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CASE SERIES

Wound Infection After Keloid Excision and Adjuvant Radiotherapy: Two Case Reports and Literature Review

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Introduction: The combination of surgical excision and adjuvant radiotherapy is widely accepted as one of the most effective treatments for keloids. Although wound infection following radiotherapy has been reported in several studies, no study has investigated how such infections are managed or whether they ultimately lead to keloid recurrence.

Case Reports: Two patients, one male with an anterior chest keloid and one female with a mons pubis keloid, underwent surgical excision followed by adjuvant radiotherapy (20 Gy in four fractions) at our institution. Both patients developed wound infections following combined therapy, both of which were successfully treated using a comprehensive protocol. This protocol involved wound drainage and debridement, antibiotic administration, and moist wound healing. Complete healing was achieved in both cases, with no recurrence observed during the 18-month follow-up period.

Discussion: The possible causes of radiation-induced infection were analyzed, including radiation itself, atopic dermatitis and specific surgical areas (such as the mons pubis region). Our study successfully addressed wound infection by adopting an effective treatment protocol involving wound drainage and debridement, antibiotic administration, and moist wound healing. Although favorable results were obtained in the two keloid cases, optimizing radiotherapy in terms of radiation mode, dosage, fraction and timing is still necessary to reduce the incidence of radiation-induced wound infections.

Conclusion: Neither of the two patients experienced keloid recurrence when treated with an effective therapy for wound infection. This result demonstrates that a favorable outcome can be achieved with the appropriate and timely treatment protocol, even if an infection occurs after radiotherapy. Further clinical studies and basic research are needed to investigate the underlying mechanisms of the favorable outcome following radiation-induced infections.

Keywords: keloid, excision, radiotherapy, wound infection

Introduction

Keloids are recognized as a highly fibroproliferative skin disease that develops as a result of abnormal healing after trauma, surgery, or other injuries.[1] Although they are histologically benign, keloids tend to grow over time, causing constant pain, pruritus and an unaesthetic appearance.[2,3] The management of keloids remains a clinical challenge, and a combination of surgery followed by radiotherapy is currently one of the most effective treatment options.[2,4,5] Although radiotherapy is a safe adjuvant therapy with a low keloid recurrence rate, it can cause adverse effects.[5,6] One such effect is wound infection, which has been reported in several studies, with an incidence rate ranging from 0% to 8%.[7–13] However, despite these studies reporting wound infections, we could not find any further information on how to treat them or whether they ultimately led to keloid recurrence.

In this study, two patients with keloids underwent electron beam radiation within 24 hours of surgical excision; unfortunately, both developed wound infections. Notably, following timely intervention, both wounds achieved complete epithelialization, and neither patient experienced keloid recurrence during the 18-month follow-up. Based on the

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favorable outcomes of these two cases, our study aimed to identify the potential causes of post-radiotherapy wound infection and propose effective treatment protocols to prevent keloid recurrence. In this endeavor, the present report seeks to provide clinical references for managing radiation-induced wound infections in keloid treatment.

Case Presentations

The two case reports were approved by the Ethics Committee of the Affiliated Hangzhou First People's Hospital, Westlake University School of Medicine (Approval No.: 2025ZN157-1). Written informed consent was obtained from both patients for the publication of their case details and images.

Case 1

A 40-year-old male presented to our department with two skin masses on the anterior chest wall (Figure 1A). These masses originated from recurrent acne vulgaris during adolescence and had persisted for over one decade. They were continuously enlarging and causing itching and pain. This patient had previously undergone multiple intralesional injections of triamcinolone; however, the therapeutic effect was suboptimal, with no significant improvement observed in the keloid's appearance. Based on the medical history and clinical manifestations, these chest wall masses were preliminarily diagnosed as keloids.

Physical examination revealed that the larger mass, measuring 2.9 (length) * 1.8 (width) * 0.6 cm (thickness), was located on the midline of the chest. The smaller mass, sized 1.7 (length) * 0.9 (width) * 0.3 cm (thickness), was positioned inferiorly and laterally to the larger one. Given that the two keloids were in a high-tension area and closely located, the larger keloid was excised first, and the smaller lesion was scheduled for excision at least six months later. The combined therapeutic protocol, potential complications, and postoperative care guidelines were meticulously explained to the patients, followed by the formal acquisition of informed consent.

