound bed immediately after tumor excision (during the same anesthetic episode) assigned to the single-session procedure group and those that had the graft applied after granulation tissue was present throughout the recipient wound bed assigned to the staged procedure group. Dogs were excluded if the skin graft was performed for any reason other than tumor excision or if the medical records were incomplete. The minimum information required in the records included results of preoperative diagnostic tests, a complete surgery report, a histology report, and follow-up information until the time the graft was reported as healed. Dogs were not excluded on the basis of tumor type (benign vs malignant, as determined by histologic analysis).

Medical records review

Electronic medical records of Veterinary Surgical Centers, Vienna, Va, were searched to identify all dogs that underwent free-skin graft placement after tumor excision between January 1, 2013, and December 18, 2018. The search terms included skin graft and skin reconstruction, and all medical records were evaluated for the inclusion criteria. Data retrieved from the medical records included signalment; results of diagnostic tests performed prior to surgery; comorbidities; procedure type; tumor location; donor site, recipient site, and surface area of the graft; procedures performed concurrently with tumor excision or graft placement; surgeon identification; results of histologic analysis for the excised tumor, including evaluation of margins; perioperative and postoperative antimicrobial administration after graft placement; type of external coaptation; total number of bandage applications after tumor excision; percentage of graft survival (ie, proportion of the original graft that remained viable); graft outcome; postoperative complications; and time to complete healing.

Graft viability was estimated on the basis of subjective assessment of the graft by the surgeon at each recheck evaluation and recorded in the medical record. Graft outcome was evaluated according to the percentage of viable tissue (ie, percentage of graft survival) at the time graft healing was considered complete; outcome was classified as successful if there was full-thickness graft viability over ≥ 75% of the original graft as assessed by surface area and was classified as unsuccessful otherwise.[2] Postoperative complications were recorded from the time of hospital discharge after graft placement until the graft site was considered completely healed as indicated in the medical records. Complications were recorded as minor if additional surgical intervention was not required (conditions that resolved with conservative management) or as major if additional surgical intervention was needed for resolution.[20] Complete healing was determined subjectively by the attending surgeon. Criteria for healing included adherence of the graft to underlying tissue and surrounding skin and epithelialization over previous graft fenestrations. Time to complete healing was calculated from the time of graft placement regardless of group assignment. For dogs in the staged procedure group, the interval between tumor excision and skin grafting and the number of bandage applications between surgeries were additionally recorded.

Surgical technique

All tumors were excised completely with lateral margins typically 0.1 to 3 cm wide depending on the size, location, and cytologic diagnosis of the tumor and the surgeon's discretion. The deep margin included an intact layer of fascia, if possible, while preserving vital structures. All samples were fixed in neutral-buffered 10% formalin solution and submitted to a reference laboratory[a] for histologic analysis, including measurement of the lateral tumor margins. For the staged procedure group, the wounds were initially left open and external coaptation was applied; bandages were changed weekly until a healthy bed of granulation tissue was observed. For both groups, the proximal or distal (or both) skin edges of the surgical wound were advanced to reduce overall defect size if it could be done without creating substantial tension. The decision to apply the graft at the time of tumor excision or in a staged procedure was made on the basis of surgeon preference, discussion with the dog owners prior to surgery, and intraoperative evaluation of the wound bed.

Skin grafts were harvested and prepared immediately prior to application. After estimation of the size of the surgical wound, a skin region of approximately the same size was marked at the shaved and aseptically prepared donor site with a sterile pen, and the full skin thickness was incised with a scalpel blade. The length and width of the graft was measured with a sterile ruler, and the graft surface area was roughly calculated as the area of an oval with 2 axes of symmetry.

