Antimicrobial super oxidised solutions and laser therapy: a novel wound healing approach



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Wound infection remains a challenge for wound care clinicians. It causes significant delay in wound healing and tissue damage, and increases morbidity and mortality. Infected wounds require more complex management, including initiation of topical and systemic antimicrobial agents and surgical interventions. Affected patients may require hospitalisation, affecting quality of life and increasing the risks for hospital-acquired complications. In this article, a novel approach combining super oxidised solutions and laser wound healing therapy is discussed, illustrated by five cases of severely infected wounds — surgical site infection, burn, carbuncle abscess, diabetic foot ulcer and pressure injury. The aim of this approach is to manage infection and optimise wound healing, while minimising hospitalisation and the need for complex surgical closure methods.

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Wound infection is a common complication that can occur in acute and chronic wounds (World Union of Wound Healing Societies [WUWHS], 2008; International Wound Infection Institute [IWII], 2016). The most common healthcare-associated infections are surgical site infections (31%); these require extended hospitalisation (Magill, 2012).

In burn patients, almost 61% of deaths are caused by infection (Gomez et al, 2009). Around 56% of diabetic foot ulcers become infected and about 20% of patients with an infected foot wound will undergo a lower-extremity amputation (Wu et al, 2007).

The risk of wound infection is affected by many factors (*[Table 1]*; WUWHS, 2008). Wound infections cause delays in wound healing. An infection can take a severe turn, where it can turn into life-threatening sepsis (IWII, 2016).

This article will discuss a novel wound healing approach that combines antimicrobial super oxidised solutions and laser therapy. This approach has been used in patients with infected wounds where healing was delayed or stalled. This approach facilitated effective management, while reducing the need for prolonged hospitalisation, improving quality of life, reducing the need for complex surgical closure techniques and preventing further complications.

Super oxidised solutions

A super oxidised solution (SOS) has a broad-spectrum antimicrobial effect (bactericidal, virucidal, fungicidal and sporicidal, *[Table 2]*), which helps to reduce wound bacterial burden and aids in biofilm removal (Landa-Solis et al, 2005; Sauer et al, 2009).

An SOS is made from the electrolysis of water and sodium chloride, resulting in 99.97% oxidised water, 0.023% sodium chloride, 0.003% hypochlorous acid and 0.004% sodium hypochlorite; generating reactive species of chlorine and oxygen. It is pH neutral, requiring no mixing, dilution or rinsing. SOSs are indicated for cleaning and irrigating acute/chronic wounds and burns. Commercially available preparations include Dermacyn® Wound Care Solution and Microcyn® Hydrogel (both Oculus Innovative Sciences).

Studies have shown that SOSs are non-toxic, non-irritant, have no cytotoxicity *[Table 3]* and accelerate wound healing *in vitro* and *in vivo* (Tanaka et al, 1996; Yahagi et al, 2000; Mohd et al, 2007). They help to increase tissue oxygenation, reduce inflammation and promote fibroblast migration, all benefits that enable faster wound healing (Tanaka et al, 1996; Bongiovanni, 2006; Medina-Tamayo et al, 2007). SOSs are non-toxic for fibroblasts and wound healing cells (Bongiovanni, 2006). They cause no pain or irritation during wound irrigation and cleaning.

Box 1. The Dr Farhat 5-point Laser Wound Healing Technique.

The Dr Farhat 5 Point Wound Healing Technique is a novel technique, which utilises an ultra-pulse 80 W system with high-energy density and special scanner 10,600 nm (multiple mode in one system). It radically changes the wound microclimate by providing the delicate balance required for optimal wound healing and ideal wound bed preparation, targeting TIMES, as described below.

- Photoabilation (T): tissue debridement to eradicate biofilms and devitalised tissue.
- Photomodulation (I): creating openings in bone located in wound centre, allowing undifferentiated stem cells and molecular signals to fill the centre of the wound and retrafficking neutrophils, aiding in reducing inflammation.
- Photo-excitation (M): micro-needling of the wound edges and periwound skin, causing tissue components to be stimulated and changing vascular permeability to reduce oedema.
- Photo-cutting (E): refreshing edges and make them well demarcated to facilitate optimal cellular migration and epithelialisation.
- Photo-vaporisation (S): linear or zig-zag shape manoeuvres targeting water chromophores in tissue, allowing the wound to reduce in size by 0.6–1.2 cm immediately.

