http://dx.doi.org/10.1590/1678-4162-12656

Arq. Bras. Med. Vet. Zootec., v.74, n.5, p.869-880, 2022

Use of omentum flap for induction of free skin graft healing

[*Utilização de flap de omento para indução da cicatrização de enxertos cutâneos*]

A.L. *Pascoli*[1,2], N.P. *Reis Filho*[1], M.G.P.A. *Ferreira*[1], R.B. *Viéra*[1], S.L. *Negrão*[2], D.I. *Yamada*[1], G.M. *Magalhães*[3], R.A.R. *Uscategui*[1,4], J.S. *Barata*[1], J.L. *Laus*[1], A.B. *De Nardi*[1]

[1]Universidade Estadual Paulista "Júlio de Mesquita Filho", (Unesp), Jaboticabal, SP, Brasil
[2]Universidade Regional de Blumenau (FURB), Blumenau, SC, Brasil
[3]Universidade de Franca, Franca, SP, Brasil
[4] Grupo de Investigación INCA-CES. Faculdad de Medicina|Veterinaria y Zootecnia, Universidad CES, Medellín, Colombia.

ABSTRACT

The objective of this study was to assess healing induction of free skin grafts following transposition of omental flap through a subcutaneous tunnel to the recipient bed. Macroscopic and microscopic evaluations were performed. Nineteen piglets were used. Two surgical wounds were created of each subject. The graft removed from the left side (LS) was placed on the right side (RS) without the omental flap in the graft-bed (control group-CG). On the LS, an omental flap was placed between the graft removed from the RS and the recipient bed (omentum group-OG). Macroscopic evaluations showed edema, which gradually decreased on both groups. Suture dehiscence was highest at day 10 compared to other days in both groups. The CG had a higher incidence of unvitalized tissue compared to OG, although no difference was found among days of postoperative evaluation. The presence of unvitalized tissue was seen on 32% on OG and 53% on CG. Microscopic evaluations revealed higher collagenization, reepithelization, keratinization and less swelling in the OG compared to CG. In conclusion, mesh skin grafts evolved satisfactorily in swine even in newly created bedding without granulation tissue, but with appropriate vascularization. The omentum flap provided better macroscopic and microscopic outcomes regarding graft integration.

Keywords: angiogenesis, reconstructive surgery, flap, vascularization

RESUMO

O objetivo deste estudo foi verificar a indução da cicatrização de enxertos cutâneos em malha após a utilização de flap de omento transposto através de túnel no subcutâneo até o leito receptor. Avaliações macroscópica e microscópica foram realizadas. Foram utilizados 19 suínos. Duas feridas cirúrgicas foram criadas em cada animal. O enxerto removido do lado esquerdo (LE) foi fixado do lado direito (LD), sem a presença do flap de omento entre o enxerto e o leito receptor (grupo controle - GC). No LE, foi fixado um flap de omento entre o enxerto cutâneo removido do LD e o leito receptor (grupo omento - GO). As avaliações macroscópicas mostraram que o edema diminuiu gradativamente em ambos os grupos. A deiscência foi maior no dia 10 em comparação aos demais dias, em ambos os grupos, entre os diferentes dias de avaliação. Foi verificada a presença de tecido desvitalizado em 32% do GO e em 53% no GC. Foi observada, na avaliação microscópica, maior colagenização, reepitelização, queratinização e menor edema no GO, quando comparado ao GC. Concluiu-se, com este estudo, que enxertos cutâneos em malha evoluíram satisfatoriamente em suínos, mesmo em leito receptor recém-criado e sem presença de tecido de granulação, desde que vascularizado, e que o flap de omento propiciou melhores resultados macro e microscópicos relativos à integração do enxerto.

Palavras-chave: angiogênese, cirurgia reconstrutiva, retalho, vascularização

Corresponding author: anapascoli@hotmail.com
Submitted: January 16, 2022. Accepted: April 27, 2022.

INTRODUCTION

Skin grafting comprises the transfer of a free skin segment to a distant receptor site without its vascular supply. Therefore, the viability of skin grafting is assured only when there is adequate blood supply to the receptor bed (Teixeira Neto *et al*., 2010), absorption of tissue fluids, and growth of new blood vessels in the grafted skin (Swaim, 2007; Macphail, 2014). All these factors contribute to establish a barrier in the open wound, mainly its extremities, where wound closure by apposition or use of flaps is challenging (Pavletic, 2010; Macphail, 2014).

Skin grafts have been widely used in Medicine, but their use is limited in Veterinary Medicine, because before being submitted to the grafting procedure, the wound must receive adequate treatment, so that it provides the formation of viable and infection-free granulation tissue in the receiving bed (Fowler, 2006). Some studies have been reported in relation to the application of skin grafts in open wounds after the formation of granulation tissue (Brockman *et al*., 1996; Lascelles *et al*., 1998; Gray, 2005; Fowler, 2006), however few studies on the use of skin grafts to cover freshly created surgical wounds (Tong; Simpson, 2012; Reis Filho *et al*., 2017).

Tong and Simpson (2012) used a skin graft immediately after resection of extensive neoplasms in the distal limb of seven dogs and noted complete graft survival in three dogs and partial survival in four dogs with superficial epidermal necrosis in some areas. Another recent study was done with 52 dogs and compared outcomes after application of full-thickness, meshed free-skin grafts in single-session (Group 1) versus delayed procedures (Group 2) after tumor excision on the distal aspects of the limbs, and concluded that patients in group 1 required a lower time of bandage application, and short time to complete healing than group 2. They also related that the percentage of graft survival, graft outcome and complication rate did not differ between groups (Boanventura; Ganjei, 2021).