The donor site was chosen at the surgeon's discretion but involved a flat area of the trunk, thigh, or shoulder region adjacent to the affected limb in each instance. The skin graft was elevated and removed from the underlying subcutaneous tissues, and the donor site was closed routinely. All muscle and subcutaneous fat were removed from the graft with Metzenbaum scissors until the bases of the hair follicles were visible through the dermis, creating the described characteristic cobblestone appearance.[10] Meshing of the graft was performed with approximately 0.5-cm-long incisions in parallel, staggered rows. The prepared graft was then placed on the recipient bed with hair follicles oriented to match those of the surrounding skin. The edges of the skin graft and recipient site were apposed with nonabsorbable monofilament suture in a simple interrupted pattern. The grafts were placed in a manner to ensure normal skin tension that allowed mild mesh slit expansion. In some patients, simple interrupted tacking sutures were also placed across the center of the graft to ensure appropriate graft-bed contact.

Postoperative care

All dogs received perioperative antimicrobial administration. Postoperative antimicrobial administration and topical treatments varied depending on surgeon preference. All skin grafts were covered with a nonadherent wound dressing and a modified Robert Jones bandage. The incorporation of a splint was recorded when applicable. Owners were instructed to keep their dog's activity restricted and to apply an Elizabethan collar when the dog could not be directly monitored. After skin graft application, the frequency of bandage changes and timing of bandage removal were dependent on surgeon preference, appearance of the graft, and condition of the bandage.

Statistical analysis

Outcome variables of interest included the percentage of graft survival, graft outcome (success vs failure), postoperative complications (yes vs no), and time (in days) from graft placement to complete healing. The primary exposure of interest was the procedure type (single session vs staged procedure). Variables assessed as potential prognostic or confounding factors included the dogs' age, body weight, and sex and reproductive status (neutered or sexually intact); comorbidities (yes vs no); limb affected (thoracic vs pelvic); side of the affected limb (left vs right); graft donor site (shoulder region, thorax, flank, or thigh); graft recipient site (relative to the carpus or tarsus; proximal to, directly over, or distal to the joint); surface area of the graft (in square centimeters); concurrent procedures performed (yes vs no); surgeon identification; narrowest lateral histologic margin ($\geq$ 0.1 cm [deemed complete for study purposes] vs $<$ 0.1 cm) for the excised tumor; antimicrobial administration (drug selected); incorporation of a splint (yes vs no); and total number of bandage applications.

Probability plot examination of numeric data revealed that age, body weight, and interval between surgeries each followed a normal distribution, whereas graft surface area, total number of bandage applications, percentage of graft survival, and time to complete healing were skewed. Normally distributed data were summarized as mean ± SD, skewed data were reported as median and range, and categorical data were reported as counts and percentages. Data were compared between the single-session and staged procedure groups with the 2-sample *t* test (age and body weight), Wilcoxon rank sum test (graft surface area, number of bandage applications, percentage of graft survival, and time to complete healing), and Fisher exact test (sex and reproductive status, comorbidities, limb affected, side affected, graft donor site, graft recipient site, concurrent procedures, surgeon identification, antimicrobial administration, splint incorporation, histologic margin, graft outcome, and postoperative complications).

Multivariable analysis for association between potential prognostic factors and graft outcome was not attempted because of the small number of graft failures. All analyses were performed with commercial software.[b]

Results

Fifty-four dogs underwent full-thickness, meshed free-skin graft placement after excision of a tumor on the distal aspect of a limb during the study period. Two dogs were excluded from the study; one was euthanized shortly after surgery for reasons unrelated to skin graft placement, and the other had incomplete medical records. Of the 52 dogs included in the study, 30 were included in the single-session procedure group, and 22 were included in the staged procedure group. For dogs in the staged procedure group, the mean ± SD time between tumor excision and graft placement was 14.3 ± 4.0 days, and all dogs in this group had evidence of healthy granulation tissue throughout the recipient wound bed at the time of skin graft placement.

Signalment data for dogs in each group were summarized **(Table 1)**. Dogs in the single-session procedure group were significantly (P = 0.045) older than dogs in the staged procedure group. Body weight and sex and reproductive status did not differ between

Table 1—Results of intergroup comparison of signalment-related variables and presence of comorbidities for 52 client-owned dogs that underwent full-thickness, meshed free-skin graft placement for closure of a surgical wound after tumor excision from the distal aspects of the limbs between January 1, 2013, and December 18, 2018.

