The effect of a silver hydrogel sheet dressing on postsurgical incision healing after foot and ankle surgery

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Abstract

Introduction: Silver hydrogel dressings are antimicrobial dressings with the potential to aid post-surgical healing. The purpose of this study is to evaluate the effects of a silver hydrogel dressing on postoperative scarring and complications.

Methods: 40 foot and ankle patients (48.43 ± 16.82 years) were included in the study with 20 patients in each group. Postoperatively, the treatment group was treated with a silver hydrogel sheet dressing, and the control group was treated with a standard petroleum-based dressing. Follow-up was performed at two, six, and 12 weeks. Postoperative scarring and complications were evaluated and compared between groups. Scarring was evaluated using the Patient and Observer Scar Assessment Scale (POSAS). Scar length and width were measured using digital calipers and used to compute scar area.

Results: The treatment group demonstrated statistically significant improvements in the POSAS observer score and observer opinion at six and 12 weeks ($p < 0.001$). Additionally, patient reported pain was significantly lower for the treatment group than the control group at 12 weeks ($p < 0.001$). Patient reported itch declined across time for both groups ($p < 0.001$) with significantly less itching reported by the treatment group ($p = 0.027$). Scar area was also significantly lower for the treatment group than the control group at six weeks and 12 weeks ($p \leq 0.002$). Neither group experienced any postoperative complications.

Conclusion: These results suggest that the inherent properties of the silver hydrogel dressing may improve post-surgical scarring.

Keywords
Scar, incision, silver, hydrogel, POSAS

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Lay Summary

Surgical incisions result in scar, which can present both cosmetic and rehabilitation concerns after foot or ankle surgery. It is standard to use a petroleum-based dressing on incisions after surgery, however, advancements in incisional dressings have been made over the past 20 years. One such advancement is silver-impregnated hydrogel sheet dressings which have been shown to maintain a moist wound environment conducive to healing, while decreasing the chance of infection through its antimicrobial properties. This paper evaluates scar healing after foot or ankle surgery in patients treated with either the standard petroleum-based dressing, or the silver hydrogel sheet dressing. Patients who were treated with the silver hydrogel dressing had less itching and pain, as well as a smaller scar area than patients in the standard dressing group. Therefore, our results suggest that the silver hydrogel dressing may improve scarring after surgery.

Introduction

All surgical incisions will result in a scar.[1] Scar formation after foot and ankle surgery presents a variety of concerns for the patient and surgeon, from cosmetic to rehabilitation. Linear incisions, like those commonly utilized in foot and ankle surgery, comprise the largest category of surgical scars.[2] There are many intrinsic factors related to foot and ankle surgery that can impact incision healing and complicate scar formation and remodeling. For example, these surgical incisions are often in areas of high tension and dependent edema. Unsightly or uncomfortable scar formation on a foot or ankle presents cosmetic concerns for many patients. From the surgeon's perspective, poor scarring may impede range of motion, alter one's gait, and complicate return to certain shoe gear or activity, which can lead to poor patient outcomes.[3]

Hence, incision management after foot and ankle surgery is critical and complex. Important factors for treating surgical incisions in the initial postoperative period include preventing wound infection, providing protection from shearing and mechanical disturbance, decreasing peri-incisional inflammation, maintaining moisture, and promoting cosmesis.[1,4] Moist environments for surgical incisions have been shown to result in accelerated healing.[5] Coverage and maintenance of a moist wound environment with a dressing encourages epithelialization and collagen synthesis, among other benefits.[6] A commonly used dressing on surgical incisions is a petroleum-based mesh gauze. This non-adherent dressing is generally well-tolerated by patients and reduces disruption to the incision upon removal. In our experience, this is typically the initial postoperative dressing of choice for most foot and ankle surgeons. These dressings can aid in maintaining wound moisture

but have not been found to demonstrate significant antimicrobial activity.[7]

Hydrogels are another commonly used product utilized in wound healing and the treatment of burns. This structurally advanced dressing has the ability to maintain a moist environment, impart moisture upon a dry environment, and to wick away wound exudate. They are not indicated for high-output wounds as they may create a macerated environment.[6] They are also anti-inflammatory, non-irritant, and non-reactive, making them extremely versatile dressing adjuncts. Studies suggest that the use of hydrogels may encourage epithelization, inhibit scar formation and lead to a decrease in scar size.[8]

Hydrogel-based dressings impregnated with silver have been introduced onto the market, now providing the additional benefit of antimicrobial action.[9,10] Studies have shown that silver-impregnated dressings display bactericidal properties against a wide variety of pathogens as well as accelerate wound healing.[11–14] Some of these products are even available over-the-counter for greater patient availability.