Some studies have been published regarding the use of omentum flap or graft to induce angiogenesis, lymphatic drainage, protection and fighting infection, and tissue reconstruction. The ability to block intra-abdominal inflammation (due to its rich source of mesothelial cells) and absorptive capability have rendered the omentum the role of 'abdominal guardian' (Ruffini, 1992).

In view of the properties of the omentum, this study aimed to assess the feasibility of transposing an omentum flap through a subcutaneous tunnel to induce healing of mesh skin grafts in swine, and to investigate macroscopic characteristics related to healing among different treatments (omentum versus control group) and days of postoperative evaluations (3, 7, 10 and 14).

METHODS

Nineteen 45-day old piglets (*Sus scropha domesticus*) of both sexes (Large White × Landrace) and weighing 18-22 kg were enrolled in the study. Subjects were deemed healthy based on complete blood count. The study was approved by the local Ethics Committee for Animal Usage (protocol No. 3.278, March 2015).

Animals were fasted for 6 hours prior to surgery. Premedication comprised intramuscular (IM) administration of acepromazine (0.05mg kg-1), midazolam (0.5mg kg-1) and ketamine (15mg kg-1). After ten minutes, anesthesia was induced with intravenous (IV) propofol (2mg kg-1) and maintained with isoflurane. Animals were intubated (6.5 to 7.5mm endotracheal tube) after topical instillation of 10% lidocaine.

Prophylactic antibiotic therapy comprised IM administration of a combination of procaine benzylpenicillin, benzathine and dihydrostreptomycin (1mL 10kg-1). Postoperative analgesia comprised IM tramadol hydrochloride (4mg kg-1) and metamizole (25mg kg-1). During surgery, all subjects received IV infusion of lactated ringer solution at 6mL kg-1 hour-1 through the auricular vein (marginal ear vein), and the auricular artery was catheterized for invasive arterial blood pressure measurement.

The ventral thorax was clipped and prepared for aseptical surgery on both sides with 2% chlorhexidine degermant and 70% ethyl alcohol. Animals were positioned in dorsal recumbency for draping. A 40×40 mm wound was created on each side of the thorax between mammary glands M1 and M2 using sharp dissection with a No. 20 blade and Metzenbaum scissors over a

previously drawn model made from an x-ray sheet. The surface of the skin graft was marked with a surgical pen so it would be applied following the direction of hair growth (Fig. 1 and 2).

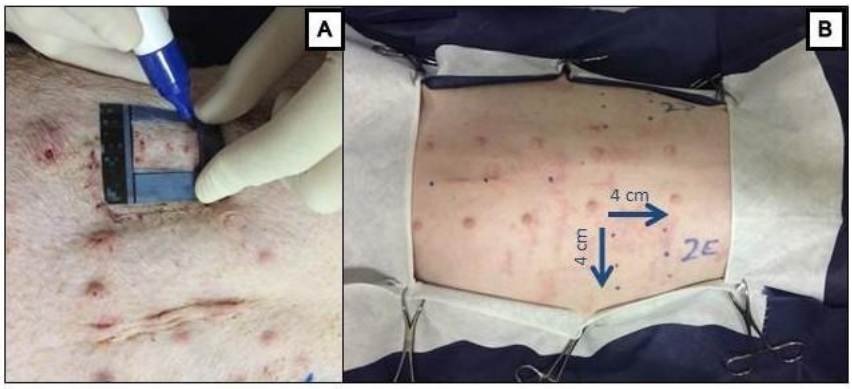

Figure 1. Images depicting the surgical procedure for skin grafting in swine, caudocranial direction. A) Skin marking with surgical pen and model made from an x-ray sheet. B) Delimitation of graft for both treatments on subject No. 2 (2E – omentum flap group; 2D – control group) and ventral incision line (*three aligned dots*) to access the omentum in the abdominal cavity. E, left side; D, right side.

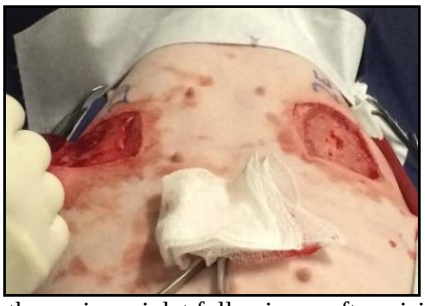

Figure 2. Depiction of the ventral thorax in a piglet following graft excision on both sides/treatment groups (omentum flap and control group).

The receptor site was protected with sterile moistened gauze sponges during preparation of the graft. The graft was prepared through complete removal of subcutaneous tissue using Metzenbaum scissors. Some 3-mm incisions spaced 5 mm apart were made on the long axis of the graft using a No. 11 blade (Fig. 3).

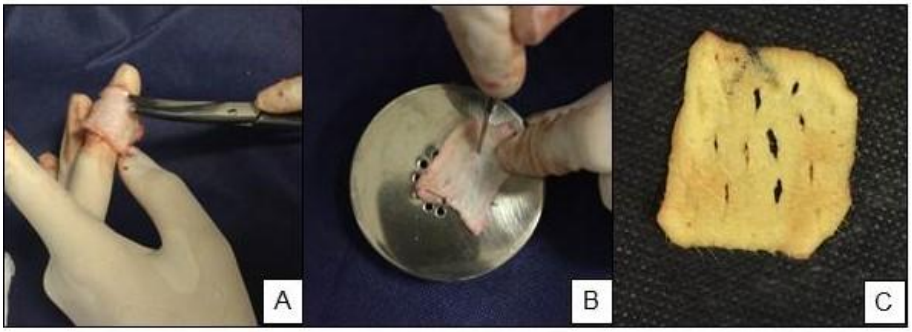

Figure 3. Images depicting the preparation of a mesh skin graft from swine skin. A) Removal of subcutaneous tissue using Metzenbaum scissors. B) Longitudinal 3-mm incisions being made on the graft. C) Completion of mesh skin graft preparation.