Variable	Single-session procedure (n = 30)	Staged procedure (n = 22)	*P* value
Age (y)	10.9 ± 2.9	9.2 ± 2.9	0.045
Weight (kg)	25.4 ± 12.3	25.1 ± 12.9	0.924
Sex and reproductive status			0.328
Neutered female	18 (60)	10 (45)	
Neutered male	11 (37)	12 (55)	
Sexually intact male	1 (3)	0 (0)	
Sexually intact female	0 (0)	0 (0)	
Comorbidities			0.586
Yes	10 (33)	8 (36)	
No	20 (67)	14 (64)	

Dogs in the single-session procedure group had the skin graft placed immediately after tumor excision (during the same anesthetic episode). Dogs in the staged procedure group had the graft applied after granulation tissue was present throughout the recipient wound bed. Data are reported as mean ± SD or number (%) of dogs.

Table 2—Results of intergroup comparison of surgical variables for the dogs in Table 1.

Variable	Single-session procedure (n = 30)	Staged procedure (n = 22)	*P* value
Limb affected			0.762
Thoracic	22 (73)	15 (68)	
Pelvic	8 (27)	7 (32)	
Side of affected limb			0.269
Right	14 (47)	14 (64)	
Left	16 (53)	8 (36)	
Graft donor site			0.433
Shoulder region*	17 (57)	13 (59)	
Thorax*	7 (23)	3 (14)	
Flank	2 (7)	0 (0)	
Thigh*	4 (13)	6 (27)	
Graft recipient site relative to carpus or tarsus			0.277
Proximal to joint	17 (57)	10 (45)	
Directly over joint	9 (30)	5 (23)	
Distal to joint	4 (13)	7 (32)	
Graft surface area (cm^2)	23.3 (4.9–112)	37.5 (8–156)	0.018
Concurrent procedures			0.023
Yes	13 (43)	17 (77)	
No	17 (57)	5 (23)	
Surgeon			< 0.001
A	11 (37)	0 (0)	
B	8 (27)	0 (0)	
C	6 (20)	5 (23)	
D	3 (10)	0 (0)	
E	1 (3)	0 (0)	
F	1 (3)	0 (0)	
G	0 (0)	17 (77)	
Narrowest histologic margin†			0.543
≥ 0.1 cm	18 (60)	13 (59)	
< 0.1 cm	12 (40)	9 (41)	

Data are reported as median (range) measurement or number (%) of dogs.
*Donor site was the lateral aspect of the specified region. †Narrowest lateral margin measurement.

groups. Comorbidities for the single-session procedure group included degenerative valvular disease (n = 8), seizures (1), and arrhythmogenic right ventricular cardiomyopathy (1). Comorbidities for the staged procedure group included degenerative valvular disease (n = 3), seizures (3), hypothyroidism (1), and a benign splenic mass (1). The frequency of comorbidities did not differ between groups.

Surgical and treatment-related data for each group are provided **(Tables 2 and 3)**. Variables related to the locations of the graft donor and recipient sites did not differ between groups. Graft surface area was significantly ($P = 0.018$) larger for the staged procedure group than for the single-session procedure group. A significantly ($P = 0.023$) greater proportion of dogs that underwent a staged procedure had an-

Table 3—Results of intergroup comparison of postoperative variables for the dogs in Table 1.

Variable	Single-session procedure (n = 30)	Staged procedure (n = 22)	*P* value
Postoperative antimicrobial administration*			0.235
Cefpodoxime	22 (73)	11 (50)	
Cephalexin	5 (17)	7 (32)	
Amoxicillin–clavulanic acid	1 (3)	3 (14)	
None	2 (7)	1 (5)	
Splint incorporated			0.004
Yes	18 (60)	21 (95)	
No	12 (40)	1 (5)	
No. of bandage applications†	4 (2–8)	9 (5–16)	< 0.001
Graft survival (%)	100 (0–100)	97 (0–100)	0.236
Graft outcome‡			0.439
Successful	27 (90)	18 (82)	
Unsuccessful	3 (10)	4 (18)	
Postoperative complications*			0.171
Yes	13 (43)	14 (64)	
No	17 (57)	8 (36)	
Time to complete healing (d)*	29.5 (16–83)	51 (27–126)	< 0.001

Data are reported as median (range) value or number (%) of dogs.