Table 1. Risk of infection (IWII, 2016).

The risk of wound infection is increased by:

• Any factor that debilitates the patient, impairs immune resistance or reduces tissue perfusion, eg:

1. Co-morbidities: diabetes,immunocompromised status,hypoxia/poor tissue perfusion due to: anaemia or arterial/cardiac/respiratory disease, renal impairment, malignancy, rheumatoid arthritis, obesity, malnutrition.
2. Medication – corticosteroids, cytotoxic agents, immunosuppressants.
3. Psychosocial factors – hospitalisation/institutionalisation, poor personal hygiene, unhealthy lifestyle choices.

• Certain wound characteristics (described below) or poor standards of wound care hygiene

Acute wounds	Chronic wounds
- Contaminated surgery	- Necrotic tissue or foreign body
- Long operative procedure	- Prolonged duration
- Trauma with delayed treatment	- Large in size and/or deep
- Necrotic tissue or foreign body	- Anatomically situated near a site of potential contamination, eg anal area

In addition, Microcyn also debrides the wound as the gel formulation provides a moist healing environment, which facilitates autolytic debridement through moistening and softening slough and eschar.

For the past 4 years at Qassimi Hospital, Dermacyn and Microcyn have been used as a wound antiseptic and autolytic debridement agent, respectively. These products were used on a range of conditions, including chronic and acute wounds and burns, and for intra-operative peritoneal lavage in cases of acute secondary peritonitis.

Laser wound healing therapy

At Qassimi Hospital, a five-point laser technique has been adopted as standard management for complex wounds. The Dr Farhat five-point laser technique and its impact on chronic wounds is described in *Box 1*. The synergy between those two modalities has been found to be effective in managing patients who are experiencing delays in wound healing due to severe infections and various comorbidities; through achieving a set of goals *[Table 4]*.

The following case series illustrate the approach and its outcomes.

Case 1: Complicated liposuction with assisted abdominoplasty

A 40-year-old woman with no significant medical history was admitted via the emergency department. The patient had undergone liposuction with assisted abdominoplasty in another hospital 20 days before admission.

On examination, the patient had a dehisced and infected surgical site, as well as disrupted suture line, leaving an opened 20 × 13 × 3 cm wound, with 7 cm undermining. There was abdominal fluid collection, the wound was sloughy, erythema, maceration and cellulitis were noted on the wound edges and periwound skin. The patient had pain at the wound site, with heavy purulent discharge and malodour, and also had fever, indicating a spreading systemic wound infection. Laboratory tests revealed low haemoglobin, fever, and high white blood cell and low platelet counts, while wound cultures showed heavy *Staphylococcus* and *Pseudomonas* growth *[Figure 1a]*.

Once admitted, the patient was started on intravenous fluids and blood transfusion to correct haemoglobin and platelet levels and to prevent hypovolemic shock; antibiotics and antipyretics were used to control infection and fever.

Devitalised tissue was partially removed via sharp bedside debridement. The wound was

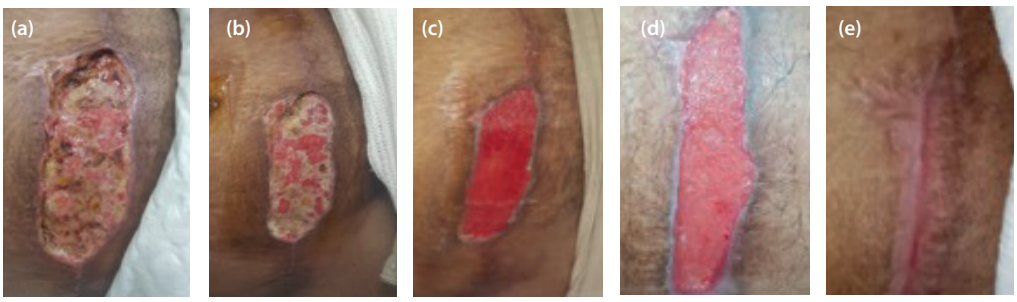

Figure 1. Case study one: Complicated liposuction with assisted abdominoplasty.

Table 2. Broad-spectrum antimicrobial effect of super oxidised solutions.