The skin graft harvested from the LS was placed on the right ventral thorax without the omentum flap. On the LS, the skin graft harvested from the right thorax was placed over an omentum flap fixed with four absorbable multifilament sutures in a simple interrupted pattern (No. 3-0 multifilament polyglactin-910 suture). The subcutaneous tissue was excised from the receptor site using Metzenbaum scissors before placement of the omentum flap (LS) and the skin graft (RS).

The omentum flap was obtained through a 5-cm pre-umbilical incision on the linea alba. The omentum was carefully manipulated to prevent its detachment from the greater stomach curvature, which would impair blood supply. The omentum was then transposed to the receptor site through a subcutaneous tunnel from the cranial-most portion of the linea alba to proximal-most portion of the defect using a Kelly hemostat.

The rectus abdominis muscle was reattached using nonabsorbable monofilament suture (No. 0 monofilament nylon) in a cruciate pattern up to the cranial-most portion of the abdominal gap. The gap for omentum transposition was created with enough space to prevent strangulation of the flap, but not so open as to allow evisceration. Skin closure was performed with nonabsorbable monofilament suture (No. 3-0 monofilament nylon) in a simple interrupted pattern. The omentum flap was covered with a gauze sponge moistened with saline during abdominal closure to avoid vasoconstriction.

The edges of the graft were fixed to the receptor site using nonabsorbable monofilament suture (No. 3-0 monofilament nylon) at the position previously marked with the surgical pen with simple interrupted pattern, starting at each corner of the graft (Fig. 4).

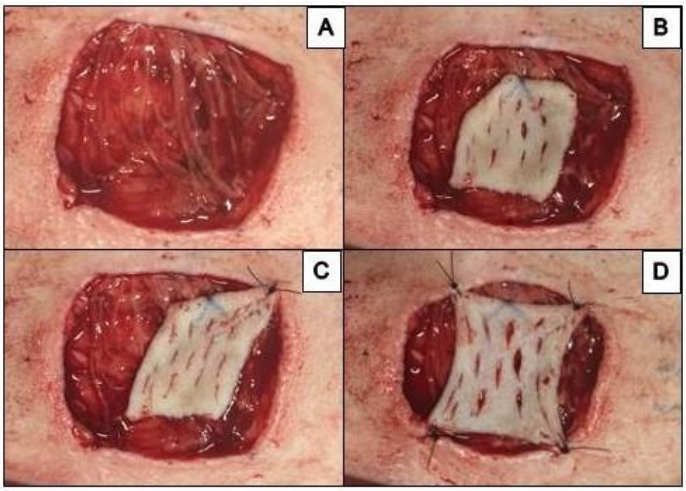

Figure 4. Images depicting graft fixation to the receptor site over an omentum flap in swine. A) Receptor bed prepared with an omentum flap transposed through a subcutaneous tunnel and fixed using interrupted sutures at the four corners. B) Skin graft from the right site (RS) positioned over the omentum flap. C and D) Skin graft suture with simple interrupted pattern, starting at each corner of the graft. Note the marking on the graft made previously with a surgical pen to correctly place the graft according to the direction of hair growth.

The surgical approach used in this study was simple, quick, and easily performed over approximately 30 minutes on every subject and surgery was performed by the same two surgeons, simultaneously (Fig. 5). No perioperative complications were observed during subcutaneous transposition of the omentum flap.

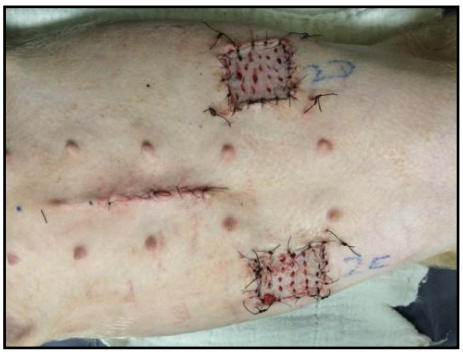

Figure 5. Image depicting the final aspect of skin grafting in swine.

Immediately following completion of the surgery, sterile gauze sponges were placed on the graft in a tie-over dressing with fixation of four shoelaces to No. 2-0 nonabsorbable sutures applied at approximately 1 cm from the edges of the surgical wound and after, the thorax was wrapped with elastic gauze and adhesive tape stirrups (Fig. 6). Bandages were replaced at 72 hours, 7 and 10 days after surgery.

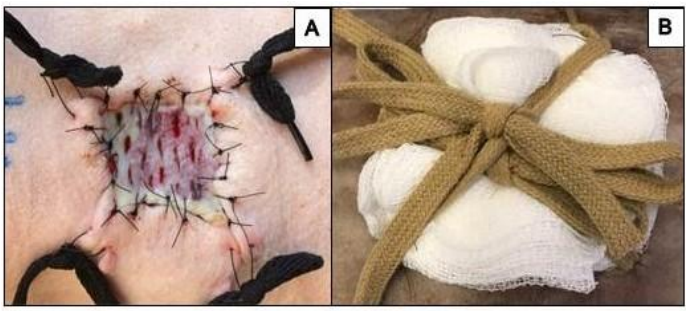

Figure 6. Images depicting a postoperative tie-over dressing after skin grafting in swine. A) Fixation of four shoelaces to No. 2-0 nonabsorbable sutures applied at approximately 1 cm from the edges of the surgical wound. B) Placement of a thick layer of sponges over the wound and fixation of the dressing with the shoelaces.

