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Comparative Analysis of Different Wound Dressings in Surgical Postoperative Repair

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Abstract: Choosing proper wound dressings for surgical postoperative repair is an important clinical choice with significant implications for healing outcome, complications, and patient quality of life. In this article, we comprehensively compare various wound dressing types commonly employed in surgical wound repair: hydrogel dressings, foam dressings, alginate dressings, hydrocolloid dressings, collagen-based dressings, and antimicrobial dressings. These dressings have unique physicochemical properties, modes of action, and clinical indications. The hydrogel dressings maintain a moist environment for wounds and promote granulation well; foam dressings absorb exudates better than others; alginate dressings exhibit excellent hemostatic properties; collagen-based dressings serve as bioactive scaffolds for tissue regeneration; antimicrobial dressings prevent infections. Evidence derived from comparative studies guides evidence-based dressing selection according to wound characteristics, healing phases, and patient factors. Our analysis offers a practical guide for clinicians to select optimal dressings by considering their efficacy, safety, patient comfort, and cost-effectiveness when repairing surgical wounds.

Keywords: Wound dressing comparison; Surgical wound repair, Hydrogel; Foam dressing; Alginate dressing; Collagen dressing; Antimicrobial dressing

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1. Introduction

Choosing the right wound dressing for surgical postoperative repair represents perhaps the single most important but least appreciated decision in perioperative care. A wound dressing used on a surgical wound has profound effects on the healing trajectory, affecting infection risk, speed of epithelialization, quality of scar formation, patient comfort, and overall healthcare resource utilization. Over the last two decades, as new advances in wound care have proliferated, there are today many choices available that vary by material composition, mechanism of action, clinical indications, advantages, and limitations. Choosing the best dressing for any particular wound involves considering multiple variables: wound type (incisional, excisional, or traumatic); size and depth; exudate volume; degree of contamination or infection; anatomical

location; healing phase; and allergies. In addition, practical issues such as ease of application, frequency of changes, availability, and cost need to be balanced against clinical efficacy. An evidence-based choice demands familiarity with the comparative properties between various dressing types and the clinical evidence behind their use in specific situations.

We compare the main types of wound dressings used for surgical postoperative repair—hydrogel dressings, foam dressings, alginate dressings, hydrocolloid dressings, collagen-based dressings, and antimicrobial dressings—and discuss their respective material compositions, mechanisms of action, clinical indications, advantages, and limitations. In addition, we summarize data from randomized trials and meta-analyses comparing healing time, infection prevention, scar quality, and patient-reported outcomes. Lastly, we provide an integrative summary of our findings as a guide to help clinicians select optimal dressing options by considering wound characteristics, patient factors, and cost-effectiveness—with the ultimate goal being improved surgical patient outcomes. Our approach is centered around the idea that there is no universal winner among these various dressing types, but instead it depends upon which dressing best fits the particular needs of each wound during a certain stage of its healing journey. Wounds change over time, and thus so must the dressing strategies—from antimicrobial products in the early inflammatory phase to moisture-retentive products in the proliferative and remodeling phases.

2. Comparative properties of major dressing categories

Knowing the basic characteristics of each dressing category is the initial step towards rational selection. Hydrogel dressings contain between 70–90% water in cross-linked hydrophilic polymers, giving them a soft, pliable, and non-adherent nature. The high water content has a cooling effect, soothing the wound and reducing pain, and its transparent nature enables easy visual inspection without removal. Hydrogels create an optimally moist wound environment necessary for promoting cell migration, proliferation, and tissue regeneration; promote autolytic debridement through hydration of necrotic tissue and enhanced activity of endogenous proteolytic enzymes; provide a barrier from external contaminants but allow gas exchange. Hydrogels absorb less than other types of dressings, so they do not work well in highly exuding wounds because they cause periwound maceration—a state wherein the surrounding skin becomes too hydrated, soft, and prone to break down. Also, they might need another type of covering dressing secured over them, particularly on mobile areas like joints. Hydrogels are ideal for surgical incisions with minimal to moderate exudate, partial-thickness burns, donor sites after skin grafting, and wounds with eschar or slough requiring debridement. Herein, they were proven to decrease pain, speed up re-epithelialization, and improve scar quality when used versus dry gauze.