*Evaluated from the time of graft placement in both groups. †Evaluated from the time of tumor excision for both groups. ‡A successful outcome was defined as full-thickness viability of ≥ 75% of the original graft (assessed by surface area).

other procedure performed concurrently. Additional procedures for dogs in the single-session procedure group included additional cutaneous tumor excisions (n = 9), lymphadenectomy (1), splenectomy (2), and tonsillectomy (1). For dogs in the staged procedure group, concurrent procedures included additional tumor excision (n = 5), lymphadenectomy (16), and digit amputation (1), with some dogs having > 1 concurrent procedure. Surgeries were performed by 7 surgeons during the study period, and the proportion of surgeries performed by each surgeon differed significantly ($P < 0.001$) between groups. Most dogs had histologic margins ≥ 0.1 cm, and the proportions of dogs with this finding did not differ between groups.

All dogs in both groups received perioperative cefazolin treatment (22 mg/kg [10 mg/lb], IV). Postoperative oral antimicrobial treatment was administered to 28 of 30 (93%) dogs in the single-session procedure group and 21 of 22 (95%) dogs in the staged procedure group. There was no intergroup difference in postoperative antimicrobial treatments (Table 3). After surgery, a significantly ($P = 0.004$) higher proportion of dogs in the staged procedure group had a splint incorporated into the bandage, compared with the proportion in the single-session procedure group. The total number of bandage applications in the staged procedure group was also significantly ($P < 0.001$) higher than that in the single-session procedure group. A mean of 4 bandage applications (range, 1 to 9) was performed between the time of tumor excision and time of graft placement in the staged procedure group.

The median percentage of graft survival was high in both groups, and neither the percentage of graft survival nor the proportion of dogs with a successful graft outcome differed between groups (Table 3). However, the time to complete healing after graft placement was significantly ($P < 0.001$) longer for dogs in the staged procedure group.

No major postoperative complications were observed in either group. Minor complications included skin injury from bandages (eg, superficial abrasion from bandage displacement or pressure injuries; n = 4), interdigital dermatitis (5), self-trauma at the graft site (3), and diarrhea (1) in the single-session procedure group and skin injury from bandages (3), interdigital dermatitis (6), self-trauma at the graft site (5), and mildly decreased carpal flexion (1) in the staged procedure group. The dog that had mildly decreased carpal flexion also had substantial self-trauma to the graft site that resulted in complete necrosis of the graft, and the wound was allowed to heal completely by second intention. There was no difference between groups in the proportion of dogs that developed minor complications (Table 3).

Discussion

Results of the present study indicated no significant differences in the percentage of graft survival or the rate of successful graft outcome between dogs that underwent full-thickness, meshed free-skin graft placement in a single-session procedure (during the same anesthetic episode) or in a staged procedure (after formation of granulation tissue in the surgical wound bed) following tumor removal from the distal aspect of a limb. Both techniques had a high rate of successful graft outcome, with ≥ 75% full-thickness graft viability in 27 of 30 (90%) and 18 of 22 (82%) dogs in the single-session and staged procedure groups, respectively. The classification of a successful graft in the present study was derived from a report by Riggs et al.[2] This definition for successful grafting was based on clinical experiences in which loss of viability for > 25% of graft surface area more commonly required additional therapeutic intervention.[1,2,13,19] Our results suggested that both techniques can be considered appropriate methods for full-thickness, meshed free-skin graft placement. The overall success rates in the present study were higher, compared with those previously reported.[2,13,21] Riggs et al[2] reported successful graft outcomes for 12 of 32 (38%) dogs when placed on the distal aspect of limbs. In an early experimental study, McKeever and Braden[21] found a mean viability of 59.1% (relative to the original graft surface area) for grafts placed on granulating forelimb wounds of dogs.