Another IM dose (1mL kg^{-1}) of the same antibiotic was given at day 3, and analgesia comprised methadone (0.3mL kg^{-1}) and metamizole (25mL kg^{-1}) every 12 hours for 3 consecutive days following surgery. Skin sutures were removed at day 14 after surgery and a sample for biopsy was obtained at the same day. The skin sample was harvested from the lateral portion of the wound at the intersection between the graft and the adjacent skin. Animals were housed until complete healing of biopsy wounds and were donated to a swine farmer.

Macroscopic evaluations were performed at every bandage change, days 3, 7, 10 and 14, by the same blinded investigator. Grafts were assessed for swelling, drainage intensity, suture dehiscence and unvitalized tissue using scores corresponding to percentages: 0 (absent) for 0%, 1 (mild) for ≤25%, 2 (moderate) for 25 to 75%, and 3 (severe) for ≥75%; for aspect of drainage using classifications: absent, serous, purulent, or hemorrhagic and for graft coloration: pale, roseous, bluish or blackish.

Tissues sent for biopsy were fixed in 10% buffered formaldehyde for 48 hours and then kept in 70% ethyl alcohol. Biopsies were carried out following standard histopathology procedure with dehydration in increasing concentrations of alcohol and diaphanization in xylol, to be transferred to recipient paraffin blocks. Sections of 4 µm were routinely stained with hematoxylin-eosin (HE) for microscopic evaluation. For collagen investigation, the Masson trichrome stain was used along with HE for microscopic evaluation of intensity as follows: 0 for absent, 1 for mildly stained, 2 for

moderately stained, and 3 for strongly stained. Biopsy sections and analyses were performed by the same blinded specialist. Data were transformed to numbers regarding the intensity of the findings.

Statistical analysis was performed using R software (R Foundation for Statistical Computing®, Vienna, Austria). Macroscopic variables were compared among groups and times using Friedman test and Dunn post-hoc test. Microscopic variables were compared between groups using Mann-Whitney test. Postoperative complications were analyzed using Fisher's exact test. Significance was considered when $p<0.05$).

RESULTS

Swelling gradually decreased to its lowest scores by day 14 and was significantly different from day 3 ($p=0.006$). Although no difference was found between treatments, there was a clinical difference on swelling, since grafts from the CG showed 10.52% swelling compared to no swelling on OG.

Suture dehiscence was predominantly seen at day 10 compared to other days ($p=0.012$) in both groups. The presence of unvitalized tissue was significantly greater on the CG ($p=0.004$), yet time comparisons showed no differences ($p=0.213$) (Fig. 7). Unvitalized tissue was seen on 32% on OG and 53% on CG. Two subjects showed suture dehiscence on the CG compared to none on the OG.

No difference was found among treatments or time comparisons regarding to graft coloration ($p=0.317$ and $p=0.443$, respectively), intensity of drainage ($p=0.564$; $p=0.204$), and drainage aspect ($p=0.564$; $p=0.706$). Marked biologic differences were seen on graft coloration, however, seeing that OG showed more vitality compared to CG (Fig. 7). Bluish and blackish coloration were also found on a greater number of flaps from the CG compared to the OG (42.1% and 21%, respectively).

The OG had a 100% (19/19) integration rate compared to 89.47% (17/19) on the CG, which showed suture dehiscence in 2 subjects and healing by secondary intention.

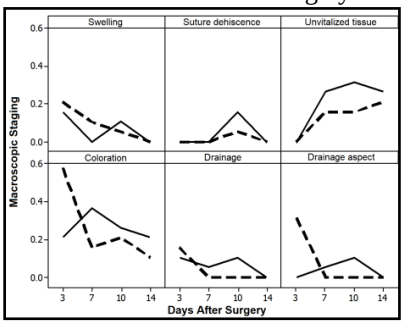

Figure 7. Graphic representation of medians ± IQR of macroscopic characteristics of skin grafts with (*solid line*) and without (*dotted line*) omentum flap at days 3, 7, 10 and 14 after surgery in 19 swine. IQR = interquartile range.

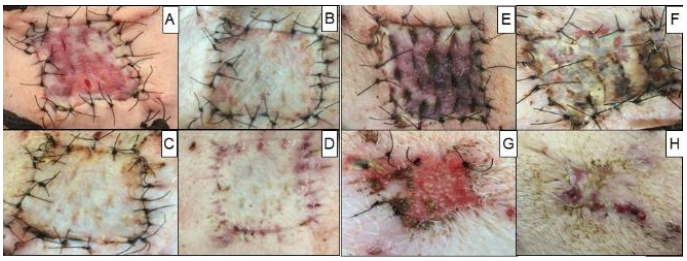

Figure 8. Postoperative macroscopic characteristics of skin grafts in swine. Note the expected outcome of healing at A) 3, B) 7, C) 10, and D) 14 days in grafts with omentum flap and at E) 3, F) 7, G) 10, and H) 14 days in grafts without omentum flap. Note the undesirable outcome of one graft from the control side. A blackish hue can be seen at day 3, followed by necrosis and peeling of skin at day 7, suture dehiscence at day 10, and wound contraction with secondary scar tissue at day 14.