Name of organism	Log reduction	Time to kill	Per cent reduction
Staphylococcus aureus MRSA	6.34	30 seconds	99.999%
Enterococcus faecalis VRE	6.36	30 seconds	99.999%
Staphylococcus aureus	6.23	30 seconds	99.999%
Escherichia coli	5.70	30 seconds	99.999%
Acinetobacter baumannii	6.37	30 seconds	99.999%
Bacteroides fragilis	7.64	30 seconds	99.999%
Candida albicans	6.33	30 seconds	99.999%
Enterobacter aerogenes	6.09	30 seconds	99.999%
Enterococcus faecium VRE - MDR	6.51	30 seconds	99.999%
Haemophilius influenzae	5.18	30 seconds	99.999%
Klebsiella oxytoca MDR	6.05	30 seconds	99.999%
Klebsiella pneumoniae	6.14	30 seconds	99.999%
Micrococcus luteus	5.84	30 seconds	99.999%
Proteus mirabilis	6.20	30 seconds	99.999%
Pseudomonas aeruginosa	5.81	30 seconds	99.999%
Serratia marcescens	6.74	30 seconds	99.999%
Staphylococcus epidermidis	6.02	30 seconds	99.999%
Staphylococcus haemolyticus	5.91	30 seconds	99.999%
Staphylococcus homins	5.45	30 seconds	99.999%
Staphylococcus saprophyticus	5.96	30 seconds	99.999%
Streptococcus pyogenes	6.72	30 seconds	99.999%

cleaned, irrigated and soaked using Dermacyn Wound Care Solution and Microcyn wet-dry packing dressing three times a day for the first 3 days post debridement.

On first dressing change, the Dr Farhat five-point laser wound healing technique was initiated and repeated twice a week. After 3 days, devitalised tissue was reduced, purulent discharge, erythema, cellulitis and malodour subsided *[Figure 1b]*. Negative pressure wound therapy (NPWT) was initiated after laser therapy to assist in granulation tissue formation and facilitate wound contraction. After three sessions of NPWT and laser therapy (performed twice a week), the wound developed healthy granulation tissue, the undermining was reduced in size and exudate levels reduced significantly, so NPWT was stopped and a silver alginate dressing moistened with Microcyn Hydrogel and covered by secondary absorbent foam dressing was applied twice a week *[Figure 1c]*.

At every dressing change, laser therapy was used and the wound was irrigated thoroughly with Dermacyn. After 21 days, the patient was discharged from the hospital as the wound started to be free from infection and started to heal significantly *[Figure 1d]*. She was then treated as an outpatient at the authors' clinic using the same technique twice a week. The authors followed up the patient for 20 days, until the wound was completely healed by secondary intention in 7 weeks *[Figure 1e]*.

Case 2: Superficial and deep second degree burn

A 4-year-old boy was admitted via the emergency department and referred to the plastic surgery team with a burn from hot water *[Figure 2a]*. The burn affected the anterior thorax and abdomen with 15% body surface area, graded as superficial and deep second degree. The burn had multiple blisters *[Figure 2b]*; on the fourth day of admission, the wound became infected and it developed large levels of slough, high exudate level, malodour, mild oedema and erythema was noticed on the periwound skin *[Figure 2c]*. The patient developed a fever, indicating systemic infection, with a pain score of 7.

The patient was started on intravenous fluids, pain killers, antipyretic agents and antibiotics. The wound was cleaned, irrigated and soaked using Dermacyn Wound Care Solution. Each day, Microcyn was applied for 5 minutes, followed by sharp and gentle mechanical debridement that the patient could tolerate. The wound was covered by a hydrofiber silver dressing moistened with Microcyn and secondary absorbent foam, and changed twice a week. After 7 days, the wound showed less slough and infection had subsided *[Figure 2d]*.