One of the most widely utilized dressing for the prevention of hypertrophic and keloid scars in postsurgical patients is silicone gel sheeting.[3,15,16] While the mechanism of action is not completely understood, the silicone creates an occlusive environment, which thereby promotes hydration as the scar remodels. These dressings are often described as being consumer-friendly, as they are non-invasive and can be applied by patients within their own homes. The silicone gel dressing is required to be worn over the scar constantly for upwards of six months to achieve the best results.[15] One study found that silicone gel sheeting applied for 12 weeks to incisions after bunion surgery resulted in improved scarring compared to the control group.[3]

While historically utilized to treat scars associated with burns or wounds, hydrogel dressings also have applications in treating postsurgical incisions. Silver-impregnated hydrogel dressings have similarities in their mechanism of action to silicone gel. They are also similarly non-invasive, relatively inexpensive, and can be applied by the patient at home. Our group has previously reported on the use of silver hydrogel sheet (SHS) dressings on postsurgical incisions in foot and ankle surgery.[17] This prospective comparative pilot study demonstrated that the SHS dressing had a similar incidence of infections compared to a standard petroleum-based dressing. However, the standard dressing group had a greater incidence of incisional complications and a smaller reduction in scar length compared to the group treated with the SHS dressing. This study was limited in its assessment of the incisional scar healing and did not include any patient-reported outcome measures. As a result, in the present study we sought to compare the effects of a SHS dressing to a standard petroleum-based dressing on postoperative scarring using a validated scar assessment scale that incorporates both patient and observer evaluation. Objective measures, including scar area and postoperative complications are reported as secondary outcomes.

Methods

Study population

A prospective, randomized comparative study was performed on a total of 40 patients undergoing elective foot and ankle surgery with 20 patients in the treatment group (SHS dressing), and 20 patients in the control group (petroleum-based dressing). Patients were enrolled in the study from January to June 2021 after meeting inclusion and exclusion criteria (Table 1). Patients were included if they were 18 years or older and undergoing elective foot or ankle surgery with a planned surgical incision greater than 1 cm in length. Non-elective procedures including

Table 1. Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
18 years or older	Trauma
Undergoing elective surgery to the foot or ankle	Active infection or antibiotic use
Incision > 1 cm in length	Presence of wound

patients with active infection or trauma were excluded. All patients gave informed consent.

The patients underwent surgery on the foot or ankle by a single board-certified foot and ankle surgeon (SAB). Standard surgical protocol was followed for each procedure. Incision closure was performed with 3-0 monofilament absorbable suture for subcutaneous tissue and 4-0 monofilament non-absorbable suture for skin in a horizontal mattress fashion.

At the time of surgery, patients were randomized into either the SHS treatment group, or the control group by the surgeon (SAB). This was performed using the sealed envelope method.[18] The envelopes were created by another study member (JL) who was not involved in the allocation of subjects to groups. Envelopes were opaque, sequentially numbered, and signed on the back when initially sealed. The envelopes were stored securely throughout the duration of the study.

A silver hydrogel sheet (SilverSeal®, NEXGEL, Inc., Langhorne, PA) was applied to the incision at time of surgical dressing application for the patients in the treatment group. The silver hydrogel sheet was then re-applied postoperatively at the time of suture removal. As is typical for surgery in the foot and ankle, suture removal was performed at two weeks postoperatively for all patients. The SHS was then used 8 h daily for the next 12 weeks. A standard petroleum-based mesh gauze was applied initially to the patients in the control group and used until suture removal, at which point no further dressing was utilized, which has previously been our standard practice. Anecdotally, this is also the standard practice for most foot and ankle surgeons.

Scar assessment

The scars were evaluated at two weeks, six weeks, and 12 weeks postoperatively by a single blinded investigator (JL). Prior to the investigator's evaluation, all dressings were removed and discarded by a member of the clinical team not involved in the study. The Patient and Observer Scar Assessment Scale (POSAS) was used to prospectively evaluate postoperative scarring for all subjects.[2] Each item of the POSAS is rated on a 10-point score. The lowest score is '1', which corresponds to normal skin (i.e. normal color, no itching). A score of 10 equals the largest difference from normal skin (i.e. the worst imaginable scar or sensation). The POSAS consists of two scales of 6 items each: the patient scale and the

observer scale. The patients subjectively reported on scar pain, itchiness, color, stiffness, thickness, and irregularity. The observers reported on scar vascularity, pigmentation, pliability, thickness, relief, and surface area. Observers used the definitions of these parameters found in van de Kar et al.'s study from 2005 to complete their assessment.[2] The total score of both scales can be simply calculated by summing up the scores of each of the six items, meaning the total score can range from 6 to 60. There is also an overall opinion rating for each group that is not included in the sum score. In this report, the total observer score was computed and reported, and then compared between groups and over time. We also chose to report the individual item, observer opinion, which was also compared between groups and over time. From the patient-reported scale, two individual items (i.e. patient reported pain and patient reported itch) were reported and compared between groups and over time.

Objective scar assessment was performed by measuring scar length and width. These measurements were obtained using digital calipers. The central aspect of the scar was defined as one half the length of the scar and used to measure scar width. Digital calipers were zeroed between patients and measurements. Scar area was computed by multiplying scar length and scar width. The average scar length, width, and overall area was then reported and compared between groups over time.