Surgery and Radiotherapy Procedure for Keloid

Following standard surgical field disinfection and draping, local anesthesia was administered using 1% lidocaine with 1:100,000 epinephrine. The keloid was completely excised along a fusiform incision line, and the subcutaneous tissue

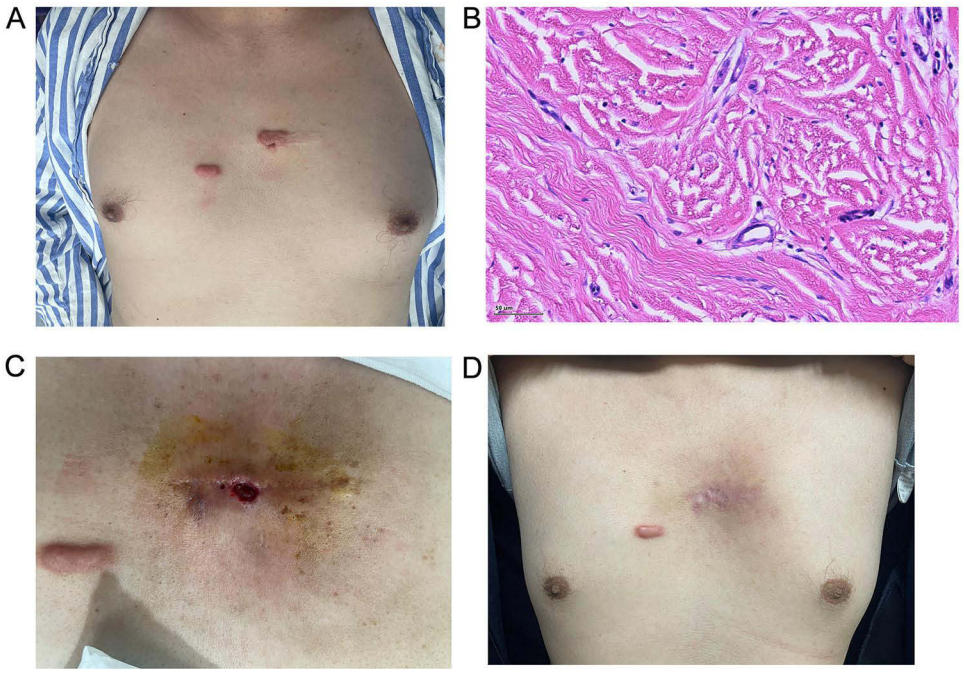

Figure 1 Keloids on the anterior chest wall of a male patient. (**A**) Keloids on the chest wall before surgery. (**B**) Hematoxylin and eosin (H&E) staining at 10×40 magnification. (**C**) Wound dehiscence and defect after debridement. (**D**) No signs of keloid recurrence 18 months after surgery.

was undermined sufficiently to reduce tension on the incision. Layered tension-reducing suture techniques were then employed to close the wound. The subcutaneous tissue layers were fixed using buried vertical mattress sutures with 2–0 Vicryl and 5–0 PDS-II, respectively. Skin closure was achieved using 6–0 Prolene in an interrupted pattern. Finally, a skin tension reduction device was applied to minimize the postoperative wound tension further. The excised tissue was sent for pathological examination, which confirmed the diagnosis of keloid (Figure 1B).

Electron beam radiation was initiated within 24 hours after surgical excision. Using the Elekta Precise Instrument (Elekta Limited, Stockholm, Sweden), a total dose of 20 Gy was delivered in four fractions (biologically effective dose [BED] 30 Gy) over four consecutive days. The irradiation field extended 1 cm beyond the wound edge, and the surrounding area was protected with a suitable lead mold.