The patient was discharged and attended the authors' clinic as an outpatient. The hydrofiber silver dressing was replaced with Microcyn Hydrogel to keep the wound moist and laser

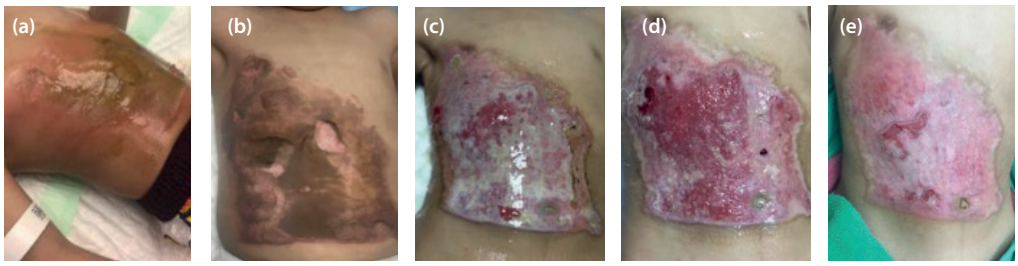

Figure 2. Case study two: Superficial and deep second degree burn.

Table 3. Bio-compatability studies (Oculus Innovative Sciences, 2018; Armstrong et al, 2015).

Category	Sub-category	Standard/method	Results
Toxicity	Genotoxicity	ISO 10993-33: 2003	Pass
	Cytotoxicity	ISO 10993-S: 1999	Pass
	Acute oral toxity	ISO 10993-11: 1996	Pass
	Acute dermal toxicity	ISO 10993-11: 1996	Pass
	Acute inhalation toxicity	ISO 10993-11: 1996	Pass
Sensitisation	Dermal sensitisation	ISO 10993-10: 2002	Pass
Irritation	Skin irritation	ISO 10993-10: 2002	Pass
	Ocular irritation	ISO 10993-10: 2002	Pass

therapy was used at every visit. The expected outcome for this patient was to close parts of the burn with skin grafting, however, in 2 weeks, the wound was partially closed by secondary intention and the treatment goal was changed to continue without skin graft. Later, the wound was managed with an open dressing technique by spraying Microcyn Hydrogel whenever it was dry. The family was taught to do a gentle massage of the healed area. However, the patient continued to visit the clinic twice a week for assessment and laser therapy of some areas with hypergranulation. Once the wound completely healed *[Figure 2e]*, treatment with Microcyn hydrogel continued, along with massaging the healed area, and the patient was given a compression vest to prevent wound contractures and hypertrophic scar. This wound was completely healed in 4 weeks.

Table 4. Antimicrobial super oxidised solutions and laser wound healing therapy.

The combination of antimicrobial super oxidised solutions and laser wound healing therapy used in the cases discussed in this article aimed to:

1. Reduce wound bioburden; through gradually removing devitalised tissue and reducing the need for surgical debridement while promoting tissue salvage.
2. Control bacterial burden, through eradicating micro-organisms while preventing cellular cytotoxicity and preventing wound infection complications.
3. Enhance cellular migration and wound contraction.
4. Achieve wound closure by secondary intention and minimising the need for complex surgical approaches.
5. Minimise hospitalisation and treat patients in outpatient clinic; reducing healthcare expenditure.
6. Minimise dressing changes and subsequent pain, in order to improve quality of life.

Case 3: Heavily infected carbuncle abscess

A 49-year-old male with a history of ischaemic heart disease presented to the authors' clinic. He had a history of two myocardial infarctions, low heart ejection fraction, diabetes and uncontrolled blood glucose and was immunocompromised. He had been scheduled for heart surgery; however, he developed a carbuncle abscess on the left upper posterior thorax and surgery was delayed until the abscess could be treated.

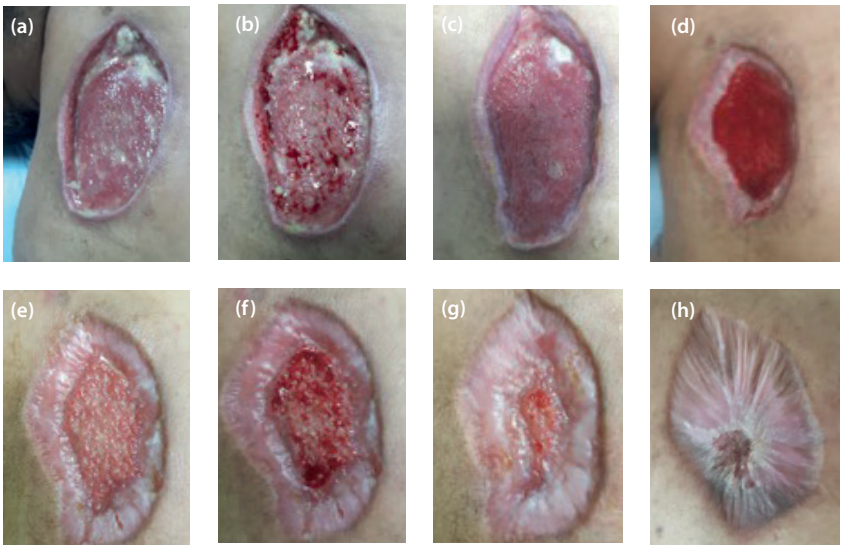

Figure 3. Case study three: Heavily infected carbuncle abscess.