Postoperative complications were also recorded and compared between groups. Postoperative complications include infection (i.e. superficial or deep), dehiscence, required antibiotics, additional surgeries, and hypertrophic or keloid scarring that required additional treatment. If a patient in either group developed abnormal scarring, including hypertrophic or keloid scarring at any point during the 12-week study period, the patient would be excluded from the study and further scar treatment initiated.

Statistical analysis

All analyses were conducted using IBM SPSS (Build 1.0.0.1444). Independent samples t-tests were used to make comparisons between the two groups. Chi-squared and Fisher's exact tests were used to compare the prevalence of cases between groups. Repeated measures analysis of variance (ANOVA) with post-hoc Bonferroni adjustments were conducted to evaluate the POSAS observer score, POSAS observer opinion, patient reported pain, patient reported itch,

and scar area. ANOVA results are reported as an F-statistic and its associated degrees of freedom. The significance level for all statistical tests was set at p value ≤ 0.05.

Results

Patient demographics

In total, 40 patients (48.43 ± 16.82 years) were included in the study with 20 (50%) in the treatment group (SHS dressing) and 20 (50%) in the control group (standard petroleum-based dressing). No patients were lost to follow up or excluded from the final data analysis. The two groups were similar in terms of gender ($p = 0.527$), age ($p = 0.176$), number of smokers ($p = 0.231$), and comorbidities ($p = 0.091$). Patient demographics are reported in Table 2.

Surgery details

The number of surgical incisions located at the forefoot, midfoot, and ankle were comparable between groups ($p = 0.752$, Table 3). There were no plantar incisions in either group. In the forefoot, the most common incision location was overlying the first metatarsophalangeal joint in both groups. In the midfoot, the most common location was over the first tarsometatarsal joint. In the ankle, the most common location was overlying the lateral ankle ligaments. Additionally, there was no significant difference in incision length between the control group (46.65 ± 15.61 mm) and treatment group (50.95 ± 14.45 mm, $t(38) = -0.904$, $p = 0.186$).

Subjective outcomes

POSAS observer score. The mean POSAS observer scores reported for each group at two weeks, six weeks, and 12 weeks postoperatively are reported in Table 4 and demonstrated graphically in Figure 1. A repeated measures ANOVA determined that there was a significant interaction for the effects of time and group for the POSAS observer score ($F(2,76) = 72.623$, $p < 0.001$). Post-hoc tests revealed that there was no statistically significant difference in mean POSAS observer scores between groups at two weeks ($t(38) = 0.064$, $p = 0.949$). However, there was a statistically significant difference seen at both six and 12 weeks. At six weeks, the SHS dressing group had significantly lower scores than the control group (treatment: 16.20 ± 4.19, control: 23.10 ± 4.04, $t(38) = 5.304$, $p < 0.001$). Similarly, significantly

Table 2. Patient demographics. Counts and percentages are provided. Means and standard deviations are provided when appropriate. No statistically significant difference was found between the two groups in respect to patient demographics.

Demographic	Control (n = 20)	Treatment (n = 20)	p value
Gender (female)	12 (60%)	9 (45%)	0.527
Age (years)	44.80 ± 16.30	52.05 ± 16.96	0.176
Smoker	3 (15.00%)	0 (0.00%)	0.231
Comorbidity			0.091
Asthma	1 (5.00%)	2 (10.00%)	
Atrial fibrillation	0 (0.00%)	2 (10.00%)	
Benign prostatic hyperplasia	0 (0.00%)	2 (10.00%)	
Bipolar disorder	0 (0.00%)	2 (10.00%)	
Chronic kidney disease	1 (5.00%)	2 (10.00%)	
Coronary artery disease	0 (0.00%)	1 (5.00%)	
Congestive heart failure	0 (0.00%)	2 (10.00%)	
Depression	1 (5.00%)	6 (30.00%)	
Diabetes mellitus (type 1)	1 (5.00%)	0 (0.00%)	
Diabetes mellitus (type 2)	2 (10.00%)	2 (10.00%)	
Eczema	1 (5.00%)	0 (0.00%)	
Gastroesophageal reflux disease	1 (5.00%)	2 (10.00%)	
Hyperlipidemia	6 (30.00%)	6 (30.00%)	
Hypertension	8 (40.00%)	5 (25.00%)	
Rheumatoid arthritis	1 (5.00%)	0 (0.00%)	
Sarcoidosis	1 (5.00%)	0 (0.00%)	
Sickle cell trait	2 (10.00%)	0 (0.00%)	
Vitamin D deficiency	1 (5.00%)	2 (10.00%)	

Abbreviation: BMI, body mass index.

lower scores were also seen in the treatment group at 12 weeks (treatment: 9.35 ± 2.74, control: 21.10 ± 3.52, $t(38) = 11.776$, $p < 0.001$).

We also found that there was a main effect for group, which indicates that the mean total POSAS observer score for all time periods was statistically significantly lower for the SHS dressing group (17.13 ± 7.92) than the standard dressing group $(23.38 \pm 4.58$, $F(1,38) = 27.929$, $p < 0.001$, Table 4).