Identification and Management of Wound Infection

The patient was instructed to attend the outpatient clinic for dressing change every other day. On postoperative day 5, erythema and rashes appeared around the wound margins. Further enquiry revealed that the patient had a history of atopic dermatitis (AD). AD is among the most common inflammatory skin conditions in dermatology, characterized by chronic or relapsing eczema, severe pruritus, and a range of hypersensitivity disorders such as food allergies, allergic rhinitis and asthma.[14] This predisposition to a hypersensitivity state is thought to be associated with skin barrier impairment, immune system dysfunction, cutaneous bacterial colonization (particularly with Staphylococcus aureus), and an altered skin microbiome.[14,15] These factors increase the risk of skin infections in patients with AD.[15] Therefore, for patients with AD presenting signs of infection, the elimination of irritating factors is of great significance. Accordingly, the skin tension reduction device, a potential skin irritant, was then eliminated and a hypoallergenic emollient cream was subsequently applied.

However, on postoperative day 8, the erythema worsened, accompanied by marked tenderness. Although no fluctuance was palpable, purulent discharge was observed. Given these clinical manifestations, wound infection was suspected, and immediate actions were taken. The infected part of the wound was cleaned by removing the sutures and irrigating it with a solution of hydrogen peroxide and normal saline. The necrotic, yellowish tissue within the wound bed was removed (Figure 1C), after which a saline-soaked gauze was placed to facilitate drainage. Although the laboratory results, including the white blood cell (WBC) count and C-reactive protein (CRP) level, were normal, a positive wound swab culture for Staphylococcus aureus indicated that the wound was infected. Based on bacterial culture and antibiotic susceptibility testing results, oral cephalexin (500 mg q6h) was administrated.

Dressing changes for the infected wound continued for three weeks, until the wound bed was free of purulent discharge and necrotic tissue and granulation tissue had formed. A hydrocolloid dressing was applied to promote moist wound healing and maintain an optimal healing environment. Finally, the wound healed six weeks after surgery.

Treatment Outcome of Infected Wound

The patient underwent follow-up evaluations at 3-month intervals for 18 months postoperatively. The tension-reducing management persisted for six months after the application of 3M Steri-Strip™ tape, provided the skin tolerated it. The wound remained well-healed, and there was no clinical recurrence of keloids (Figure 1D).

Case 2

A 34-year-old female came to our department for treatment of a lump on her mons pubis. The lump appeared suddenly without any obvious trigger eight years ago and has grown continuously and rapidly ever since. It caused unbearable itchiness and pain. Previous intralesional corticosteroid injections had demonstrated poor efficacy, achieving only minimal volume reduction. According to the patient's medical history and the observed clinical manifestations, the lump on the mons pubis was initially diagnosed as a keloid.

The keloid measured 6.2 cm in length, 2.4 cm in width and 0.6 cm in thickness, and felt firm on palpation (Figure 2A). The patient had a history of polycystic ovary syndrome (PCOS), characterized by irregular menstrual cycles, and no other significant systemic diseases. After detailed discussion of the treatment plan, potential risks, and postoperative care, informed consent was obtained from the patient.