The patient was referred to the authors' department from general surgery after opening and draining a heavily infected carbuncle with *Pseudomonas* and *Klebsiella* bacteria. The wound was 15 × 8 × 2.5 cm with 3cm undermining, and the wound bed was unhealthy, showing slough in some areas, cellulitis, erythema, with heavy purulent discharge, unhealthy edges with erythema, malodour and maceration *[Figure 3a]*. The patient was having spikes of fever and shivering, especially at night, indicating a deep spreading systemic infection.

Due to socioeconomic circumstances, he was treated as an outpatient. He was started on

oral antipyretics, painkillers as needed and oral antibiotics.

The wound was cleaned, irrigated and soaked using Dermacyn Wound Care Solution. The patient could not tolerate sharp debridement, so Microcyn Hydrogel was utilised to facilitate autolytic debridement, using wet-dry technique applied 8 hourly at home.

After 3 days, the Dr Farhat five-point laser wound healing technique was initiated and the patient continued with the same dressing regimen. The wound still had some slough, however, it was less infected and some healthy granulation tissue had developed *[Figure 3b]*.

After nine sessions of Dermacyn irrigation and Microcyn wet-dry packing dressing, the wound had mild exudate, serous in nature, with less redness and oedema at both the wound bed and edges. The undermining area started to reduce in size and the patient reported no fever or shivering. After 6 more days, the undermining reduced in size. The wound started to be filled with granulation tissue and began to contract from all sides *[Figure 3c]*.

The patient started to complain about a feeling of something moving across his wound and itching, and so was given antihistamine. However, this was a good sign of cellular migration and epithelialisation *[Figure 3d]*. At week 3, the wound was smaller and clean, and a nano-fibre dressing was applied to enhance epithelialisation and wound closure by secondary intention. The dressing was soaked with Microcyn Hydrogel and changed twice a week *[Figure 3e]*. Seven weeks later, the wound was closed by secondary intention with full epithelialisation *[Figures 3f, 3g and 3h]*.

Figure 4. Case study four: Diabetic foot ulcer.

Case 4: Diabetic foot ulcer

A 78-year-old woman presented with a heavily infected sloughy diabetic foot ulcer at the dorsal and lateral aspects of the right foot. The patient was referred from another hospital after refusing a below-knee amputation. She had a history of heart disease, diabetes and a left foot metatarsal amputation, and was malnourished and immunocompromised, with uncontrolled blood glucose and low haemoglobin. Her wound dimensions were 7 × 6 × 2cm with exposed bone, heavy purulent discharge and malodour. The periwound skin was severely macerated and erythema was present. She had spikes of fever indicating a deep spreading systemic infection *[Figures 4a, 4b and 4c]*.

Due to socioeconomic circumstances, this patient was treated as an outpatient in the authors' clinic. A partial amputation for the infected areas of the wound had been suggested, but the patient was given some time to see the outcomes of the authors' interventions first. The patient was started on oral antipyretics as needed and oral antibiotics.

The wound was cleaned daily, irrigated and soaked using Dermacyn Wound Care Solution. She could not tolerate sharp debridement so Microcyn Hydrogel was utilised to facilitate autolytic debridement. Microcyn Hydrogel wet-dry packing dressing was applied every 8 hours at home.

After 3 days, the Dr Farhat five-point laser wound healing technique was initiated and she continued with the same dressing, while laser treatment was repeated twice a week. After 2 weeks, the wound had mild exudate, serous in nature, no malodour, less redness, oedema and slough, while there were no complaints of fever *[Figures 4d and 4e]*.

After 3 weeks, exudate level had decreased. The wound had started to fill with granulation tissue and began to cover the exposed bone and the wound started to contract from all sides and reduced in size *[Figures 4f and 4g]*. Twelve weeks later, the wound was completely healed by secondary intention, thus avoiding amputation *[Figure 4h]*.