A significantly higher collagenization rate (p=0.017); reepithelization (p=0.024); keratinization (p=0.04); and significantly lesser swelling (p=0.013) were seen with the OG (Fig. 10A-B) compared to the CG (Fig. 10C-D). However, angiogenesis (p=0.897; Fig. 11), spongiosis (p=0.691), hemorrhage (p=0.314), fibroblastic proliferation (p=0.987), mononuclear cells (p=0.560), and polymorphonuclear cells (p=0.532) were similar with both treatments. Multinuclear cells were found in the deep dermis of a few grafts on the control side and most grafts without omentum flap showed reepithelization at the epidermis with mild pathologic changes (Fig. 12).

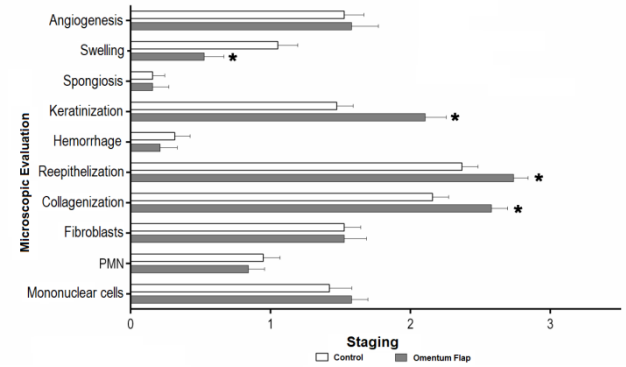

Figure 9. Graphic representation of medians ± IQR of microscopic characteristics of skin grafts with (*gray bars*) and without (*white bars*) omentum flap at day 14 after surgery in 19 swine. IQR = interquartile range.

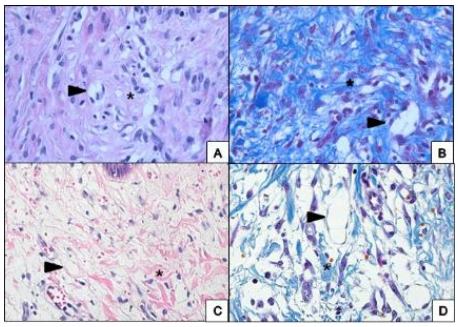

Figure 10. Micrography images of swine skin graft. A and B) with the use of omentum flap, showing intense collagenization and mild swelling (*arrowhead*). C and D) without the use of omentum flap, showing mild collagenization and severe swelling (*arrowhead*). Note presence of collagen fibers (*). A and C) Hematoxylin-eosin staining. B and D) Masson trichrome staining.

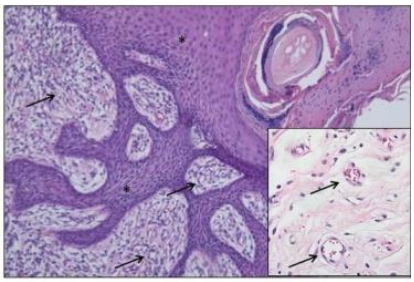

Figure 11**.** Micrography image of swine skin graft with the use of omentum flap showing strong dermal angiogenesis (*arrows*) and new vessels (*excerpt*, 40×), and strong epithelium hyperplasia (*) with hematoxylin-eosin staining.

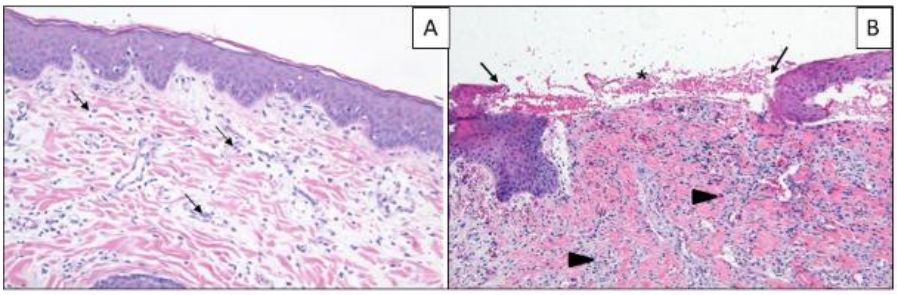

Figure 12. Micrography image of swine skin graft. **A.** with the use of omentum flap showing appropriate epithelization of skin and small foci of inflammatory infiltrates (*arrows*) **B.** without the use of omentum flap showing failure of epithelization (*arrows*) in parts of the graft and hemorrhage (*). Multifocal areas of intense inflammatory infiltration can also be seen (*arrowheads*). A and B) hematoxylin-eosin staining.

DISCUSSION

This experiment used a swine model to investigate the use of an omentum flap for skin grafting, seeing that results in swine are better extrapolated to humans and dogs, among other species (Swindle, 1992). Swine skin is structurally similar to human skin with regard to thickness and space between hair follicles, which renders swine the majorly studied species for skin healing, reconstructive surgery and burn injuries (Sullivan *et al*., 2001). For the past decade, pigs have replaced dogs and primates as models for clinical studies in human medicine for their anatomy and physiology (Swindle, 1992), as well as metabolic profile (Swindle *et al.,* 2012). According to MacPhail (2014), the musculocutaneous vessels are the primary vessels responsible for supplying the skin in humans, monkeys, and swine, but they are absent in dogs and cats. The musculocutaneous vessels run perpendicular to the skin, while the vessels supplying the skin of canines and felines run parallel to the skin and are direct cutaneous vessels. For this reason, some techniques used in humans have limitations in dogs and cats.

