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Original Research

Polyester Mesh Dressings Reduce Delayed Wound Healing and Reoperations Compared with Silver-Impregnated Occlusive Dressings after Knee Arthroplasty

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ABSTRACT

Background: New dressings aimed at reducing surgical wound complications after knee arthroplasty continue to evolve. We compared wound complications and reoperations between 2 dressings: 2-octyl cyanoacrylate adhesive and polyester mesh (Dermabond® Prineo®, "mesh") and silver-impregnated occlusive dressings and n-butyl-2-cyancacrylate adhesive (AQUACEL® Ag SURGICAL cover dressing with SwiftSet™, "standard").

Methods: This retrospective cohort study reviewed 353 consecutive partial and total knee arthroplasties performed by a single surgeon; 6 were excluded for not using either dressing type. Thus, 347 cases were separated into 2 cohorts: mesh (n = 176) and standard dressing (n = 171). Demographics and risk factors were similar, except for age. Surgical and closure techniques were consistent in all patients. Delayed wound healing was assessed by the surgeon at the 2-week office visit for drainage, suture abscess, or wound edge separation. Secondary outcome measures include infection, office-based closure, and return to the operating room for reclosure.

Results: There were 2 instances of delayed wound healing in the mesh group and 16 in the standard dressing group (1.14% vs 9.36%, $P \leq .0001$). There were significantly fewer reoperations in the mesh group than in the standard group (0 vs 2.33%, $P = .04$). There were no infections or office-based closures.

Conclusion: Mesh dressings were associated with fewer episodes of delayed wound healing and reoperations than the standard dressing. A possible mechanism may be that this brand of mesh distributes wound tension more evenly. In addition, because it remains in place longer during the immediate postoperative period, it may work via prolonged wound edge support.

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Introduction

Unicondylar knee arthroplasty (UKA), total knee arthroplasty (TKA), and patellofemoral arthroplasty (PFA) are successful treatments for knee osteoarthritis but can have complications [1]. Prosthetic joint infections (PJIs), surgical site infections (SSIs), and delayed wound healing can create significant patient morbidity and add to the baseline cost burden for arthroplasty [2-4]. In addition, delayed wound healing is a leading risk factor for PJIs and SSIs [5]. It also contributes to increased management costs for surgeons and physician extenders who must follow up these patients at more frequent intervals in the postoperative period and to stress for patients and families.

Wound closure and surgical preparation strongly influence rates of wound complications and PJIs in both primary and revision total joint arthroplasties (TJAs) [6–14]. At this time, there is no standard of care for postoperative knee dressings [15], and wound management after knee arthroplasty continues to be a challenge because of the unique demands on the healing incision. Knee flexion is critical during rehabilitation after surgery, but flexion increases tension on a fresh anterior surgical wound [16]. Furthermore, diminished lymphatic circulation and significant interstitial edema contribute to an imperfect healing milieu [17].

Several innovative wound dressings have been developed to address wound healing after surgery. Skin glue, such as 2-octyl

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cyanoacrylate adhesive [Dermabond®, Ethicon, Somerville, NJ] and n-butyl-2-cyanocacrylate adhesive [SwiftSet™, Covidien, Dublin, Ireland], has been used regularly to seal epidermal apposition and limit ingress or egress through a surgical wound. Aquacel Ag [AQUACEL® Ag SURGICAL cover dressing, ConvaTec, Berkshire, UK] is a silver-impregnated, occlusive, hydrofiber-based dressing that can protect a surgical wound for 7 days. Aquacel Ag has been shown in multiple studies to result in fewer wound infections and improved wound healing than traditional gauze-based dressings [18–20]. Recently, 2-octyl cyanoacrylate adhesive has been combined with a polyester mesh [Dermabond® Prineo®, Ethicon] to reinforce and share tension across a surgical wound. The mesh dressing has been shown to decrease wound edge ischemia and improve cosmesis. In theory, this is due to decreased tensile stresses on the wound apposition by load sharing with the mesh [21]. Wounds dressed with mesh have also shown decreased drainage compared with controls [22]. Importantly, wound drainage contributes to delayed wound healing, decreased patient satisfaction, increased cost, and increased risk of infection in knee arthroplasty procedures [23].

The Aquacel Ag on top of n-butyl-2-cyanocacrylate adhesive was the standard wound dressing at our institution after UKA and TKA for several years. This study sought to compare the standard dressing with the mesh dressing for both UKA and TKA. The primary outcome measure was delayed wound healing, as documented by the primary surgeon at the initial 2-week postoperative visit. Secondary outcomes evaluated were need for any further intervention, such as return to the operating room (OR) within the perioperative period for wound closure revision or office-based suturing to prevent dehiscence.

