

Photodynamic therapy for chronic scalp wounds with bone exposure after excision of non-melanoma skin cancer: A case series of three patients

Background: Chronic scalp wounds with bone exposure following excision of non-melanoma skin cancer represent a therapeutic challenge, especially when conservative treatment fails. Photodynamic therapy (PDT) has shown promising results in oncology and dermatology but is underexplored in chronic surgical wound healing.

Aim: To report the outcomes of non-healing wounds on the scalp with bone exposure following oncologic surgery in three patients treated with PDT.

Methods: Patients received 1–5 PDT sessions with methyl aminolevulinic acid (Metvix) and red light (630 nm, Aktilite CL128), with outcomes assessed over 1–35 months through serial photography.

Results: Two patients showed complete re-epithelialisation. One patient showed no response, presumably attributable to previous radiotherapy in the affected region.

Conclusion: PDT may serve as a safe and effective treatment modality for non-healing scalp wounds with bone exposure following oncologic excision, especially when standard care is insufficient.

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Key words

- Photodynamic therapy
- Chronic scalp wounds
- Exposed skull bone
- Post-oncologic surgical wounds
- Wound healing

Wounds persisting for more than 2 months are considered chronic, with an estimated prevalence of 1–2% in the general population. These wounds entail significant healthcare burdens, including prolonged care, pain, disability and loss of productivity (Vernassi and Vernassi, 2020).

Chronic wound types include venous leg ulcers, diabetic foot ulcers, pressure ulcers, arterial ulcers, and post-surgical wounds (Vernassi and Vernassi, 2020). Scalp wounds with bone exposure following tumour excision are particularly vulnerable due to limited vascularisation and tissue tension, often resulting in delayed healing. These wounds are sometimes treated with cortical craniectomy, which is an invasive procedure (Gatti et al, 2024).

Photodynamic therapy (PDT) is a light-activated treatment modality in which a topically applied photosensitiser is activated by illumination at wavelengths matching its absorption spectrum, resulting in the formation of reactive oxygen species that induce direct cellular destruction, vascular damage, and secondary inflammatory and immunological effects. Because clinical photosensitisers do not accumulate in the nucleus and singlet

oxygen has an extremely short diffusion range, the risk of DNA damage is minimal. Cutaneous tissue is highly amenable to PDT, and over the past decades PDT has become an established therapy for actinic keratoses, Bowen's disease, and superficial basal cell carcinoma.

A major advance came in 1990 with the introduction of topical 5-aminolevulinic acid (ALA), a precursor in the heme synthesis pathway that leads to intracellular accumulation of protoporphyrin IX (PpIX) when exogenous ALA bypasses normal enzymatic regulation. PpIX preferentially accumulates in epidermal and dysplastic keratinocytes as well as activated inflammatory cells, allowing selective phototoxic destruction upon illumination. Its methylated derivative, methyl-aminolevulinic acid (MAL), offers enhanced lipophilicity and is widely used in Europe for AK, Bowen's disease and basal cell carcinoma. The choice of light source is tailored to lesion depth, as blue light near the PpIX Soret band (≈ 410 nm) provides efficient excitation for superficial lesions, whereas red light (≈ 635 nm) achieves greater tissue penetration and is preferred for thicker or hyperkeratotic lesions. Treatment efficacy depends on adequate oxygenation and the interplay between delivered fluence,

irradiance, and photobleaching kinetics of PpIX. Although pain, erythema, and transient photosensitivity are common, PDT is generally well tolerated (Sari et al, 2007).

Beyond its oncologic use, PDT has been shown to stimulate angiogenesis, re-epithelialisation, collagen synthesis and microbial clearance (Nesi-Reis et al, 2018).

Despite its mechanistic rationale, PDT remains underreported in the management of chronic scalp wounds. We present three such cases treated with PDT following failed conventional management.

Methods

Three elderly patients (≥ 80 years) with chronic, non-healing scalp wounds with exposed scalp bone following surgical excision of non-melanoma skin cancer were treated with PDT. All wounds had failed to improve despite prolonged conventional wound care.