The surgical technique of this experiment was considered simple, quick, and easy to perform, which corroborates another study by Brockman *et al*. (1996)), who verified that the surgery does not require special instruments or specific training. Surgeries were completed without any complications related to tunnelization of the omentum, corroborating Schumm *et al*. (2017) that used omentum flap with tunnelization up to the head, and Lasso *et al*. (2015) using omentum flap to treat secondary lymphedema. However, Zaha and Inamine (2010) and Zaha *et al*. (2017) used omentum flap to fill the gap created after total mastectomy in humans and reported 7.3% (7/96) and 12% (24/200) incidence of complications, respectively, including partial necrosis of the flap and gastroepiploic vascular injury. Nevertheless, Zaha *et al*. (2017) concluded that the use of omentum flap can be promising, since only 1% (2/200) of the patients in their study showed recurrence at 90 days, even though 6.5% had positive edges following surgical resection.

Tunnelization through the subcutaneous space has proved simple, yet care is necessary to prevent torsion and excessive traction of the flap with subsequent vascular impairment. Wound closure should be judicious to prevent eventration and flap strangulation (Brockman *et al*., 1996; Brun, 2017). In this study, fixation of the omentum at its egress from the abdominal cavity was not performed, which was also regarded as unnecessary by Lascelles *et al*. (1998), who believe omentopexy could lead to vascular impairment. However, Brockman *et al*. (1996) state that omentopexy should be performed to prevent return of the flap to the abdominal cavity and that vascular impairment is unlikely.

A tie-over bandage was applied postoperatively combined with pressure bandage, and changes were made at 3, 7 and 10 days. This regimen agrees with a few authors who believe bandages should be applied immediately following surgery and remain in place during the first 72 hours, thereby facilitating immobilization, fluid absorption and adherence of the graft, and protection against injuries (Swaim, 2007; Macphail 2014). Bandages also reduce swelling

and hemorrhage, thus eliminating dead space and providing comfort to the patient (Macphail, 2014).

In this study, swelling gradually decreased to its lowest scores by day 14 compared to day 3 in both groups. This finding can be ascribed to the mechanism of plasma embedding, which occurs during the first 2 to 3 days following graft placement. At this phase, the plasma drained from the receptor site is absorbed by the graft and forms a fibrin mesh that holds and nourishes the graft, producing an edema that peaks at 48 to 72 hours and is gradually reabsorbed as vascular and lymphatic supply to the graft improve over time (Franco and Silva, 2002; Macphail, 2014). Despite the lack of statistical significance, a few animals (10.52%) showed moderate to severe swelling on the CG compared to no swelling on the OG of the same animal. This can be ascribed to the powerful lymphatic drainage provided by the omentum, which absorbs great amounts of fluid from swollen tissue (Ruffini, 1992; Platell *et al*., 2000).

The CG showed higher incidence of unvitalized tissue on the graft compared to the OG, although not statistically significant over time. Unvitalized tissue was observed on 32% on OG and 53% on CG. Suture dehiscence was highest at day 10 compared to other days in both groups. The incidence of unvitalized tissue and suture dehiscence is inversely related to graft revascularization. Growth of new vessels warrants graft survival. The integration of skin grafts depends on establishing arterial connections and proper drainage, which should be accomplished by day 7 or 8 following surgery (Franco and Silva, 2002; Macphail, 2014).

The incidence of suture dehiscence on two subjects of this study, although not statistically significant, is clinically relevant since no dehiscence was found on OG. The higher incidence of unvitalized tissue is indirectly related to vascularization and angiogenesis provided by the omentum, which has been reported elsewhere (Platell *et al*., 2000; Shen and Shen, 2003; Maloney *et al*., 2003; Gray, 2005).

No differences were found among groups or postoperative days regarding coloration, aspect, and amount of drainage. However, marked biological differences were seen on coloration, which seemed more vital on OG. Most grafts were pink colored at the first dressing change (3 days), corroborating the findings of Pavletic (2010), who reported appropriate graft vascularization by 48 hours following surgery and graft survival related to fluid absorption by capillary beds in the receptor bed. These findings are in contrast with a study by Swaim (2007), who reported bluish coloration of skin grafts over the first 3 days, only to turn to achieve a pinkish hued by day 7.

Another interesting finding was the number of subjects with bluish- to blackish-hue grafts on the CG compared to the OG (42.1% versus 21%, respectively). This finding can be ascribed to the vascularization ability of the omentum as cited by studies, showing remarkable advantages for wound repair (Shen and Shen, 2003; Maloney *et al*., 2003). On the CG, however, revascularization was also observed, thus corroborating the studies by Swaim (2007) and Pavletic (2010), who stated that skin grafts should be applied to healthy granulation tissue or 'fresh' surfaces (newly created wounds), free from infection or debris and vascularized enough to produce granulation tissue.

Wang *et al*. (2012) studied the H-plasty technique for wound closure in dogs and reported rapidly decreasing edema with the use of omentum flap and shorter healing time with less drainage, rapid absorption and positive coloration in all subjects compared to the CG, which showed darkish color and necrosis of the wound edges.

Greater reepithelization, keratinization and collagenization with less swelling were microscopic findings of this study associated with the use of an omentum flap. The omentum produced an increase on blood supply to the receptor bed due to its excellent vascularization from peripheral vessels originated from the left and right gastroepiploic arteries (Macphail, 2014). This feature enhances the supply of energy, oxygen, defense cells, complement and immunoglobulins to the graft (Brun, 2017), thereby assisting graft healing and providing a powerful lymphatic drainage system to the graft (Ruffini, 1992; Platell *et al*., 2000).

Angiogenesis, spongiosis, hemorrhage, fibroblastic proliferation, mononuclear cells and

polymorphonuclear cells were similar between treatments, all of which are related mostly to wound healing, rather than the use of an omentum flap. The results of this study showed improved healing of mesh skin graft in swine, in view of increased blood supply, but not angiogenesis, which was not seen until day 14. Mononuclear and polymorphonuclear cells are present during the inflammatory phase of the skin healing process (Macphail, 2014), which starts 6 hours following injury and comprises leukocyte migration and complement activation (Hosgood, 2013; Macphail, 2014). Macrophages are the main effector cells during tissue repair because they stimulate angiogenesis and secrete collagenases and growth chemotactic factors, which are the main cytokines that induce granulation (Hosgood, 2013).