Foam dressings consist of polyurethane or silicone-based material with an open-cell or closed-cell porous structure providing high absorbency, cushioning, and thermal insulation; these are lightweight, comfortable to wear, easy to cut and shape to fit irregular wound contours, and do not shed any fibers or particles contaminating the wound. The porous nature of foam dressings maintains a moist wound interface by absorbing excess exudate within its upper layers, thus avoiding pooling of fluid on the wound bed. A number of foam dressings contain a silicone adhesive border securing them without traumatizing the surrounding skin during removal. These are ideal for wounds with moderate to heavy exudate: dehisced surgical wounds, pressure ulcers, and venous leg ulcers. Cushioning prevents shear forces and friction, protecting the wound; this is essential in areas prone to movement like the sacrum, heels, and elbows.

Because foam dressings are opaque, we are unable to inspect the wound unless removed, and they are unsuitable for dry wounds or those with minimal exudate because they will absorb moisture and desiccate the wound bed. When comparing absorption data, polyurethane foams have a greater absorption capacity compared to hydrofibres, alginates, and hydrocolloids using a similar surface area of dressing, where some foams can absorb up to 15 times their own weight in fluid. For highly exuding wounds, foam dressings often need changing every day or twice per day – costly and inconvenient, but new super-absorbent foam has increased wear time to up to 7 days [1].

Derived from brown seaweed, alginate dressings comprise calcium alginate or calcium-sodium complexes which ion-exchange when exposed to wound exudate, creating a soft cohesive gel which adheres closely to the wound. The gelling creates a moist healing environment, activates platelets and concentrates clotting factors, promoting hemostasis; it is an excellent absorber (up to 20 times its own weight) of moderate to heavy exudate. These dressings are very absorbent – capably absorbing up to 20 times their weight in fluid – and are biodegradable, so they have reduced environmental impact. Their conformability makes them ideal for use on cavity wounds, undermining wounds and sinuses: filling irregular spaces and contacting the whole wound bed. Can be packed into deep surgical defects, preventing premature closure and abscess formation. They are hemostatic; therefore, they make a good choice for wounds that are oozing or bleeding lightly. A secondary dressing must be used to keep these dressings in place since they lack adhesiveness but cannot be applied to dry wounds due to the requirement for exudate to activate the gelling process. Some forms of alginate have less tensile strength than synthetic dressings, meaning they are prone to fragmenting when removed, though new fibre-reinforced alginates have enhanced handling characteristics. Studies comparing absorption demonstrated that calcium sodium alginate dressings had better absorption properties than calcium alginate dressings, hydrocolloid dressings and foam dressings, showing faster wicking and greater fluid holding capacity. Indicated for moderately to heavily exuding wounds such as post-operative dehisced incisions, pilonidal sinuses and infected wounds after debridement.

Hydrocolloid dressings comprise a polyurethane foam or film backing and a self-adhesive layer comprising hydrocolloid (pectin, gelatin, carboxymethylcellulose) particles forming a gel when exposed to wound exudate. The resulting gel creates a moist occlusive/semi-occlusive environment promoting autolytic debridement, reducing pain and providing a bacterial barrier. These dressings are self-adhesive, conformable, and waterproof, enabling patients to shower without disrupting their dressing. Hydrocolloids remain in situ for up to 7 days, saving nurses' time and minimizing patient discomfort from changing frequently. Their limitation is that they absorb only small amounts of fluid and are ideal for low to moderately exuding wounds—they may lead to maceration of the periwound skin because of the accumulated moisture beneath the occlusive backing if applied to heavily exuding wounds. They do not possess inherent antimicrobial properties – their barrier action is purely physical – and are opaque, so they cannot allow visualization of the wound unless removed. Removal of hydrocolloids produces an odor and may leave them adhered to the wound bed, leading to trauma to fragile new epithelium. Indicated for superficial surgical incisions, partial-thickness burns, pressure ulcers and abrasions, these dressings must never be used on infected wounds or those with heavy drainage.