Our hypothesis was that patients who received the mesh dressing would experience fewer episodes of delayed wound healing than those who received the standard dressing.

Material and methods

Our institutional review board approved this retrospective study. We identified 416 consecutive knee arthroplasties performed by the senior author between September 2014 and February 2018. Sixty-three (15%) were excluded as revision TKA. An additional 6 arthroplasties, all TKA, were excluded because they were treated with a primary negative pressure wound dressing rather than either of the aforementioned types of study dressings. This left 347 consecutive patients who had either partial knee arthroplasty or TKA, including 4 PFAs, 36 primary UKAs, and 307 primary TKAs. These 347 patients were split into 2 groups based on whether they received the mesh dressing (n = 176, 50.7%) or the standard dressing (n = 171, 49.3%). These were consecutive cohorts with an inflection date of February 8, 2017, at which time the mesh dressing became available for use in our hospital system.

Surgical preparation, surgical technique, and wound closure technique remained unchanged during the study duration. Skin was prepped with 2% w/v chlorhexidine gluconate in 70% v/v isopropyl alcohol sticks (ChloraPrep™, BD, Franklin Lakes, NJ) followed by an antimicrobial skin adhesive layer (Ioban™ 2 Antimicrobial Incise Drapes, 3M, St. Paul, MN). A standard minimally invasive arthroplasty technique was used, with specific identification of the superficial and deep fascial layers. During closure, the knee was flexed to 30 degrees. Deep fascia was closed with running barbed suture #2 PDO Quill™ (Surgical Specialties, Wyomissing, PA) with full backtracking to the starting point. Then, 0 monoderm Quill™ (Surgical Specialties, Wyomissing, PA) was used in the superficial fascia with backtracking in the deep dermis as a horizontal mattress to the center. Then, 2-0 monoderm Quill™ (Surgical Specialties) was used in the subcuticular layer with backtracking to the center. The antimicrobial skin adhesive layer was then removed, and the wound edges were washed with sterile saline followed by a sponge to blot-dry the skin.

In the standard dressing group, n-butyl-2-cyanocacrylate adhesive was applied and allowed to polymerize fully. Then, an Aquacel Ag bandage was applied with all edges sealed. Patients were instructed to remove the dressing on postop day 7. In the mesh group, the polyester mesh was sized and placed on the incision lengthwise, as instructed by the product insert [24]. This was followed by 2-octyl cyanoacrylate adhesive and full polymerization. Then, 4 × 4 gauze dressings were applied. In both groups, a compressive elastic wrap was placed from the ankles to thigh. A drain was used in all patients. A gauze drain sponge was placed at the lateral puncture wound, with no interference of either dressing type. The drain and surrounding gauze were removed the morning after surgery. The wounds were left uncovered after postoperative day 7 in the silver dressing group and after postoperative day 2 in the mesh group (ie, no gauze or ace was placed over the mesh after the surgical gauze was removed). Both groups were allowed to shower on postoperative day 2 without any additional cover to the mesh group during the shower; scrubbing of the mesh was prohibited, as was submersion into a bath. All patients were followed up for at least 6 months postoperatively.

All patients had a body mass index (BMI) <40 kg/m^2, hemoglobin A1c <8%, albumin >4g/dL, and hemoglobin >12g/dL before being indicated for surgery by the senior author. Tranexamic acid was used for all patients, with 2 doses given intravenously, one before incision and one during closure. No blood transfusions were given. Standard 24 hours of antibiotic prophylaxis was used, based on allergy profiles. Aspirin 325 mg twice daily was used for anticoagulation, unless the patient was already taking a stronger anticoagulant for pre-existing medical or cardiac reasons, in which case the presurgical anticoagulant was resumed postoperatively. Rehabilitation was similar for both groups and consisted of immediate weight-bearing and range-of-motion exercises under the guidance of hospital physical therapists starting the day of surgery and then progressing to in-person physical therapy at home or at a rehabilitation facility on discharge.

Delayed wound healing was diagnosed by the senior author at a standard 2-week office visit (±7 days) or sooner via text message or email pictures if contacted by the patient, visiting nurse, or post-acute care facility. Delayed wound healing was defined as drainage, suture abscess, or wound edge separation of any amount (including scab formation wider than 1 mm). If the mesh was still in place at the time of office visit, then the wound was examined through the dressing without removal of the mesh. Patient demographics were collected, including sex, smoking status, BMI, the American Society of Anesthesiologists score, and diagnosis of diabetes. Office charts were reviewed to identify instances of delayed wound healing, need for an office-based procedure for further wound closure, or return to the OR. Hospital surgical notes were also reviewed to identify return to the OR for wound-related reasons.