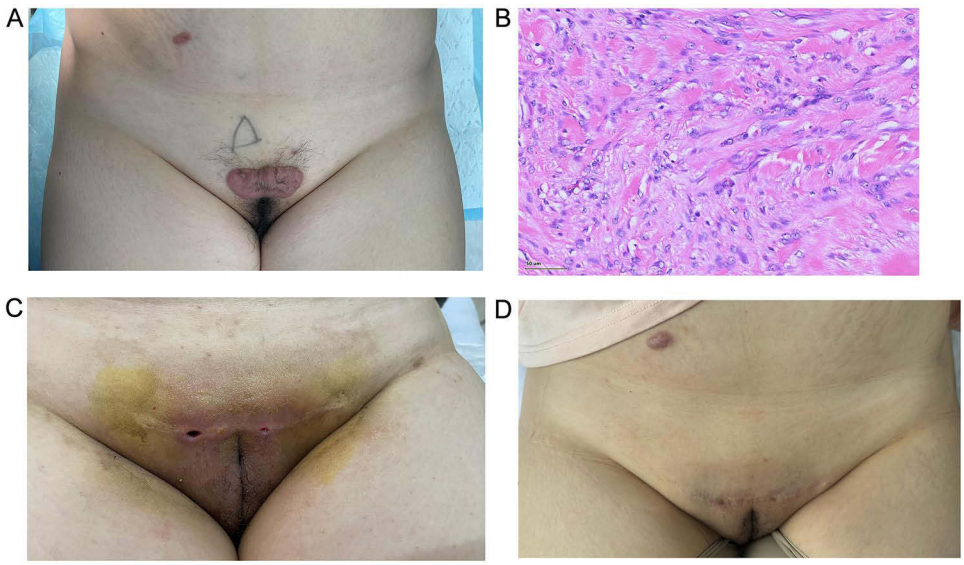

Figure 2 Keloid on the mons pubis of a female patient. (**A**) Keloid on the mons pubis before surgery. (**B**) Hematoxylin and eosin (H&E) staining at 10×40 magnification. (**C**) Wound dehiscence and defect after debridement. (**D**) No signs of keloid recurrence 18 months after surgery.

Surgery and Radiotherapy Procedure for Keloid

The surgical approach and postoperative radiotherapy protocol were consistent with those used in Case 1, as discussed in detail above. Histopathological examination of the excised tissue confirmed the keloid diagnosis (Figure 2B).

Identification and Management of Wound Infection

The patient was scheduled for dressing changes every other day.

Due to her history of PCOS, she experienced unexpected menstruation on postoperative day 3. Given the proximity of the mons pubis to the urethra and anus, bacteria derived from urine and feces are capable of heightening the risk of contamination in this area, thereby augmenting the likelihood of infection.[16] To minimize the risk of infection, the patient was advised to thoroughly rinse the wound and the mons pubis area with running water every night. The wound was then disinfected with a solution of povidone-iodine.

On postoperative day 7, erythema, edema, and purulent exudate were observed at the surgical site. Elevated inflammatory markers (WBC 12.2×10^9/L, CRP 32 mg/L), as well as a positive wound swab culture for Escherichia coli, further confirmed the diagnosis of a wound infection. The sutures at the infected site of the wound were promptly removed, followed by wound debridement (Figure 2C). In accordance with the antibiotic susceptibility testing results, intravenous infusion of ciprofloxacin 0.2 g was prescribed at a frequency of twice daily.

Wound debridement and drainage procedures were repeated as necessary, and a hydrocolloid dressing was used during wound dressing changes to accelerate wound healing. Complete epithelialization of wound was confirmed four weeks after the operation.

Treatment Outcome of Infected Wound

The patient underwent regular follow-up evaluations at 3-month intervals for 18 months postoperatively. 3M Steri-Strip™ tape was utilized for six months to reduce skin tension and minimize the risk of keloid recurrence. The wound remained well-healed, and there were no signs of clinical keloid recurrence (Figure 2D).

Discussion

Radiotherapy has been used to treat keloids for over a century, and the combination of surgery and postoperative radiotherapy is currently considered a highly effective therapy with a low recurrence rate.[2,4–6,17,18] Although the risk of secondary carcinogenesis is minimal when an appropriate protocol is adopted and adequate protection is provided during

adjuvant radiotherapy for keloids,[5,6] complications related to radiation may still occur, including acute or chronic adverse effects.[5,6,18] One of the acute skin side effects reported is wound infection, with incidence rates ranging from 0% to 8%, due to different influencing variations in the studies conducted.[3,7–13,17] However, the aetiology, treatment and prognosis of infected wounds induced by radiotherapy were not mentioned in any articles reporting on wound infections after radiation for keloids treatment. Therefore, in our study, we analyzed possible reasons of radiation-induced wound infection, the treatment protocol and outcome of wound infection after keloid excision and adjuvant radiotherapy.