POSAS observer opinion. The mean POSAS observer opinion scores reported for each group at two weeks, six weeks, and 12 weeks postoperatively are reported in Table 4 and demonstrated graphically in Figure 2. A repeated measures ANOVA determined that there was a significant interaction for the effects of time and group for the POSAS observer opinion ($F(2,76) = 35.523$, $p < 0.001$, Table 5). Again, post-hoc tests revealed that there was no statistically significant difference in the mean POSAS observer opinion between groups at two weeks ($t(38) = 0.218$, $p = 0.829$). However, similar to the mean POSAS observer score, the mean POSAS observer opinion was statistically significantly lower for the SHS dressing group (2.45 ± 1.10) compared to the control group (4.20 ± 1.24) at six weeks

Table 3. Incision location. Counts and percentages are provided.

Incision Location	Control (n = 20)	Treatment (n-20)	Total (n = 40)
Ankle	6 (30.00%)	5 (25.00%)	11 (27.50%)
Forefoot	9 (55.00%)	11 (55.00%)	20 (50.00%)
Midfoot	5 (25.00%)	4 (20.00%)	9 (22.50%)

(t(38) = 4.724, $p < 0.001$), and 12 weeks (treatment: 1.05 ± 0.22, control: 3.85 ± 1.23, t(20.263) = 10.049, $p < 0.001$).

Additionally, there was a main effect for group, which indicates that mean total POSAS observer opinion was statistically significantly lower for the treatment group (2.65 ± 1.72) than the standard dressing group (4.20 ± 1.36, F(1,38) = 22.465, $p < 0.001$, Table 4).

POSAS patient reported pain. The mean POSAS patient reported pain scores reported for each group at two weeks, six weeks, and 12 weeks postoperatively are reported in Table 4 and demonstrated graphically in Figure 3. A repeated measures ANOVA with a Greenhouse-Geisser correction determined that there was a significant interaction for the effects of time and group for patient reported pain (F(1.169,44.440) = 20.831, $p < 0.001$). Post-hoc tests revealed that there was no statistically significant difference in the mean patient reported pain score between groups at two weeks (t(38) = −1.566, $p = 0.126$) or six weeks (t(34.736) = 1.866, $p = 0.071$). However, at 12 weeks, the patient reported pain was statistically significantly lower for the treatment group (1.10 ± 0.45) than the control group (2.15 ± 1.09, t(25.227) = 3.987, $p < 0.001$).

We found no main effect for group for the mean total patient reported pain score. Instead, these were determined to be relatively similar between groups (treatment: 2.27 ± 1.73, control: 2.55 ± 1.41, F(1,38) = 0.552, $p = 0.462$).

POSAS patient reported itch. The mean POSAS patient reported pain scores reported for each group at two weeks, six weeks, and 12 weeks postoperatively are reported in Table 4 and demonstrated graphically in Figure 4. A repeated measures ANOVA with a Greenhouse-Geisser correction determined that there was no significant interaction for the effects of time and group for patient reported itch (F(1.109, 42.155) = 0.822, $p = 0.382$).

We did determine there was a main effect for group regarding the mean total patient reported itch score. There was a statistically significant lower mean total score for the SHS dressing group (1.32 ± 0.79) compared to the control group (1.90 ± 1.22, F(1,38) = 5.262, $p = 0.027$).

Objective outcomes

Scar length. The mean scar length at two weeks, six weeks, and 12 weeks postoperatively are reported in Table 5. A repeated measures ANOVA with a Greenhouse-Geisser correction determined that there was a significant interaction for the effects of time and group for scar length (F(1.524, 57.910) = 44.066, $p < 0.001$, Table 5). However, post-hoc tests revealed that there was no statistically significant difference in the mean scar length between groups at two weeks (t(38) = −0.174, $p = 0.863$), 6 weeks (t(38) = 0.517, $p = 0.304$), or 12 weeks (t(38) = 1.073, $p = 0.145$).

The mean scar length was statistically significantly different across time (F(1.524,57.910) = 107.001, $p < 0.001$). Post-hoc tests using the Bonferroni correction revealed that there was a statistically significant reduction in scar length from two weeks (50.35 ± 14.34 mm) to six weeks (47.80 ± 13.93 mm, $p < 0.001$) to 12 weeks (46.00 ± 14.18 mm, $p < 0.001$). Lastly, there was no main effect for group, which indicates that mean scar length was similar for the treatment (47.00 ± 14.07 mm) and control groups (49.10 ± 14.26 mm, F(1,38) = 0.219, $p = 0.643$).

Scar width. The mean scar width at two weeks, six weeks, and 12 weeks postoperatively are reported in Table 5. A repeated measures ANOVA determined that there was a significant interaction for the effects of time and group for scar width (F(2,76) = 5.366, $p = 0.007$, Table 5). Post-hoc tests revealed that the mean scar width was statistically significantly lower for the treatment group (1.23 ± 0.47 mm) compared to the control group (1.65 ± 0.75 mm) at two weeks (t(32.143) = 2.154, $p = 0.039$), six weeks (treatment: 0.98 ± 0.44 mm, control: 1.60 ± 0.68 mm, t(32.673) = 3.441, $p = 0.002$), and 12

Table 4. Subjective outcomes reported by observer and patient using the POSAS. Means and standard deviations are provided.

