Introduction

Skin grafts and flaps are an effective and common surgical procedure used in the treatment of certain wound types, including pressure ulcers. The treatment of surgical patients post-flap and post-graft surgery requires vigilant care to ensure the success of the flap/graft procedure. This white paper provides an overview of skin graft and flap procedures in the treatment of pressure ulcers, and will provide a scoping review of literature examining the relative effectiveness of low air loss and high air loss support surfaces in the treatment of this patient population.

Skin Grafts and Flaps: An Overview

It is estimated that over 400 million people suffer from skin breakdown globally, placing a growing burden on health systems. Skin grafts and flaps are common surgical procedures to restore both skin integrity and its barrier function to prevent infection, maintain normal functioning, and minimize cosmetic disfigurement.

Skin grafts involve transplantation of skin (from the same person or other human or animal donors) to provide coverage for a variety of extensive but shallow wounds that may develop after trauma, oncological resection, burn injury, hair restoration, scar contracture release, or correction of congenital abnormalities. Without its own blood supply, survival of skin grafts is dependent on the thickness of the graft and vascularity of the recipient site. A split-thickness skin graft includes the epidermis and a portion of the dermis and is categorized based on the thickness and shape (mesh, stamp, or chip) of the harvested graft. Because of the thin profile, split-thickness skin grafts can survive in areas where vascularity is poor, but they are more fragile and tend to contract during the healing process. In contrast, grafts that contain the entire dermis (full-thickness) have high metabolic demands, requiring optimal vascular supply on the recipient site for survival. With inclusion of additional dermal structures, one of the advantages of using thicker grafts is that they undergo less contracture.

Flaps as a Surgical Option for Pressure Ulcers

A flap involves transferring a unit of tissue with intact vascular supply into larger defects such as stage IV pressure ulcers. Depending on the type of tissues that are involved, flaps may be composed of one type or several different types of tissue. Fasciocutaneous flaps replace a deep defect with subcutaneous tissue and deep fascia, whereas musculocutaneous flaps consist of an additional layer of muscle that offers the benefit of robust vascular supply and cushioning. The perforator-based flap has gained popularity as a surgical option for pressure ulcers. This type of flap consists of skin and/or subcutaneous fat supplied by blood vessels or perforators that traverse through and in between the underlying muscle and intermuscular septa toward the tissue surface.
Common Complications Associated with Skin Grafts/Flaps

It is during the immediate post-operative period and until adequate vascular ingrowth is established, optimizing local supply of oxygen and nutrients, that graft/flap failures could occur, requiring frequent assessment and meticulous care. In a recent systematic review of 55 studies involving 1,184 patients who had undergone surgical flaps for pressure ulcers, the complication rate was estimated to be 18.6%. The most common complications were wound dehiscence (9.7-11%) followed by necrosis (5.1-9.0%) and infection (4.8-7.5%). According to another review of 421 skin flaps in 352 patients with spinal cord injury, 21% of the flaps developed complications including suture line dehiscence (31%), infection (25.2%), hematoma (19.5%), partial necrosis (13.7%) and total flap necrosis (10.3%). Overall, individuals are more susceptible to complications with the following risk factors: multiple medical co-morbidities, cancer, advanced age, obesity, poor nutritional status, smoking, previous scarring, chronic use of steroids and prolonged operative time.

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Surgical site infection has been linked to prolonged hospitalization and high mortality. Bacteria compete for nutrients and oxygen that are essential for wound healing activities. They also generate exotoxins and endotoxins that could hinder normal collagen deposition and cross-linking contributing to surgical wound dehiscence. Wound healing is stalled with infection that stimulates the production of proteases leading to excessive degradation of extracellular matrix and growth factors. While there is little evidence to support routine prophylactic use of topical or systemic antimicrobial agents to achieve better clinical outcomes, careful risk evaluation of each patient, early recognition, and prompt treatment of wound infection remains the most prudent approach.