Keloids are excessive fibroproliferative pathological scars resulting from tissue injury deeper than the reticular dermis, such as trauma, burns, surgery, skin piercing, acne and folliculitis.[1] Keloids usually spread beyond the original site of injury and rarely improve spontaneously over time.[2] Keloids not only bring unaesthetic appearance, constant itching and pain to patients, but also affect mental health and quality of life.[3,5] Many risk factors,[4] including local factors, systemic factors, genetic factors and lifestyle factors, can promote the development of keloids. These findings regarding aetiology have optimized the evidence-based treatment and prevention of keloids by reducing local risk factors, although surgeons cannot control systemic and genetic risk factors. A variety of effective treatment options[1,2,4] have been employed in clinics to reduce the occurrence of keloids, including surgery, radiotherapy, compression therapy, corticosteroid injection, laser therapy and 5-fluorouracil injection. Many studies and guidelines[3,4,6,17–19] suggest that a combination of surgery and subsequent radiotherapy is currently one of the most effective treatments for keloids. This is why we opted for this combined treatment protocol for our patients.

As an effective adjuvant treatment to reduce keloid recurrence, the mechanism of postoperative radiotherapy has been linked to the suppression of angiogenesis and the inhibition of fibroblast activity and proliferation[1–4,17,19] and functional impairment of activated immune cell.[20,21] Although radiotherapy is considered acceptable with a low risk of secondary carcinogenesis if the surrounding treatment zone is well protected,[2,6,18] acute and chronic adverse effects may occur.[5,6,18] Erythema and wound infection are common acute adverse effects, whereas hyperpigmentation, hypopigmentation and telangiectasia are common chronic complications.[3,5,18] Although some articles[3,7–9,12,13] mentioned several cases of wound infection after radiotherapy for keloids, the cause of the infection was not discussed as it was not the main issue reported in these articles. Table 1 summarizes findings from relevant studies[8–10,12,13,22,23] on postoperative radiotherapy for keloid treatment, including details of radiation modalities, dosage, fraction, and timing of initial therapy, as well as underlying adverse effects such as infection. According to the clinical practice consensus on wound infection,[24] radiotherapy increases the risk of a wound becoming infected. Radiation could disrupt the inflammatory and proliferative phases of wound repair, such as overexpressed cytokines, leading to impaired wound healing.[25,26] This may be one of the causes of wound infection in our study and in some other articles.

To investigate other possible causes of infection, we consulted a dermatologist and further investigated the medical history of the two patients. In this male patient, skin sensitivity to the dressing and taping around the wound, manifesting as erythema and itching, was observed in the first few days following radiation therapy. Further inquiry revealed that this male patient had a history of atopic dermatitis (AD). The disorder is one of the most common inflammatory skin diseases, with its prevalence and incidence increasing continuously over the last few decades.[14,15] The clinical characteristics of AD[14] include chronic or relapsing eczema, severe pruritus and a sequence of hypersensitivity disorders, such as allergic rhinitis and asthma. A complex interaction of predisposing factors (genetic and environmental factors and immune dysregulation) and triggering factors (stress and skin allergens) play a role in the pathogenesis of AD.[14,27] Some studies have shown a strong association between keloid and AD in different ethnic populations.[28,29] Keloid and AD have overlapping pathophysiological mechanisms and share some common pathways and key genes such as CCR5.[30] AD increases the risk of cutaneous and systemic infections. Skin barrier defects, immune dysregulation, Staphylococcus aureus (S. aureus) colonization and cutaneous dysbiosis are the main susceptibility factors for increased infections.[14,15] Radiotherapy exacerbates these problems and in this situation S aureus becomes a common cause of infection. The finding that the wound bacterial culture in this male case was S aureus also confirmed our conclusion about the possible causes of post-radiotherapy infections. In this patient with mons pubis infection, menstruation occurred on the third day after excision of the surgical keloid. As the mons pubis is close to the urethra and anus, bacteria from urine and feces may increase the risk of contamination of this area.[16] We speculate that this may be the cause of the wound infection in the female case.