Case 5: Pressure ulcer

A 97-year-old woman with a history of heart disease, hypertension and type 2 diabetes was malnourished and immunocompromised, and had been bedridden for 10 weeks after having knee replacement surgery. She was received in the authors' clinic with a sacral, unstageable pressure injury. The wound measured 18 × 10 cm and was 90% covered by hard eschar.

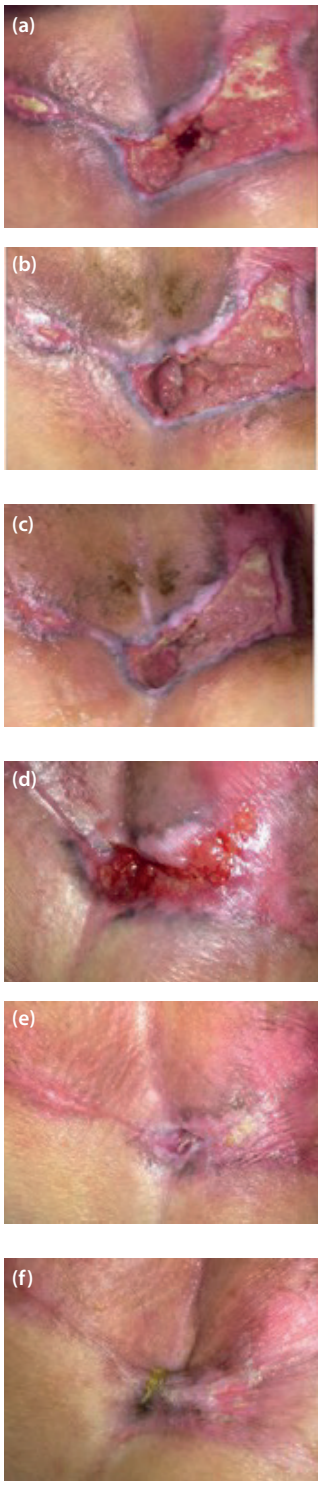

Figure 5. Case study five: Pressure ulcer.

Erythema on the periwound skin was observed, indicating deep spreading infection.

The patient was not fit for surgical debridement and due to socioeconomic circumstances, she was treated as an outpatient in the authors' clinic. The patient was started on antibiotics, the wound was cleaned, irrigated and soaked using Dermacyn Wound Care Solution. She could not tolerate surgical debridement so Microcyn Hydrogel was utilised to facilitate autolytic debridement. However, a few random incisions were created in the eschar to facilitate the delivery of Microcyn Hydrogel into the wound. To further facilitate softening of the dry necrotic tissue, the dressing was changed daily. The Dr Farhat five-point laser wound healing technique was initiated and the patient was sent back home with the same dressing. The patient was visiting clinic weekly for wound assessment and laser therapy. After 14 days, the eschar was removed revealing 5 cm depth and exposed sacral bone *[Figure 5a]*. The same management continued while adding silver hydrofibre to the regimen *[Figures 5b and 5c]*. After 3 more weeks, the wound was free from necrotic tissue, except some slough areas, and signs and symptoms of infection had subsided *[Figure 5d]*.

At the beginning of treatment, this wound was treated as maintenance therapy. The authors were not aiming to heal the wound completely, and focused management on preventing complications, however, as the wound progressed, the potential of full wound closure became possible. Once healing began, the silver dressing was replaced with nano-natural fibres augmented by Microcyn Hydrogel twice a week. After 3 months from the initial treatment, the wound was closed by secondary intention *[Figures 5e and 5f]*.

Conclusion

Wound infection remains a challenge for wound care practitioners, especially in patients who are experiencing comorbidities that can cause prolonged healing. If infection is untreated, it can result in prolonged hospitalisation and complex interventions to heal wounds.

The approach discussed aimed to manage wound infection, utilising the antimicrobial properties of Dermacyn and Microcyn, and get the wound ready to start healing by secondary intention.

Laser technology was used to remove healing barriers, improving cellular migration and wound contraction with the five-point technique.

The approach outlined here helped to reduce infection severity and duration, sending patients home early to be followed up as outpatients, which significantly improved their quality of life and reduced the need for more complex surgical closures. WME

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