Topical MAL cream (Metvix, Galderma) was applied to the wound bed in an approximately 0.5 mm layer and covered with an occlusive dressing for three hours. This incubation period was chosen in line with established MAL-PDT protocols, which have demonstrated effective intracellular accumulation of protoporphyrin IX (PpIX) within 3 hours while maintaining acceptable tolerability. MAL was selected because of its increased lipophilicity and deeper tissue penetration compared with aminolevulinic acid, which is advantageous in thicker or compromised tissues such as scalp wounds with bone exposure (Sari et al, 2007).

Prior to illumination, patients were advised to take 1 g of paracetamol to reduce treatment-related pain, as PDT-associated discomfort is known to correlate with PpIX accumulation and light dose. After incubation, lesions were illuminated with red light at 630 nm for nine minutes using a non-coherent LED light source (Aktilite CLI28, Galderma), positioned at a distance of 20–25 cm. Red light at this wavelength was selected due to its superior tissue penetration compared with shorter wavelengths, making it more suitable for deeper lesions and wounds involving the dermis or underlying structures. This wavelength corresponds to the Q-band absorption peak of PpIX and is widely used in PDT for non-melanoma skin cancer and other cutaneous indications (Sari et al, 2007).

Post-treatment wound care consisted of twice-daily application of a barrier-repair cream (Cicalfate, Avène) for 14 days. This formulation contains sucalfate, copper sulfate, and zinc sulfate, which support epidermal repair and have antimicrobial properties, facilitating wound healing in fragile elderly skin.

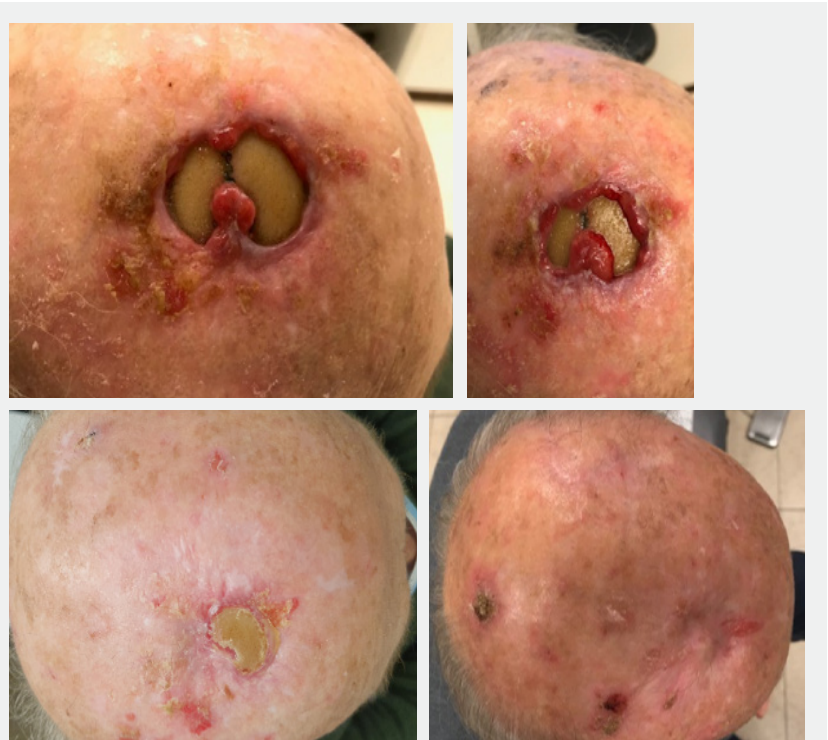


Figure 1

Wound evolution and response were assessed clinically and documented using serial standardised photography at follow-up visits

Results

Case 1

An 80-year-old man with field cancerisation on the scalp was treated with PDT. He also had a chronic parietal scalp wound 12 months after excision of a moderately differentiated squamous cell carcinoma and failed grafting. Initial wound management consisted of Flaminal Hydro (an enzymatic alginogel providing moist wound healing and bioburden control), covered with Jelonet (a non-adherent paraffin-impregnated gauze), with selective curettage performed as needed to remove crusts or devitalised tissue. This treatment was administered for several months; however, no clinical improvement was observed. This wound was experimentally treated with PDT, together with the rest of the scalp lesions (mostly actinic keratosis). One month post-PDT, newly formed granulation tissue was clearly visible. Over 1 year, five PDT sessions were executed and the wound healed completely [Figure 1].