Categorical variables are reported as percentages. Categorical variables between the groups were evaluated using the chi-square test, and continuous variables were evaluated with a paired Student's *t*-test. A *P* value of <.05 indicated statistically significant differences. Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL).

Results

There were no significant differences in the type of surgery (UKA + PFA vs TKA) between groups (Table 1). There were no differences in sex, laterality, or risk factors for wound healing complications [the American Society of Anesthesiologists score, BMI,

smoking status, use of anticoagulation other than aspirin, and diagnosis of diabetes mellitus] between the groups. There was a statistically significant difference in age between the groups, with the mesh group having an average age of 2.6 years older than the standard dressing group ($P = .02$) (Table 1). The average length of surgery was not significantly different, with the standard and mesh groups having averages of 100.6 and 102.8 minutes, respectively ($P = .31$).

In total, there were 18 episodes of delayed wound healing in this patient cohort (5.18%) (Table 2). Patients treated with the mesh had significantly fewer episodes of delayed wound healing (n = 2, 1.1%) than the standard dressing group (n = 16, 9.4%) ($P < .0001$). The 16 patients with delayed wound healing in the standard dressing group had undergone TKA. In the mesh group, both patients with delayed wound healing also had TKA.

In the standard dressing group, 3 patients (1.75%) required reoperation for revision wound closure. One patient had a recurrent wound dehiscence after reoperation for closure and required a second reoperation. Thus, there were a total of 4 reoperations (2.3%) in the standard dressing group. There were no reoperations in the mesh group. This finding was statistically significant ($P = .04$).

No adverse events related to the dressing (eg, allergy, blistering, rash.) occurred in either group. The mesh dressing persisted in place at the 2-week visit in all patients. The silver dressing was removed at 7 days in all patients, with none persisting at the 2-week visit.

Discussion

We found a significant decrease in delayed wound healing and reoperations for wound complications when using the mesh dressing compared with the standard dressing in patients who underwent knee arthroplasty.

The overall incidence of delayed wound healing in our case series was 5.18%, which is similar to other studies. Three series examining wound complications when closing with barbed sutures demonstrated a 5.7%-13% rate of superficial complications [11,13,25]. A reduction of delayed wound healing to around 1% would result in a dramatic decrease in expenditures after knee arthroplasty [26]. As the volume of TJAs continues to grow [27], the number of infections and wound complications also grows [3]. A large series has shown that SSIs extend the length of hospitalization by approximately 10 days and increase costs by ~$15,000 after orthopaedic surgery [26,28].

Table 1
Demographics and type of surgery.

Variable	Standard dressing (n = 171) Mean (SD)	Mesh (n = 176) Mean (SD)	*P*-value
Age (y)	65.7 (9.7)	68.3 (10.5)	.02[a]
Female sex (%)	124 (72.5%)	127 (72.2%)	.94
BMI (kg/m^2)	30.4 (5.6)	30.2 (5.0)	.59
ASA score	2.2 (0.5)	2.2 (0.5)	.80
DM (%)	30 (18%)	28 (16%)	.28
Active smokers (%)	5 (3%)	4 (2%)	.70
Use of anticoagulant other than aspirin (%)	20 (12%)	18 (10%)	.66
Side (% right)	84 (49.1%)	90 (51.1%)	.71
Length of surgery (min)	100.6 (20.3)	102.8 (20.3)	.31
PFA (%)	2 (1.2%)	2 (1.1%)	
UKA (%)	14 (8.2%)	22 (12.5%)	
TKA (%)	152 (88.9%)	151 (85.8%)	.44

ASA, American Society of Anesthesiologists; DM, diabetes mellitus.
[a] Indicates statistical significance.

Table 2
Results.

Variable	Standard dressing (n = 171)	Mesh (n = 176)	*P*-value
Delayed wound healing	16 (9.4%)	2 (1.1%)	<.0001[a]
Return to the OR	4 (2.3%)[b]	0 (0%)	.04[a]

[a] Indicates statistical significance.
[b] One patient returned to the OR twice for wound closure.