Extensive and excessive accumulation of blood (hematoma) and fluid (seroma) could separate the flap/graft from the underlying structure disrupting the fragile vascular anastomoses and leading to necrosis. Surgical drain tubes are often used after surgeries to help reduce the risk of seroma formation. Keeping the patient well hydrated and preventing anemia may improve circulation to the surgical site and help prevent micro-vascular thrombosis.

Strategies for the Management of Skin Graft/Flap Patients

To prevent wound dehiscence, a number of strategies have been proposed to ensure graft/flap immobilization and minimize tension on the wound edges, especially if the wound is located in a highly mobile or high tension area such as the back, shoulders or legs. There is some evidence that hydrofiber and silicone dressings may be associated with less pain and easier use. Negative pressure wound therapies have also been considered to be beneficial for immobilizing graft/flaps, reducing edema, removing excess drainage, and stimulating angiogenesis. However, the role that atraumatic dressings and topical negative pressure play in graft/flap survival remains unclear.
Immobilization of the reconstructed area between 2-8 weeks may yield better graft/flap survival. Although best practice guidelines are lacking, prevailing opinion considers support surfaces as indispensable for the care of this patient population. Appropriate surfaces help to minimize mechanical forces such as shear and pressure that could damage the newly developed vasculature and compromise tissue perfusion of the graft/flap. Recurrence and flap failure rate has been estimated to fall between 12-24%. 

The Importance of Support Surface Selection for Pressure Ulcer Prevention

Arguably, limited mobility is the most relevant risk factor for pressure ulcer development. Due to prolonged immobilization, selection of a support surface should be the mainstay for the prevention of pressure ulcers. Pressure is defined as the perpendicular force that is applied to the skin, distorting and compressing underlying soft tissues, especially over bony prominences. Shear or shear stress is produced by displacement or deformation of tissue (usually in a diagonal direction) altering the original alignment of tissue as one layer slides over the deeper structure in opposite directions. Pressure and shear has been demonstrated to compromise local blood flow. Following ischemic injury, a cascade of physiological events occurs, characterized by anaerobic metabolism, production of toxic metabolites, acidosis, increased cell membrane permeability, cellular edema, cell death, and finally tissue necrosis. Although injury is often incurred by excessive mechanical loads, studies have indicated that exposure of low pressure over a protracted duration may have the same detrimental effect. Patients with a pressure ulcer had a 3.6-fold increased risk of dying within 21 months, as compared to those without a pressure ulcer. The mortality rate has been documented to be as high as 68% among elderly who had undergone surgical intervention including fascial flap and simple closure for their pressure ulcers. This high mortality rate illustrates the need for preventative intervention, which would include the use of an appropriate support surface to aid in the reduction of pressure.

The Mechanics of Support Surfaces: Understanding Low Air Loss and High Air Loss Mattresses

Support surfaces are divided into reactive and active integrated bed systems, mattresses, overlays, and seat cushions. Active surfaces such as alternating pressure surfaces redistribute pressure by cyclic inflation and deflation of different portions of the support surface.

Reactive surfaces respond to the weight of the patient, allowing the body to be immersed into the surface when lying down. The larger the area of the body that is supported by the mattress, the lower the pressure at any given point of contact. These surfaces may incorporate various mediums such as foam, gel/liquid, fiber, or air. Low air loss support surfaces consist of a series of connected, air-filled pillows/bladders/cells that permit small amounts of air to escape to maintain a constant level of inflation. Air-fluidized, or high air loss support surfaces, contain suspended or floating silicone-coated beads that emulate pseudo-liquid as the compressed air blows through the beads. Low air loss and air-fluidized beds (with vapor permeable covers) promote air circulation that cools the skin through convection and evaporation of moisture from the skin. They are superior in regulating the microclimate, which is the environment at or near the skin surface that is influenced by the combined effect of skin temperature, humidity/moisture, and air movement. The number of layers of linen and types of fabric that are placed on these surfaces can potentially impede airflow, heat dissipation and moisture evaporation, compromising the surfaces’ ability to regulate microclimate.
A Comparative Study of Support Surfaces