POSAS Item	2 weeks	6 weeks	12 weeks	Total
	**Postoperative timepoint**			
Observer score				
Control	25.95 ± 4.89	23.10 ± 4.04	21.10 ± 3.52	23.38 ± 4.58
Treatment	25.85 ± 5.01	16.20 ± 4.19^a	9.35 ± 2.74^a	17.13 ± 7.92^a
Observer opinion				
Control	4.55 ± 1.57	4.20 ± 1.24	3.85 ± 1.23	4.20 ± 1.36
Treatment	4.45 ± 1.32	2.45 ± 1.10^a	1.05 ± 0.22^a	2.65 ± 1.72^a
Patient reported pain				
Control	2.95 ± 1.67	2.55 ± 1.36	2.15 ± 1.09	2.55 ± 1.41
Treatment	3.85 ± 1.95	1.85 ± 0.99	1.10 ± 0.45^a	2.27 ± 1.73
Patient reported itch				
Control	2.35 ± 1.63	1.85 ± 0.99	1.50 ± 0.76	1.90 ± 1.22
Treatment	1.90 ± 1.17	1.05 ± 0.22	1.00 ± 0.00	1.32 ± 0.79

[a]Indicates a statistically significant difference between the treatment and control groups.

weeks (treatment: 0.78 ± 0.26 mm, control: 1.55 ± 0.60 mm, t(25.558) = 5.280, $p < 0.001$).

The mean scar width was statistically significantly different across time (F(2,76) = 13.198, $p < 0.001$). Post-hoc tests using the Bonferroni correction revealed that there was a statistically significant reduction in scar width from two weeks (1.44 ± 0.65 mm) to six weeks (1.29 ± 0.65 mm, $p = 0.043$) to 12 weeks (1.16 ± 0.60, $p = 0.028$).

Lastly, there was a main effect for group, which indicates that mean scar width was statistically significantly lower for the treatment group (0.99 ± 0.44 mm) than the control groups (1.60 ± 0.67 mm, F(1,38) = 13.545, $p < 0.001$).

Scar area. The mean scar area at two weeks, six weeks, and 12 weeks postoperatively are reported in Table 5 and demonstrated graphically in Figure 5. A repeated measures ANOVA with a Greenhouse-Geisser correction determined that there was a significant interaction for the effects of time and group for scar area (F(1.607, 61.060) = 6.065, $p = 0.007$, Table 5). Post-hoc tests revealed that the mean scar area was similar between the two groups at two weeks (t(30.431) = 1.706, $p = 0.098$). However, the scar area was statistically significantly lower for the treatment group (43.05 ± 21.40 mm^2) than the control group at six weeks (81.65 ± 48.43 mm^2,

t(32.673) = 3.441, $p = 0.002$) and 12 weeks (treatment: 33.08 ± 13.66 mm^2, control: 77.85 ± 43.68 mm^2, t(25.558) = 5.280, $p < 0.001$).

The mean scar area was statistically significantly different across time (F(1.607, 61.060) = 20.792, $p < 0.001$). Post-hoc tests using the Bonferroni correction revealed that there was a statistically significant reduction in scar area from two weeks (74.54 ± 46.38 mm^2) to six weeks (62.35 ± 41.81 mm^2, $p = 0.043$) to 12 weeks (55.46 ± 39.17 mm^2, $p = 0.028$).

Lastly, there was a main effect for group, which indicates that mean scar area was statistically significantly lower for the treatment group (46.15 ± 26.24 mm^2) than the control groups (82.08 ± 48.71 mm^2, F(1,38) = 9.355, $p = 0.004$).

Postoperative complications. There were no cases of postoperative infection (i.e. superficial or deep) nor dehiscence for either the treatment or control group. Additionally, no patients required antibiotics or additional surgeries. No patients in either group developed a hypertrophic or keloid scar that required additional treatment.