As wound closure technology has advanced, so has the cost of the innovative dressings. Traditional gauze dressings can cost below $1. The standard dressing used here can cost approximately $40, and the mesh dressing approximately $80. Without factoring in wound complications or reoperation rates, Sadik et al. [29] found that usage of this mesh dressing resulted in $56-$80 saved per patient in a 90-day economic model, given the fact that fewer materials are used and the need for suture or staple removal is obviated by its use. In addition, this mesh closure has been shown to improve discharge disposition to home rather than rehabilitation institutions and reduce rates of 30-, 60-, and 90-day readmissions [30]. While a formal cost-benefit analysis is outside the scope of this study, the cumulative increased cost associated with mesh dressings (about $7000 in total, given the size of this patient cohort), is more than offset by the reduction in return to the OR (from 4 events to zero) and these other factors.

Grosso et al. [19] reported a fourfold decrease in the incidence of PJI after TJA when using skin adhesive and silver-impregnated dressings (identical to our standard dressing) as compared with xeroform and gauze. With acute infection as the primary outcome, they reported a decrease in the incidence from 1.58% to 0.33%. In this current report, the incidence of acute deep infection was zero in both groups. However, there was a significant reduction in delayed wound healing and reoperations related to wound complications in the mesh group. A reduction in delayed wound healing could be reasonably extrapolated to reduce acute infection rates in a larger study group. Holte et al. reported a 0.8% rate of superficial wound complications in a cohort of 360 knee arthroplasties using a similar mesh and glue dressing, and they had zero deep infections [31]. Although we did not quantify or assess patient and provider mental anguish from managing at-risk wounds, it is equally reasonable to assume that fewer episodes of delayed wound healing were associated with less stress for patients and providers.

There have been reports of adverse reactions to the mesh dressing, including allergic dermatitis [31–36]. In those reports, the reactions were generally mild and responded to a course of topical corticosteroid cream. The product packaging warns against use in patients sensitive to cyanoacrylate, formaldehyde, benzalkonium chloride, or any pressure-sensitive adhesive [24]. Furthermore, any breaks in skin closure could result in the adhesive contacting deep tissue below the skin, which can result in a foreign body reaction. In our study, there were no allergic reactions, with the limitation that this retrospective review would not be as sensitive as a prospective study in identifying adverse events.

One explanation for the improved outcomes with the mesh dressing is that the mesh purports to add strength and tension-sharing properties when compared with standard dressings. It has been shown to have equivalent strength to 3-0 suture, except that its strength is evenly distributed across the width of the mesh instead of at individual anchor points [37]. Although the final skin suture of 2-0 monoderm-type suture may be obviated, we maintained a typical suture closure, thereby making the additional mesh strength purely additive. The mesh also creates a mechanical barrier over the wound that persists for weeks. The barrier is similar but more substantive than skin adhesive alone and has been reported to prevent the entry of 99% of pathogens into the wound over 72 hours [37].

There are some limitations to this study, including its retrospective nature, limited documentation of late scar cosmetic appearance, and the use of 2 different brands of skin adhesive. There was also a significant age difference between the groups, with the mesh group an average of 2.6 years older than the standard dressing group. This difference is likely clinically insignificant. In addition, only the operative surgeon assessed wounds in the office rather than a blinded third party. However, as this is a retrospective study, the assessments were performed outside the context of a research study, and therefore, blinding is less applicable. Strengths include its single-surgeon design, which controls for technique variations in the surgery and closure between groups. Another strength is lack of attrition of the surgical group and close follow-up until full healing and stability of all surgical wounds by 6 months postoperatively. Postoperative physical therapy protocols were also identical between the groups, emphasizing active knee range of motion with a goal of 0-100 degrees by 2 weeks. In addition, wound assessments were made directly by the surgeon, sample sizes were large, and the consecutive distribution of patients reduces some of the biases of a retrospective cohort study. This study could be stronger if performed in a randomized blinded fashion, with blinded wound assessments postoperatively.

Conclusion

A mesh dressing was associated with fewer episodes of delayed wound healing and reoperations than the standard dressing in this consecutive series of 347 partial knee arthroplasty and TKA. There is some intuitive support for this finding, including the tension-sharing feature of mesh during immediate postoperative knee-bending exercises. Surgeons may wish to consider mesh dressings after knee arthroplasty to reduce wound complications.

Conflict of interest

Two relevant COI occurred after manuscript submission. Patient surgery and post-op evaluations were performed before 02/2018 by RPS. This manuscript was initially submitted in 2/2019 with minor edits until publication. Seven months after manuscript submission and 19 months after data collection, 2 authors served on an J&J/Ethicon Advisory Board (HJC 9/2019; RPS 11/2019) and J&J/Depuy hip implant usability lab (RPS 9/2019). One ongoing unrelated consulting arrangement with J&J/Depuy began in 10/2017 (HJC).

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