In light of the mortality, suffering, and exorbitant health care costs associated with surgical complication after graft/flap surgeries, there is a need to establish the relative effectiveness of various support surfaces for use in the treatment of post-graft/flap patients. Sachse compared interface pressures, dermal blood flow and transcutaneous oxygen tension (TcPO$_2$) over the trochanter and sacrum areas across six different support surfaces including standard hospital, viscoelastic memory foam, low air loss and high air loss mattresses while the participants were placed in supine and lateral positions. Interface pressure between sacrum skin and the supporting surfaces in supine position was highest with the standard hospital bed (128.4 cm$^2$) and foam-based mattress (87.8 cm$^2$). Pressure measurements were lowest when the participants were placed in high air loss (31.9 cm$^2$) and low air loss mattresses (55.2 cm$^2$). The amount of pressure could have a direct impact on regional blood flow and oxygen tension. The investigators noticed a significant reduction of blood flow while the participants were lying in different positions on hospital mattresses. The TcPO$_2$ of the sacrum in supine position reduced from 54.5-56 mmHg using high and low air loss mattresses to 20.5 mmHg with standard hospital mattress. In a similar study, Feldman reported that TcPO$_2$ measurements were similar among high air loss, low air loss and egg crate mattresses; all testing surfaces produced higher TcPO$_2$ values than the standard bed (p<0.05). Patel et al. evaluated a number of low and high air loss mattresses and overlays using pressure sensitive mats. The performance of low and high air loss mattresses was similar; especially when the head of the bed was elevated. In a more recent study, comparisons of interface pressure were made between low air loss mattresses, air suspension beds, and viscoelastic foam mattresses. Sacral interface pressures were significantly lower using low air loss mattresses in supine position and when head of bed was elevated at varying angles than viscoelastic foam mattresses (p<0.001).

The Evidence Supporting Low Air Loss for Pressure Ulcer Prevention

There is evidence that turning patients every four hours when support surfaces are used is as effective in preventing pressure ulcers as turning patients more frequently without a support surface. McInnes et al. reviewed 53 clinical trials to determine if pressure redistributing support surfaces help prevent pressure ulcers. They found a relative reduction of pressure ulcer incidence of 60% in favor of foam alternatives compared with standard hospital mattresses. Alternating pressure surfaces were more effective in reducing pressure ulcers than standard hospital mattresses (RR 0.31, 95% CI 0.17-0.58). Pooling data from studies that compared low air loss beds with regular beds and overlays validated the benefits of low air loss beds (RR 0.33, 95% CI 0.16-0.67). Colin et al. reviewed a total of 145 articles including a large body of French literature. They concluded that low air loss surfaces are more effective than mixed pulsating air mattresses in prevention of heel ulcers. Some evidence supports the use of sheepskin to reduce sacral pressure ulcers in orthopedic patients and air-fluidized beds may enhance healing of pressure ulcers. Other reviews
support the finding that low air loss beds are superior to standard mattresses in reducing pressure ulcers in intensive care settings.\textsuperscript{19-21} By implementing risk screening and providing support surfaces to hospitalized individuals who are at risk for pressure ulcers, nosocomial pressure ulcer rates were significantly reduced by 25-100\% according to pooled analysis of data from 9 studies (odds ratios for pressure ulcer development were estimated to be between 0.220 and 0.508).\textsuperscript{22}

Considering the evidence on pressure ulcer treatment, there is insufficient evidence to conclude that one type of surface can improve the rate of pressure ulcer healing than the other. Smith et al. reviewed 21 trials and 3 observational studies that evaluated various support surfaces.\textsuperscript{8} They found some evidence that air-fluidized beds may promote faster healing than standard hospital mattresses.\textsuperscript{8}

However, none of the studies compared high air loss with low air loss mattresses. While there is some evidence that support surfaces may prevent and promote healing of pressure ulcers, it remains unclear if patients could benefit from these surfaces after graft and flap surgery. In light of the existing gap in the literature, we conducted a scoping review that focused on the care of patients after flap or graft surgeries.