Discussion

Objective measures are important for scar evaluation. However, subjective scales can aid in obtaining a more holistic representation of scar
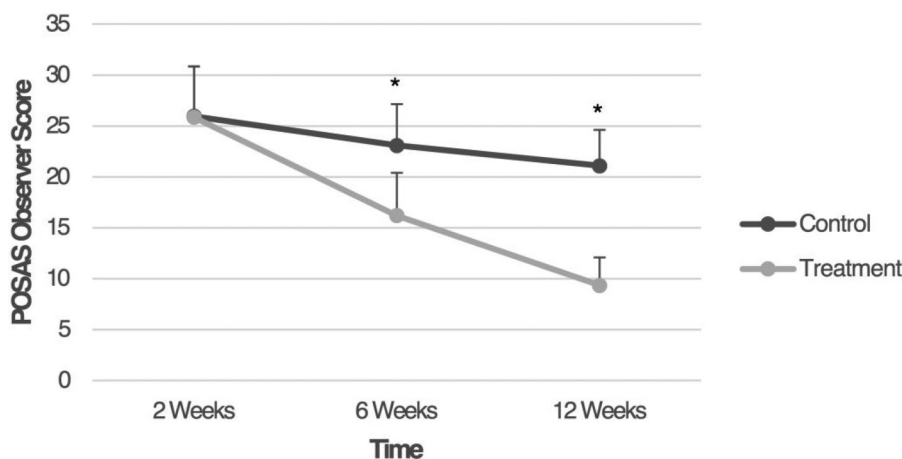
Figure 1. POSAS observer scores. Means and standard deviations are plotted.
*Indicates a statistically significant difference between the treatment and control groups.
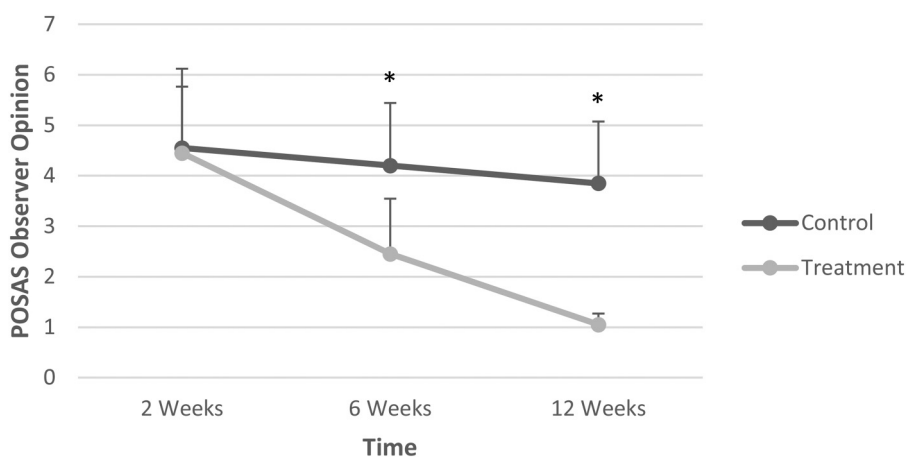

Figure 2. POSAS observer opinion. Means and standard deviations are plotted.
*Indicates a statistically significant difference between the treatment and control groups.

assessment and patient outcomes. The primary outcome of this study was to evaluate postsurgical scars using the POSAS after treatment with either a standard petroleum-based dressing or SHS dressing in patients who underwent foot or ankle surgery. The POSAS is a subjective form of scar evaluation that is easy to administer in a clinical setting and is noninvasive. This assessment scale has been shown to be reliable, consistent, and valid in the evaluation of both burns and linear scars.[2,19]

While we chose to utilize the POSAS in this study, there are various scar assessment scales. The Vancouver Scar Scale (VSS) is one of the most frequently used. This scale assesses scar vascularity, pigmentation, pliability, and height/thickness. The total score is calculated by summing up the scores of each of the four items. The total score can range from 0 to 14, with 0 representing normal skin. Like the POSAS, the Vancouver scale is easy to use in clinical practice. However, this scale has been shown to be less consistent and reliable than the POSAS in the assessment of burn scars.[19] More specifically, the POSAS was found to be more reliable than the VSS when completed by a single observer, as was the case in this study. Further, the VSS does not take the patient's perspective into account. Itching and pain are common patient symptoms during scar remodeling.[2,20] These parameters are evaluated in the POSAS, but not in the VSS. In fact, one study found that itching had the greatest impact on the patient's opinion of his/her scar.[19]

In this study, we found that POSAS observer scores, as well as observer overall opinion, decreased over time for both groups. However, the group treated with the SHS dressing demonstrated statistically significant

Table 5. Scar measurements including length, width, and overall area. Means and standard deviations are provided. Scar area was computed by multiplying scar length by scar width, which were measured using digital calipers to the hundredth of a millimeter.

Measurement	Postoperative timepoint			
	2 weeks	6 weeks	12 weeks	Total
Scar length (mm)				
Control	49.95 ± 14.50	48.95 ± 14.39	48.40 ± 14.59	49.10 ± 14.26
Treatment	50.75 ± 14.55	46.65 ± 13.73	43.60 ± 13.69	47.00 ± 14.07
Scar width (mm)				
Control	1.65 ± 0.75	1.60 ± 0.68	1.55 ± 0.60	1.60 ± 0.67
Treatment	1.23 ± 0.47[a]	0.98 ± 0.44[a]	0.78 ± 0.26[a]	0.99 ± 0.44[a]
Scar area (mm^2)				
Control	86.75 ± 55.44	81.65 ± 48.43	77.85 ± 43.68	82.08 ± 48.71
Treatment	62.33 ± 32.06	43.05 ± 21.40[a]	33.08 ± 13.66[a]	46.15 ± 26.24[a]

[a]Indicates a statistically significant difference between the treatment and control groups.

improvement in both scores at six and 12 weeks postoperatively compared to the control. This finding suggests that patients treated with the SHS dressing demonstrated greater improvement in postsurgical scar appearance according to the observer.