In this study, graft integration happened with 100% of the OG (n=19) and 89.47% (17/19) of the CG, which showed suture dehiscence and secondary intention healing. Reepithelization of the epidermis was seen on all grafts with the OG, combined with mild inflammatory infiltration. On the CG, however, intense inflammatory infiltration was present without evidence of reepithelization on 10.53% (2/19) of the subjects. Inflammatory cells during the inflammatory phase of wound healing cause debridement through neutrophil and monocyte migration to the wound (Balsa and Culp, 2015). Therefore, the greater the necrosis, the greater the inflammatory infiltrate. Reis Filho *et al.* (2017), when studying skin grafting in rabbits, reported that the technique requires an adjuvant to stimulate graft integration, because a receptor bed with no granulation tissue provides suboptimal vascularization to the graft. The same study showed that laser therapy proved effective as an adjuvant to skin graft healing in rabbits. However, studies addressing skin graft vascularization in other domestic species remain scarce. In swine, graft integration was seen with and without the use of an omentum flap to provide a granulation tissue bed, which poses an important difference to the skin of lagomorphs as reported by Reis Filho *et al*. (2017).

Histopathological studies regarding skin vascularization with omentum flap were not found with any species for comparison with the results of this study. Current literature holds only a few anecdotal reports of macroscopic evaluation.

While flap tunnelization is simple and easy to perform, it is a technique that must be considered carefully, since the omentum is obtained through invasive surgery with longer duration and higher demands of postoperative care, including analgesia.

The use of an omentum flap on sites where healing is expectedly slower or difficult, such as low vascularized tissue (tendons, nerves, bone, and cartilage), chronic wounds that do not heal, or tumor resection, can be beneficial to prevent the need of additional intervention and to facilitate graft integration by improving blood supply. For patients with traumatic injuries, topical treatment of the wound is usually the first approach, followed by grafting when there is an appropriate receptor bed, thus preventing the need of a more invasive surgery to use the omentum.

Some studies in rabbits have shown a lower occurrence of necrosis and better healing of the graft, using mesenchymal stem cells (Gómez *et al*., 2020; Maria *et al*., 2021), platelet-rich plasma (PRP) (Pazzini *et al*., 2018; Kemper *et al*., 2018) and laser therapy (Reis Filho *et al*., 2017), however additional studies should be performed in dogs and cats. Good results with the use of vacuum-assisted closure devices after skin grafting have been obtained in dogs and cats (Liptak, 2012; Nolff, 2021), this technique uses controlled negative pressure to provide evacuation of excessive fluid, tissue stimulation of granulation and neovascularization (Jun; Hope, 2018). In humans, dermal regeneration models, acellular dermal skin substitutes and cultured epithelial autografts in addition to hyperbaric oxygen therapy are already in use (Liptak, 2012), however still at high cost in veterinary medicine.

These authors believe that the omentum flap should be used more frequently as an adjuvant to wound healing on skin grafts in veterinary medicine. More studies are needed to investigate the ability of omentum to induce vascularization of skin wounds over time and microscopic evaluations are required to obtain more concise data regarding the characteristics of the omentum for skin grafting.

CONCLUSION

This study has led to the following conclusions:

- Mesh skin grafts can be successfully performed in swine even for a recently created receptor bed and without granulation tissue, but with good vascularization.
- The use of an omentum flap improves the macroscopic and microscopic outcome of skin graft regarding graft integration, thus providing better quality and safety of the technique.

ACKNOWLEDGEMENTS

"This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001" and a CNPq.

REFERENCES

BALSA, I.M.; CULP, W.T. Wound care. *Vet. Clin. North Am. Small Anim. Pract.,* v.45, p.1049-1065, 2015.

BOAVENTURA, N.C.; GANJEI, J.B. 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. *J. Am. Vet. Med. Assoc.*, v.258, n.4, 2021.

BROCKMAN, D.J.; PARDO, A.D.; CONZEMIUS, M.G. *et al*. Omentum-enhanced reconstruction of chronic nonhealing wounds in cats: techniques and clinical use. *Vet. Surg.*, v.25, p.99-104, 1996.

BRUN, M.V. Flapes de omento para cirurgia reconstrutiva. In: _____. *Cirurgias complexas em pequenos animais.* São Paulo: Paya, 2017. cap.15.

FRANCO, D.; SILVA, C. Enxertos, retalhos e implantes. In: FRANCO, T. *Princípios de cirurgia plástica*. São Paulo: Ateneu, 2002. p.87-106.

FOWLER, D. Distal Limb and Paw Injuries. Veterinary Clinics of North America: Small *Animal Practice*, v. 36, p. 819–845, 2006.

GRAY, M.J. Chronic axillary wound repair in a cat with omentalisation and omocervical skin flap. *J. Small Anim. Pract.,* v.46, p.499-503, 2005.

GÓMEZ, J.L.A.; PAZZINI, J.M.; BARROS, M.A. *et al*. Efeitos das células-tronco mesenquimais derivadas do tecido adiposo de cães na epitelização de autoenxertos de pele em coelhos (Oryctolagus cuniculus). *Pesqui. Vet. Bras*., v.40, n.12, 2020.