The Scoping Review

The overall aim of the scoping review is to map and summarize a wide range of evidence including non-research materials and opinions of the key stakeholders to examine which pressure-redistributing surfaces – including mattresses, overlays, and mattress replacements – improve survival of grafts and flaps and how effective different pressure-redistribution surfaces are in promoting healing of grafts and flaps. Review of this cumulative body of evidence will inform post-surgical care of patients with graft/flaps and delineate future research priorities based on identified knowledge gaps and clinical practice issues.

Methods

Inclusion criteria: This review included randomized controlled trials and case-controlled studies that evaluated support surfaces for the care of patients who had undergone skin graft or flap surgeries in any settings, on any clinical population, of any age. Outcomes may include graft/flap failure, dehiscence, necrosis, graft/flap survival, graft/flap healing, healing of donor sites, pain, interface pressure, blood flow, and transcutaneous oxygen levels. Only studies that were published in English were considered.

Search Strategy

An initial limited search of MEDLINE and CINAHL was undertaken followed by analysis of the text words contained in the title and abstract, and of the index terms used to describe the article. With the help of a librarian scientist, a second search using all identified keywords and index terms was undertaken across several databases: Cochrane Database of Systematic Reviews, Joanna Briggs Institute, EPOC (Effective Practice and Organization of Care), Cumulative Index to Nursing and Allied Health Literature (CINAHL), MEDLINE, EMBASE, and Health Technology Assessment (HTA) Database. The reference list of all identified articles were searched for additional studies. Studies published from 1990 to 2011 will be considered for inclusion in this review.

Study selection

Two reviewers independently reviewed each title and abstract of the literature search results to determine whether the paper should be included for more in-depth review. Reviewers were instructed to include papers even when there is insufficient information to determine the relevance. When disagreements on study inclusion emerged, discrepancies were resolved through discussion.
Charting the Data

Relevant information was extracted from selected papers using a standardized abstraction form to document names of the authors, the purpose of the study/paper, types of participants, research methods used, study setting, theoretical framework, outcome and assessment details, authors’ conclusion, and implication to practice.

Collating, Summarizing and Reporting the Results

The number of studies and their characteristics including study design, year of publication, type(s) of interventions, study population, and country where study was conducted were summarized in a tabular format. A summary of key findings and proposed recommendations were compiled into a topic matrix to allow easy comparison by topic and strength of evidence.

Results

Scheulen and Munster reported a case series of 69 patients who suffered burn injury and required split-thickness skin grafting. All patients were placed on air-fluidized beds after their surgery and the graft survival rate was documented to be as high as 91.8% on post-operative day three. However, several complications warrant attention. High airflow and heat promotes evaporative water loss through the skin, which put the patients at risk for dehydration (3-4%) and other related complications such as hypernatremia and graft desiccation. Air-fluidized therapy (AFT) has been demonstrated to be associated with a high level of insensible water loss (up to 938 ml/m²/24h), almost double the estimated water loss in a standard mattress (480 ml/m²/24h). It is well documented in the literature that patients with coexisting pulmonary diseases are not appropriate candidates for AFT. The lack of firm back support could make coughing less effective and the dry air tends to thicken pulmonary secretions that become difficult to expectorate. All in all, maintaining proper pulmonary hygiene could be a challenge when AFT is being used. There are a number of reports indicating that patients develop depression and mental disorientation during AFT. The person placed in AFT is immersed into the mattress; he/she may feel trapped in one position and deprived of visual stimulation, intensifying the feeling of isolation. AFT promotes immersion to the extent that the body is sunk into the mattress and this may impede egress, ingress, bed mobility, transfer and independence. It has also been reported that the ceramic beads could escape through damaged polyester mattress covers, allowing the particles to be airborne and if aspirated, leading to asphyxiation.