Table 1 Literature Review on Postoperative Radiotherapy, Adverse Effects, and Treatment Outcomes in Keloid Management

Author and Year	Study Design	Number of Patients and Keloids	Treatment of Keloids	Radiation Therapy	Interval Between Operation and Radiation	Follow-up Duration (Months)	Adverse Effects	Treatment Outcomes
van de Kar AL et al, 2007[22]	–	21, 32	Excision +electron beam radiotherapy	12 Gy in 3–4 fractions	Within 24 h	12–35	Mild wound-healing disturbance 1 (4.8%)	Recurrence 23 (71.9%)
van Leeuwen MCE et al, 2014[10]	Prospective study	28, 35	Excision + brachytherapy	12 Gy in 2 fractions	Within 4 h	33.6 (mean follow-up)	Infection 2 (5.7%), Pigmentation 6 (21.4%)	Recurrence 1 (3.1%)
Hoang D et al, 2017[8]	Case-control retrospective study	128,264	Excision alone (n = 28)	–	–	12.8 (mean follow-up)	–	Recurrence 15 (54%)
			Excision +electron beam radiotherapy (n = 197)	9–30 Gy in 1–10 fractions	Within 36 h	53.4 (mean follow-up)	Erythema 2 (1%), Hyperpigmentation 2 (1%)	Recurrence 37 (19%)
			Excision + brachytherapy (n = 39)	8–12 Gy in 1 fraction	Within 36 h	16.5 (mean follow-up)	Erythema 1 (3%), Hyperpigmentation 2 (5%), Surgical Site Infection/dehiscence 3 (8%)	Recurrence 9 (23%)
Ha B et al, 2023[13]	–	16, –	Excision +electron beam radiotherapy	10 Gy in 1 fraction	Within 8 h	10–14	Hyperpigmentation 2 (12.5%), acute wound problems 2 (12.5%)	Recurrence 3 (18.75%)
Ma QY et al, 2023[23]	Retrospective study	99, 131	Fractional CO2 laser therapy + electron beam radiotherapy	18 Gy in 2 fractions	Within 24 h	18	Transient hyperpigmentation 41 (41.4%), hypopigmentation 19 (19.2%), short-term hair loss 7 (7.1%), wound poor healing 4 (4.0%), dermatitis 23 (23.2%), neuritis 4 (4.0%)	Recurrence 12 (12.1%)
Zhou W et al, 2024[9]	Retrospective study	498, –	Excision +electron beam radiotherapy	16 Gy in 4 fractions	Within 24 h	42.6–129.9	Infection 2 (0.4%), Fibroblastoma 1 (0.2%)	Recurrence 130 (26.5%)
Han SH et al, 2024[12]	Retrospective study	48, 71	Excision +electron beam radiotherapy	10 Gy in 1 fraction	On the same or the next day of surgery	11–30	Acute wound dehiscence 4 (8.3%), radiation dermatitis 3 (6.3%), minor hematoma 2 (4.2%)	Recurrence 0 (0%)

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As discussed above, the occurrence of wound infection after radiotherapy for keloids were reported with a relatively low incidence, ranging from zero to a few percent.[6–13] However, these studies only mentioned wound infection and did not offer any further information about it. Furthermore, none of the studies provided information on the treatment algorithm or the final clinical outcomes after the keloids became infected following radiotherapy. We did not know whether infections after radiotherapy ultimately led to the recurrence of keloids. In our study, neither of the two patients had keloid recurrence after 18 months of follow-up. This result revealed that a good prognosis can still be achieved with active and effective treatment, even if infection occurs after radiotherapy. This is the major contribution of our study. These good results seemed to contradict the conclusions obtained from our traditional concepts of wound healing and keloid pathogenesis.[1,2,4,25,26] Based on the current understanding of the pathological mechanism, keloids result from chronic inflammation in the reticular dermis.[1,2,4] Therefore, radiation-induced wound infection could lead to prolonged inflammation and an increased risk of pathological scar formation.[1] Initially, we feared that infection might result in keloid recurrence. However, we actively address the issue of wound infection to the best of our ability. This satisfactory outcome may be due to the effective treatment protocol for post-radiotherapy infections employed in our study. This protocol[24,31] included wound drainage and debridement, the administration of antibiotics, and the application of moist wound healing according to guidelines. Wound drainage and surgical debridement - the removal of necrotic tissue to reduce the microbial burden - would create a clean wound bed that is conducive to healing. At the same time, bacterial culture and drug sensitivity testing of the wound tissue provided a rational basis for the timely and appropriate use of antibiotics, helping to control the inflammatory response quickly. Once the necrotic tissue had been substantially removed and the wound bed was relatively clean, a hydrogel wound dressing was applied to accelerate the wound repair process through moist wound healing.[32] However, these reasons were speculative and based on clinical practice. Further clinical studies and basic research are needed to investigate the underlying mechanisms of the favorable treatment outcome following radiation-induced infection.