The reported time to complete healing after graft placement was significantly longer and the number of total bandage applications after tumor excision was significantly higher for dogs that underwent staged versus single-session procedures in the present study. Investigators of an experimental study[13] of skin grafts in healthy dogs found that full-thickness, meshed free-skin grafts (with truncal placement) had a mean viability of 81% on fresh surgical wounds, and that grafting on a granulation bed may result in poorer revascularization than grafting onto a fresh wound bed. The shorter time to complete healing observed in the single-session procedure group of the present study may have been partly attributable to more rapid or robust revascularization associated with placement on the fresh wound bed. Single-session meshed free-skin graft placement may also result in reduced cost for owners if only 1 surgery and anesthetic episode are needed and fewer bandage changes are required. Results of a previous study[9] indicated that wounds along the distal aspects of limbs healed completely by second intention within a median of 53 days. This was similar to the median time to complete healing found for grafts placed in a staged manner in the present study (51 days). However, compared with second-intention healing, advantages of placing a skin graft include improved cosmesis, less wound contracture, and a more robust wound cover that can prevent long-term intermittent epidermal disruption.[9]

The surface area of the graft was significantly larger for dogs that underwent a staged procedure, compared with that for dogs that underwent a single-session procedure, in the study reported here. Possible causes for the larger surface area of grafts placed in staged procedures might have been factors such as tumor size or expansion of the wound bed during initial wound management while waiting for granulation tissue formation, which has been previously described.[9] In theory, larger defects in these dogs may have contributed to the longer overall healing time for the group, compared with that found for dogs that had single-session procedures. Although dogs that underwent staged procedures required larger skin grafts, the percentage of graft survival and proportion of dogs with successful graft outcomes did not differ from those for the single-session procedure group.

There was no difference in complication rates between groups in our study, and all complications were considered minor (ie, these did not require surgical intervention). However, the overall complication rate for the study sample was high, with 13 of 30 (43%) and 14 of 22 (64%) dogs in the single-session and staged procedure groups, respectively, having complications. These complication rates were similar to that reported by Riggs et al,[2] where the overall complication rate for dogs and cats was 27 of 54 (50%) and included skin graft failure, donor site dehiscence, and bandage-induced complications. Of the complications observed in the present study, interdigital dermatitis was the most common for both groups, followed by bandage impediments or self-mutilation at the graft site. These findings highlighted the importance of appropriate bandage placement and client education in regard to bandage management. Splint augmentation of a soft-padded bandage was performed at the surgeon's discretion and was common (39/52 [75%] dogs), more so for dogs of the staged procedure group (21/22 [95%]) than dogs of the single-session procedure group (18/30 [60%]). It may be postulated that if the graft recipient site is not subject to substantial movement, a splint may not be necessary for healing, and a modified Robert Jones bandage may be sufficient in such cases. However, clinical judgment at the time of graft placement is important because it is well known that appropriate immobilization is vital for graft healing.[2,4,22] Other studies[3,14] have suggested that negative pressure wound treatment applied to skin grafts in people and dogs may improve graft acceptance by reducing fluid accumulation and motion at the wound bed. Results of 1 study[14] showed that granulation tissue appears earlier, open meshes close more rapidly, and the percentage of graft necrosis is lower when negative pressure wound treatment is used, compared with findings when bolster dressings are applied after graft placement. Negative pressure wound treatment was not used in dogs of the present study; however, this treatment may be an alternative for postoperative management of meshed skin grafts that are in locations where applying external coaptation is difficult.

Dogs in the staged procedure group had a higher number of procedures performed concurrently with graft placement, compared with dogs in the single-session procedure group. Commonly performed concurrent procedures included additional cutaneous tumor excisions and lymphadenectomies performed for complete staging purposes or for concerns about metastatic disease on the basis of preoperative cytologic evaluation. During the plasmatic imbibition phase of engraftment, venous and lymphatic drainage improve.[4,23] New lymphatic vessels are formed to provide lymphatic drainage of the graft within 4 or 5 days after placement, resulting in regression of edema and eventual progression to the inosculation phase of engraftment.[4,23] It is possible that concurrent lymphadenectomy may reduce lymphatic drainage during the initial phases of engraftment, contributing to a prolonged plasmatic imbibition phase and subsequently overall prolonged healing time. Although the potential association was not investigated by statistical analysis, dogs in our study that had staged procedures more commonly underwent lymphadenectomy (16/22 [73%]) than dogs that had single-session procedures (1/30 [3%]). In theory, this could have contributed to the former group having significantly greater time to complete healing than the latter group. Dogs that had single-session procedures were significantly older than those that had staged procedures, although the median difference was fairly small (1.7 years). The clinical relevance of this difference was unclear, but the percentage of graft survival and graft outcome did not differ between groups. Previous investigations[1,8,10] did not reveal significant associations between patient age and graft outcome.