Collagen-based dressings: These employ collagen obtained either from native or recombinant bovine, porcine, or human origin as a bioactive scaffold promoting cellular infiltration, granulation tissue formation, and angiogenesis. Collagen is the main component of the extracellular matrix; it serves as a chemotactic

factor for fibroblasts, facilitates cell adhesion and migration, and functions as a template for deposition of new matrix. When applied against wound exudate, collagen dressings absorb fluid, forming a gel, slowly degrading while releasing peptides and amino acids stimulating the wound healing cascade. They work especially well on chronic/stalled wounds failing to proceed into the proliferative phase, such as diabetic foot ulcers, pressure ulcers, and dehisced surgical wounds exposing bone or tendon. Collagen dressings have reduced healing time by 30–50%, according to several randomized trials, and encourage development of healthy granulation tissue characterized by a high proportion of mature, type I collagen leading to strong and more pliable scars. Collagen dressings are costly, require careful handling (some are fragile when wet), and can be unsuitable for heavily infected wounds without adding an antimicrobial agent. Theoretically, there could be an allergy due to sensitization to bovine or porcine proteins, but this is rare. Available in sheet, powder, sponge and gel forms enabling their application across different wound geometries. For surgical wounds showing delayed healing, collagen dressings are typically employed as an adjunct to debridement and infection control prior to secondary closure or skin grafting.

3. Comparative clinical evidence and outcome analysis

There are strong comparative data available from the clinical literature for dressing selection. Perhaps the most intuitive metric is healing time. One network meta-analysis of 52 randomized controlled trials (n = 4,283) compared different dressing types on acute surgical wounds. The polyhexanide (PHMB) dressings had the shortest mean healing time; they differed by −14.84 days relative to standard gauze (95% CI: −22.1 to −7.6); they have both an effect of controlling infections as well as managing moisture balance. Foam dressings were also effective, having a mean reduction of 8.2 days, whereas hydrocolloid dressings had a reduction of 6.5 days. While collagen dressings take longer to have an effect, they reduce healing time by 10.3 days in chronic wounds but only 4.1 days in acute surgical wounds. Hydrogel dressings, though not the fastest, had the lowest pain scores and the least number of dressing-related adverse events (maceration, skin stripping). A head-to-head comparison between foam vs hydrogel dressings found no significant difference in time to complete healing among patients with clean surgical incisions; however, there was a mean difference of 5.67 days in favour of foam (95% CI: −4.03 to 15.37); this result did not reach statistical significance, indicating that choice might be based more on exudate management rather than a fundamental difference in healing capacity. For heavily exuding wounds, foam significantly outperforms hydrogel, reducing the time to healing by 9 days ($p = 0.02$), because of its inability to manage moisture, leading to maceration and delayed closure [2].

The wound closure rates – the percentage of wounds that achieve complete epithelialization over a specific period follow a comparable trend; hydrocolloid, carbon fibre and silver dressings have been shown to show significant healing-promoting effects when compared to controls ($P < 0.05$); hydrogel dressings and polyurethane foam dressings had surprisingly close wound closure rates (7.79 ± 1.48% vs 8.22 ± 3.33%), which shows that either one can be used on low-exudate wounds. When it comes to contamination or infections, however, both silver and PHMB dressings closed wounds by 15–20%, as opposed to non-antimicrobial dressings, highlighting the importance of controlling infection during healing. In wounds needing granulation tissue formation, collagen dressings increased their closure rate by 30% at 4 weeks relative to foam dressings due to their bioactive scaffold effect. This demonstrates how the best dressing depends on the situation – a hydrogel or hydrocolloid might be perfect for a clean, dry incision, but an antimicrobial foam or alginate is needed for a contaminated, exudative wound.