Case 2

A 93-year-old woman with a painful vertex wound 4 months after excision of actinic keratoses. The wound was initially treated with daily application of Flammazine under a non-adherent dressing (Stelaline). The wound was treated with 3-PDT sessions (with a 2-week

Figure 1. Top left: The scalp wound 12 months after excision. Top right: the same scalp wound 1 month after one PDT-session (13 months after excision). Newly formed granulation tissue is clearly visible. Bottom left: The scalp wound healed almost completely after a total of 4 PDT sessions (24 months after excision). One month later (25 months after excision) the wound was healed (no images available). Bottom right: scalp wound completely healed (35 months after the initial excision).



Figure 2



Figure 3

Figure 2. Top left: the 4-month-old chronic wound, 2 weeks after the first PDT session. Top right: the wound 6 weeks after the second PDT session (5 months after the initial excision). New epithelialisation is seen in the upper left quadrant of the wound border. Bottom left: the wound 1 month after the third PDT session (6 months after the initial excision), with re-epithelialisation visible in the mid-right wound border. Bottom right: complete re-epithelialisation without bone exposure 5 months after the third PDT session (10 months after the initial excision).

Figure 3. Left: The frontoparietal wound 5 months after the initial excision. Right: The same wound 1 month after the second PDT session (picture taken 11 months after the initial excision).

interval and a 5-week interval, respectively). Serial photographs showed complete re-epithelialisation of the scalp 5 months after the third PDT session (10 months after the initial excision). Intralesional injection of anaesthetics (lidocaine 10 mg/ml, adrenaline 5 µg/ml) was given before illumination [Figure 2]. During the interval between PDT sessions, daily application of a barrier-repair formulation containing a combination of sucralfate, copper sulfate, and zinc sulfate (Cicalfate, Avène) was performed,

followed by coverage with a non-woven dressing.

Case 3

A 92-year-old man presented with a chronic frontoparietal wound 10 months after in toto excision of a squamous cell carcinoma recurrence. Prior radiotherapy (seven times 5.25 Gy) had been administered to this area. PDT was given in two sessions, one week apart, but no significant improvement was seen 1 month after the second PDT session [Figure 3]. Further PDT sessions could not be performed due to the patient's death.

Discussion

To our knowledge, this is the first documented case series demonstrating successful use of PDT for chronic post-oncologic surgical scalp wounds with bone exposure. While PDT has been previously reported in the context of chronic leg ulcers, its role in chronic scalp wounds with bone exposure remains unexplored (Krupka et al, 2021).

The observed effects, enhanced granulation and epithelialisation, are consistent with the known bio-modulatory effects of PDT. In case 3, PDT failed to induce clinical improvement because the wound was located in previously irradiated scalp tissue. Long-standing radiation injury profoundly impairs wound healing through a combination of microvascular damage, fibroblast dysfunction and persistent transforming growth factor-β-driven fibrosis. Irradiated skin shows disrupted extracellular matrix homeostasis with accumulation of cross-linked type 1 collagen, altered balance between metalloproteinases and tissue inhibitors of metalloproteinases, endothelial phenotypic changes and reduced fibroblast proliferative and synthetic capacity. These chronic alterations create a poorly vascularised and fibrotic microenvironment in which normal reparative processes cannot occur. As PDT relies on adequate oxygenation, vascular supply and functional fibroblasts for tissue regeneration, its efficacy is severely limited in irradiated wounds, explaining the lack of therapeutic response in this case (Dormand et al, 2005).

Limitations

This study has several limitations inherent to its design. First, the small sample size and the descriptive nature of a case series preclude any definitive conclusions regarding efficacy or causality. Without a control group or comparison with standard wound care alone, it is not possible to determine to what extent wound healing can be attributed

specifically to photodynamic therapy, rather than to spontaneous healing or concomitant supportive measures.

Second, there was heterogeneity among the included cases with respect to patient characteristics, wound chronicity, prior treatments, and number of PDT sessions administered. Follow-up duration also varied substantially between patients, which may have affected assessment of long-term wound stability and recurrence.

Third, outcome assessment relied primarily on clinical evaluation and serial photography, without quantitative wound measurements, histological confirmation of tissue regeneration, or standardised wound-healing scores. Pain reduction and functional outcomes were not systematically assessed using validated instruments.

Conclusion

Photodynamic therapy may be a valuable treatment for chronic scalp wounds with bone exposure, especially in patients where conventional measures fail.

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