One limitation of the present study was the influence of surgeon preference to perform skin grafts as part of a single-session or staged procedure, resulting in significant differences in the proportion of each procedure type performed by each surgeon. This limitation likely resulted in some degree of variability in surgical technique and postoperative wound management. However, all procedures were performed by board-certified surgeons who used the standard reported method of full-thickness, meshed free-skin grafting,[10,17,18] and slight variances in surgical technique and wound management may have provided a more accurate representation of skin graft harvesting and placement in various clinical settings. Additionally, the percentage of graft survival and complete healing were subjectively assessed, and different surgeons may have had different opinions in regard to the degree of graft survival or characteristics of a completely healed skin graft. Thus, interobserver variability may have resulted in overestimation or underestimation of these variables. Potential variability in these assessments might have been reduced by use of high-resolution digital photographs of the grafts and assessment with a scale at each evaluation to more objectively determine the percentage of the graft that remained viable.[1,14] An additional limitation of our study was its retrospective nature, which meant that data reporting relied on the accuracy of medical records, and postoperative management such as the frequency of examinations and bandage changes was not standardized. For dogs that underwent staged procedures, all bandages were changed weekly until a healthy bed of granulation tissue was noted. However, it has been reported that granulation tissue begins to form between 3 and 7 days after wound formation,[10,14] suggesting that more frequent bandage changes may have allowed earlier detection of granulation tissue formation and reduced the overall time to graft placement for dogs that had staged procedures. This, in turn, might have influenced the time to complete healing for this group. Additionally, the variation in graft donor sites introduced a potential for variation in grafted skin thickness. A thicker skin graft would be considered more robust for protection from normal abrasion than a thinner skin graft.[12] However, there would also be a greater distance for the diffusion of oxygen and nutrients during the early grafting stages for thicker skin, which could have a negative impact on graft survival.[12] Although the sample size for our study was fairly large, compared with previous studies[1,2,13,21] that investigated meshed, full-thickness skin graft placement in veterinary patients, it was small overall. Additionally, the very small number of cases in which graft failure developed (7/52 [13%] overall, with 3 and 4 in the single-session and staged procedure groups, respectively) prevented multivariable analysis for assessment for statistical associations between potential prognostic factors and graft outcome for the 2 groups. Riggs et al[2] reported that anatomic location of the skin defect was a prognostic indicator of graft outcome, with skin grafts applied to the antebrachium having a poorer prognosis. Anatomic location of the grafts did not differ between groups in the present study, but no other conclusions could be made regarding this variable.

To the authors' knowledge, the present study was the first to directly compare management and outcome variables for dogs that underwent meshed, full-thickness free-skin graft placement as a single-session procedure at the time of tumor excision versus as a staged procedure after granulation tissue had formed. The results of this study suggested that both techniques are effective for a successful outcome. Prospective clinical studies that include predefined postoperative management and outcome measures and a larger number of patients are needed to allow a more accurate comparison of the 2 methods and investigation of associations between patient- or graft-related factors and graft outcome.

Acknowledgments

No third-party funding or support was received in connection with this study or the writing or publication of the manuscript. The authors declare that there were no conflicts of interest.

The authors thank Dr. Stephen Werre at Virginia-Maryland College of Veterinary Medicine for contributions to the statistical analysis.

Footnotes

a. Idexx Laboratories, Glen Burnie, MD.
b. SAS, version 9.4, SAS Institute Inc, Cary, NC.

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