In the current study, we found that POSAS patient reported pain and itch decreased over time for both groups. The group treated with the SHS dressing had statistically significantly lower pain scores at the 12-week timepoint. Further, the overall itch score was statistically significantly lower for the treatment group compared to the control. These results suggest that the SHS dressing may help improve patient-related scar factors postoperatively, such as itching and pain.

Our secondary outcomes included objective measures of the postsurgical incision - scar length, width, and overall area. We have previously conducted a study comparing a SHS dressing to a petroleum-based dressing on postsurgical scar healing.[17] Similar to the current study, this prior study assessed objective scar measurements with digital calipers. We found a statistically significant percent change in scar length, but not scar width, that was greater in the SHS dressing group (18%) compared to the control group (2%). Interestingly, in the current study, we did not find a significant decrease in scar length between the groups over time, but instead found a greater reduction in scar width. As a result, we decided to also include overall scar area in our analysis, as

we believed this would better allow us to evaluate scar contraction over time. Further, scar surface area is one of the six parameters of the POSAS observer scale, which would allow us to remain consistent in both our subjective and objective scar evaluation.

We found that patients treated with the SHS dressing had a significantly smaller scar area compared to the control group at six and 12-week timepoints as demonstrated in Figure 5. Overall, the scar area of the treatment group was almost half that of the control group.

As previously discussed, silver-impregnated dressings, like the one used in this study have been found to reduce the bioburden of a wound through its bactericidal activity.[9,10] In this study we did not observe any cases of infection or dehiscence in either dressing group. This contrasts with our prior report which had a greater incidence of infection in the petroleum-based dressing group (26.67%) over the SHS treatment group (3.45%).[17] Infection rates following elective foot and ankle surgery are low, ranging from 2.1–3.6% in the literature.[21,22] It is unclear why our lack of surgical site infection in the current study varies from that in our 2013 study. However, due to our small cohort of patients, it is not entirely unexpected. Further, infection and incisional dehiscence postoperatively is dependent on multiple factors. It remains unclear what role the postsurgical dressing plays in the development of these complications.
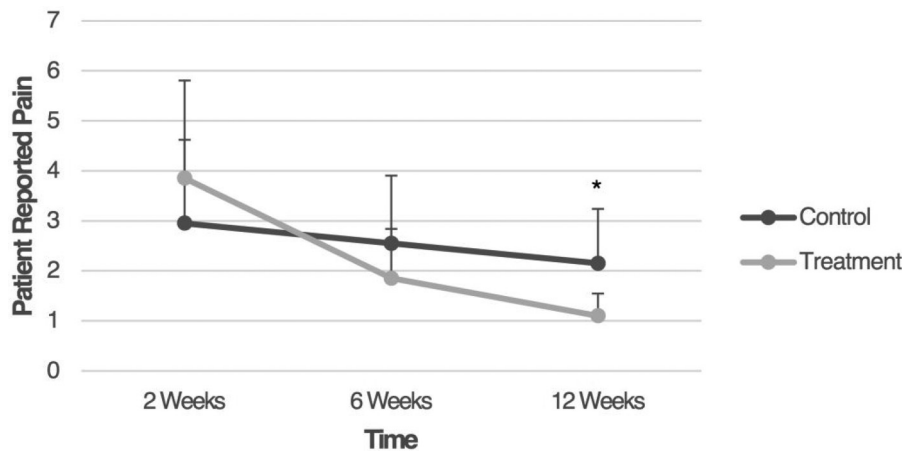
Figure 3. Patient reported pain. Means and standard deviations are plotted.
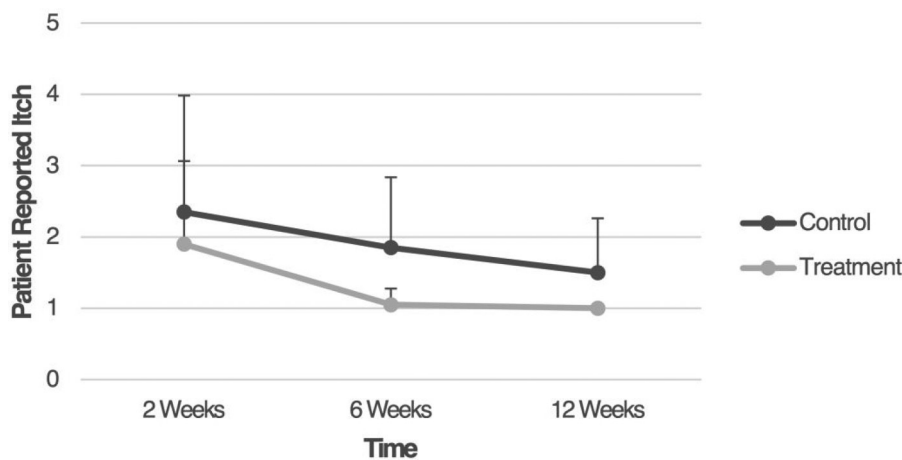*Indicates a statistically significant difference between the treatment and control groups.