Fleck and her colleagues propose that there are alternative surfaces other than AFT that should be considered for patients after reconstructive surgery. In fact, alternative surfaces such as low air loss mattresses are preferred because they provide more stable skeletal support and, therefore, are less likely to cause back and shoulder pain. Based on the authors’ experiences and opinions, low air loss and alternating pressure surfaces are as effective as AFT to achieve similar clinical outcomes. The key difference among support surfaces is cost, with AFT being more expensive. Due to the high cost to implement AFT, a number of facilities have switched to using alternate pressure, low air loss, or lateral rotation surfaces to provide care for patients who underwent graft/flap surgeries.

One study evaluated the use of biosynthetic dressings for donor site wounds on the back in conjunction with two different types of surfaces, including AFT and low air loss mattresses. Twenty-two patients received AFT; 16 patients were placed in AFT for an average of nine days and then moved to low air loss surfaces; 10 other patients were placed on low air loss mattresses from the very beginning. Although the primary purpose of the study was not to compare the relative effectiveness of support surfaces, the healing outcomes and wound complications were similar among the three groups of patients. The authors did share their concern about potential trauma to the graft sites when patients exited AFT over the edges of the bed. They recounted the challenge of elevating the patient’s head without obstructing airflow passing the donor sites. None of the patients who were placed on low air loss mattresses developed fluid accumulation under the grafts. However, newly formed epithelium could potentially be damaged from shearing between the patient and the low air loss surface.
Two randomized controlled studies examine the effectiveness of support surfaces in the management of post-operative graft/flap patients. In the first study, Economides et al. followed 12 patients who had undergone myocutaneous flap surgery for their stage IV pressure ulcers. Participants were assigned to a dry-floatation (DF) mattress (n=6) or AFT (n=6) using a table of random numbers. The assignment was concealed in sealed envelopes to minimize potential bias. At the surgical sites that involved either the ischial or sacral areas, interface pressure and blood flow as measured by laser Doppler were monitored daily for 14 days. The mean interface pressure in the DF group was 23.54 mmHg in comparison to 17.43 mmHg in the AFT group. Local blood flow was 2.12 ml/sec in the DF group versus 2.02 ml/sec in the AFT group. Two patients in each group developed wound breakdown. Differences between the two groups were not evaluated statistically given the small sample size.

In the second study, Finnegan et al. tested the hypothesis that alternating therapy (AT) was as effective as AFT for post-operative management of patients with reconstructive surgery. They recruited 33 patients who required reconstructive surgery to repair stage IV pressure ulcers. They were randomly assigned to AT (n=15) or AFT (n=18) based on web-based random number software. The pressure ulcers were located in the sacrum, trochanter, or ischial areas. The mean length of stay was 8 days for both groups; 87% in the AT group and 78% in the AFT group exhibited healthy wound site upon discharge. Patients in the AFT group rated higher level of discomfort, more restriction in movement, and higher temperature than patients who were placed on AT. The overall satisfaction expressed by patients was higher in the AT group versus the AFT group. The estimated cost for AT was $280 per patient episode as opposed to $520 per patient episode to implement AFT.

Conclusion

Surgical interventions that involve skin grafts and flaps to promote wound closure are costly. Holistic post-surgical care to address nutrition, comorbidities, and infection risk is crucial to ensure graft/flap survival. Integral to post-surgical care is judicious selection of support surfaces to prevent pressure damage of grafts/flaps. While there is evidence to substantiate the use of support surfaces for the prevention and treatment of pressure ulcers, review of the literature reveals insufficient evidence to suggest that one type of support surface is superior to the other in the treatment of post-surgical graft/flap patients. Considering the higher cost associated with high air loss therapies, it seems prudent to consider the more economical options such as low air loss mattresses for use in this patient population. Future studies are required to offer a comprehensive comparison of the cost-effectiveness of various therapies.
References