The infection prevention measure is important for antimicrobial dressings; there was a 46% relative risk reduction from using advanced vs. standard dressings in a pool of 42 trials with a risk ratio of 0.54. In particular, silver-impregnated surgical dressings had an odds ratio of 0.288 ($p < 0.001$) as demonstrated in a meta-analysis of 11 trials – this shows a very strong protective effect. Comparing antimicrobial dressings against non-antimicrobial advanced dressings (e.g., foam without silver), we observed a further 40% decrease in SSI risk among high-risk patients and thus conclude that the antimicrobial element provides additional benefit over the dressing's physical properties. However, when used on clean surgeries where the baseline SSI rate is <2%, it takes >100 to treat with a silver dressing to prevent one SSI, which makes routine usage hard to justify economically. On the other hand, for contaminated surgery, the number needed to treat was only 12–15, making antimicrobial dressings highly cost-effective [3].

Although scar quality has been less studied, it is paramount to patients, especially if visible; silver hydrogel dressings showed a significant reduction in scar area at six weeks and twelve weeks post-surgery versus control ($p \leq 0.002$), likely from reduced inflammation/infection. Collagen dressings improve scar quality: studies show improved pliability, vascularity, and pigmentation using the Vancouver Scar Scale. Although foam and alginate dressings manage exudate well, there are no consistent scar benefits without adding silicone/antimicrobials. Pain, comfort, convenience, and satisfaction reported by patients tend to be higher when wearing hydrogels and foams – these are soft, conformable, and non-adherent; alginate and collagen dressings can be less comfortable on removal. Hydrocolloids are very highly rated for convenience owing to their long wear time and waterproof nature; however, they can produce an odor upon removal, which is considered unpleasant by some patients. In general, patient satisfaction is greatest with dressings that are easy to apply, change rarely, and remove with minimal pain — all attributes commonly found in modern silicone-based foam and hydrocolloid products.

4. Practical dressing selection framework and decision-making

Using the comparative properties and clinical evidence, we propose a simple step-by-step approach to choosing an optimal dressing during surgical postoperative repair: Step one – evaluate the level of exudate from the wound. Minimal/no exudate, such as a clean, closed surgical incision, superficial burns, and abrasions, require either hydrogel or hydrocolloid dressings. Hydrogels are preferable if you want to reduce pain and visualize your wound whereas hydrocolloids are favourably chosen if you need a waterproof, long-wear (up to 7 days) dressing. Moderate exudate, such as dehisced incisions with serous drainage or small pressure ulcers, requires either foam or alginate dressings, which have sufficient absorption whilst maintaining a moist interface. Foams are easy to apply on flat, accessible surfaces, but alginates are ideal for cavity wounds or irregular geometries. Heavy exudate such as infected surgical wounds, venous leg ulcers, or pilonidal sinuses require alginate or super-absorbent foam dressings that may be used together with a secondary absorbent pad if required.

Antimicrobial dressings are indicated on contaminated wounds, those showing signs of local infection, or in patients at risk for SSI. First-line choice for moderate to high infection risk is silver dressings because they offer broad-spectrum and sustained release; PHMB dressings are an excellent alternative when there is suspicion of biofilm or when silver is contraindicated; copper oxide dressings are emerging as a promising option. On clean wounds in low-risk patients, antimicrobial dressings are not routinely recommended given that cost and potential cytotoxicity outweigh the marginal benefit. Collagen-based dressings are indicated

on wounds that have stalled in the proliferative phase – exhibiting little granulation tissue, epithelialization, or closure. These may be combined with antimicrobials if infection is also present, but this adds cost and complexity.

Wound geometry and location. Sheets or pads work well in flat, superficial wounds, but alginate rope/ribbon or injectable hydrogels will be better for deep cavities or undermining tracts. Dressings that have good conformability and elasticity (hydrogels and foam with silicone adhesive) are preferable for wounds over joints or areas of movement to avoid shearing. Foam dressings with a high cushioning capacity are essential when caring for wounds on the sacrum or heels to offload pressure and prevent additional tissue damage. Thin, transparent hydrogels or silicon-based dressings may be used for cosmetic reasons in facial or visible areas even though they tend to be costly.

Disclosure statement

The author declares no conflict of interest.

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