Figure 4. Patient reported itch. Means and standard deviations are plotted.

We chose to evaluate postsurgical scars at three different timepoints – two, six, and 12 weeks postoperatively. We chose these timepoints for multiple reasons. These timepoints generally correlate with our standard postoperative evaluation in clinic, but also represent important milestones in the stages of wound healing.[6] While 12 weeks may seem like relatively short-term follow up, physiologically, the scar has progressed through the stages of wound healing by this point. Further, patient adherence and follow up tends to diminish after the 90-day postoperative global period expires. It is also unlikely that the patient will develop significant complications associated with the incision after this point.

This study was not without its limitations. As previously mentioned, we had a relatively small patient population (n = 40) and lacked long-term follow up. We did not take skin tone or ethnicity

into account with our analysis. We also did not assess patient adherence to their assigned treatment protocol. As a result, we do not know if patients were indeed applying the SHS dressing daily as instructed. It is likely that there was some degree of non-adherence in our population. Theoretically, we may achieve better outcomes with increased patient adherence. Future studies are planned to further evaluate this limitation.

Further, while the observer was blinded, the patients completing their portion of the scoring system were not. While they were not told what cohort they were placed in at the beginning of the study, it was possible that they could infer this by the dressing that was applied at their postoperative clinic visits. We also only had one investigator who was responsible for scar assessment, and as a result we were unable to
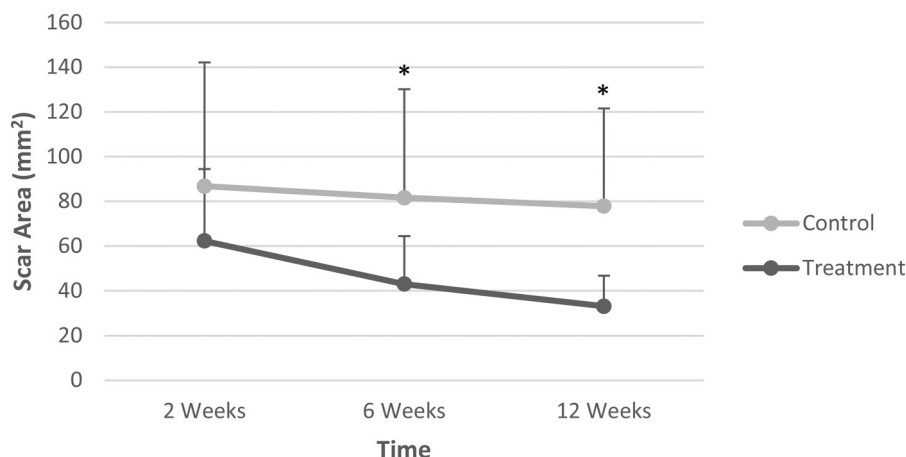
Figure 5. Scar area. Means and standard deviation are plotted. Scar area was calculated as length times width.
*Indicates a statistically significant difference between the treatment and control groups.

perform any evaluation of inter-rater reliability. Due to the small nature of the study, we chose not to perform a subanalysis of the individual components of the POSAS observer scale. We also only focused on the pain and itching in regard to the patient assessment portion of the POSAS. We hope to further evaluate these components in future studies with a greater population size.

While we found statistically significant differences between our two cohorts in both our subjective and objective measures, it should be remembered that these are based on subtle differences in scar evaluation and measurements. The relevance this has clinically and on patient-satisfaction was not adequately explored with this study, but may be of interest in future investigations of postsurgical scars. Further, there are multiple contributing factors that were unable to be controlled for in the current study that can affect scar healing and are independent of the dressing utilized. We also relied on post-hoc analysis of our data. While this allowed us to evaluate differences over time, post-hoc data analysis is susceptible to overestimating these differences between groups. When considering the aforementioned limitations, the results of this study should be cautiously interpreted.

Despite these limitations, we believe our current results demonstrate that the use of a SHS dressing in the initial postoperative period after foot and ankle surgery is beneficial to scar remodeling compared to the standard control. Future studies with larger study populations are necessary to further evaluate individual characteristics of scar assessment, as well as the effect of skin tone and ethnicity with the use of SHS dressings.

Conclusion

In this prospective comparative study, we demonstrated that observer and patient reported assessments of post-surgical scars improved over a 12-week period in both our control and treatment groups. Patients treated with a SHS dressing showed greater improvements in POSAS compared to the control. Mean scar area was also significantly lower in the treatment group. Despite the limitations of this study, these results suggest that the inherent properties of the silver hydrogel dressing may improve early postsurgical scarring. These results are promising not only for foot and ankle surgery, but also for healing of all postsurgical incisions.

Declaration of conflicting interests

Funding

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Note

Level of evidence: Level II, Prospective randomized comparative.

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