HOSGOOD, G. Biologia da cicatrização de feridas. In: WILLIAMS, J.; MOORES, A. *Manual de feridas em cães e gatos*. 2.ed., São Paulo: Roca, 2013. cap.1.

JUN, H.; HOPE, H.K. The Management of vacuum-assisted closure following vulvectomy with skin grafting. *Plastic Reconstr. Surg.,* v.6, n.4, 2018.

KEMPER, B.; BRANDÃO, C.V.S.; ROSSETTO, V.J.V. *et al*. Autologous and homologous skin grafts treated with platelet-rich plasma (PRP): experimental study in rabbits. *Pesqui. Vet. Bras*., v.38, n.9, 2018.

LASCELLES, B.D.X.; DAVISON, L.; DUNNING, M. *et al.* Use of omental pedicle grafts in the management of nonhealing axillary wounds in 10 cats. *J. Small Anim. Pract.,* v.39, p.475-480, 1998.

LASSO, J.M.; PINILLA, C.; CASTELLANO, M. New refinements in greater omentum free flap transfer for severe secondary lymphedema surgical treatment. *Plastic Reconstr. Surg. Global Open*, v.3, p.e387, 2015.

LIPTAK, J.M. Immediate skin grafting following tumour excision. *J. Small Anim. Pract.,* v.53, p. 493-494, 2012.

MACPHAIL, C. Cirurgia do sistema tegumentar. In: FOSSUM, T.W. *Cirurgia de pequenos animais*. 4.ed. Rio de Janeiro: Elsevier, 2014. cap.16.

MALONEY, C.T.; WAGES, D.; UPTON, J. *et al*. Free omental tissue transfer for extremity coverage and revascularization. *Plastic Reconstr. Surg.,* v.111, p.1899-1904, 2003.

MARIA; S.P.; NARDI, A.B.; ALVAREZ, J.L. *et al*. Diminuição do índice de necrose em enxertos cutâneos em coelhos mediante a aplicação de células tronco mesenquimais xenógenas. *ARS VET.,* v.37, p.177-186, 2021.

NOLFF, M.C. Filling the vacuum: Role of negative pressure wound therapy in open wound management in cats. *J. Feline Med. Surg.*, v.23, p.823-833, 2021.

PAVLETIC, M.M. Free Grafts. In: _____ *Atlas of small animal reconstructive surgery.* 3.ed. Ames: Wiley Blackwell, 2010. chap.14.

PAZZINI, J.M.; SEREFIN, E.L.; USCATEGUI, R.R.A. *et al*. Esponja cirúrgica associada com plasma rico em plaquetas em enxertos cutâneos em malha e camada em coelhos (Oryctolagus cuniculus). *Arq. Bras. Med. Vet. Zootec*., v.70, p.1339-1348, 2018.

PLATELL, C.; COOPER, D.; PAPADIMITRIOU, M. *et al*. The omentum. *Word J. Gastroenterol.*, v.6, p.169-176, 2000.

REIS FILHO, N.; FERREIRA, M.; PASCOLI, A. L. *et al*. Epitelização de enxertos cutâneos em feridas recentes de coelhos tratados com membrana amniótica canina e/ou laserterapia. *Arq. Bras. Med. Vet. Zootec.*, v.69, p.603-612, 2017.

RUFFINI, E. Surgical aplications of the greater omentum: a critical review of the literature. *Panminerva Med.*, v.34, p.135-140, 1992.

SCHUMM, M.; SIMON, K.; SACHO, R. *et al*. Successful laparoscopic harvesting of omental pedicle flap for salvage cerebral revascularization in 2 adults with moyamoya disease: technique and lessons learned. *Surg. Laparosc. Endosc. Percut. Techn.*, v.27, p.111-115, 2017.

SHEN, Y.M.; SHEN, Z.Y. Greater omentum in reconstruction of refractory wounds. *Chin. J. Traumatol.*, v.6, p.81-85, 2003.

SULLIVAN, T.P.; EAGLSTEIN, W.H.; DAVIS, S.C.; MERTZ, P. The pig as a model for human wound healing. *Wound Repair Regen.*, v.9, p.66-76, 2001.

SWAIM, S.F. Enxertos cutâneos. In: SLATTER, M. *Manual de cirurgia em pequenos animais.* 3.ed., São Paulo: Manole, 2007. cap. 24.

SWINDLE, M.M. *Swine as models in biomedical research*. Ames, Iowa: Iowa State University Press, 1992.

SWINDLE, M.M.; MAKIN, A.; HERRON, A. J. *et al.* Swine as models in biomedical research and toxicology testing. *Veterinary Pathology*, v. 49, n. 2, p. 344-356, 2012.

TEIXEIRA NETO, N.; CHI, A.; PAGGIARO, A.O.; FERREIRA, M.C. Tratamento cirúrgico das feridas complexas. *Rev. Med*., v.89, p.147-152, 2010.

TONG, T.; SIMPSON, D.J. Free skin grafts for immediate wound coverage following tumour resection from the canine distal limb. *J. Small Anim. Pract*., v.53, p.520-525, 2012.

WANG, C.X.; LI, C.; DENG, G. *et al*. Value of the pedicle omentum transfer for the healing of large skin wound in dogs. *Int. J. Appl. Res. Vet. Med.*, v.10, p.300-304, 2012.

ZAHA, H.; INAMINE, S. Laparoscopically harvested omental flap: results for 96 patients. *Surg. Endosc.*, v.24, p.103-107, 2010.

ZAHA, H.; ABE, N.; SAGAWA, N.; UNESOKO, M. Oncoplastic surgery with omental flap reconstruction: a study of 200 cases. *Breast Cancer Res. Treat.*, v.162, p.267-274, 2017.