The keloids in our study did not recur after post-radiotherapy infections. However, given the complexity and duration of infection treatment, the management of radiation-induced wound infection remains challenging in clinical practice.[25] Further measures are required to optimize treatment and minimize the risk of wound infection in patients with keloids following radiotherapy. To reduce radiation-related complications, the biologically effective dose (BED) of 30 Gy is currently recommended as optimal for keloid therapy with high efficacy and low risk.[4,19] In our study, electron beam radiation was safely and feasibly delivered using the Elekta Precise Instrument (Elekta Limited, Stockholm, Sweden), in line with scar treatment guidelines and based on our clinical experience. This is because it has fewer adverse effects on internal organs compared with superficial X-rays.[4,5] The initial treatment was administered within 24 hours of keloid excision and the total dose of 20 Gy in our fractions over 4 days (BED 30 Gy) was adopted.[5,6,17,18] Although two cases of infection occurred in our study, this radiation protocol is suitable and has been used in our clinical practice for several years. Most of the patients with keloids in our department did not develop infections after radiotherapy. Post-radiotherapy care should also be considered, especially for patients with AD. No potential correlation was observed between radiation dose and infection risk in the studies[8–10,12,13,22,23] summarized in Table 1, and there was also a lack of evidence supporting radiation dose adjustments in patients with heightened infection susceptibility. According to current guidelines and researches,[4–6] the total radiation dose is primarily adjusted according to the anatomical site—such as the chest wall or earlobe—with consideration of the varying recurrence rates across different body locations. Consequently, more proactive preventive measures, such as strict skin care regimens and closer monitoring for signs of infection after radiotherapy, may be required to reduce the incidence of infection in these patients.[15,33]

Conclusion

We presented two cases of wound infection following keloid excision and adjuvant radiotherapy and analyzed the possible causes. Notably, neither patient experienced keloid recurrence when the infection was treated actively and effectively. Interestingly, this result highlights that a favorable outcome can be achieved with the appropriate and timely treatment protocol, even if an infection occurs after radiotherapy. Further clinical studies and basic research are needed to investigate the underlying mechanisms of the favorable outcome following radiation-induced infection.

Ethics and Consent Statement

Approval for the two case reports was granted by the Ethics Committee of the Affiliated Hangzhou First People's Hospital, Westlake University School of Medicine (Approval Number: 2025ZN157-1). Written informed consent was obtained from both patients for the publication of their case details and images. Institutional approval was not required to publish the case details.

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Disclosure

The authors report no conflicts of interest in this work.

References

1. Ogawa R. Keloid and hypertrophic scars are the result of chronic inflammation in the reticular dermis. *Int J Mol Sci*. 2017;18(3):606. doi:10.3390/ijms18030606
2. Berman B, Maderal A, Raphael B. Keloids and hypertrophic scars: pathophysiology, classification, and treatment. *Dermatol Surg*. 2017;43(Suppl 1):S3–s18. doi:10.1097/dss.0000000000000819
3. Fu S, Duan L, Zhong Y, Zeng Y. Comparison of surgical excision followed by adjuvant radiotherapy and laser combined with steroids for the treatment of keloids: a systematic review and meta-analysis. *Int Wound J*. 2024;21(3):e14449. doi:10.1111/iwj.14449
4. Ogawa R. The most current algorithms for the treatment and prevention of hypertrophic scars and keloids: a 2020 update of the algorithms published 10 years ago. *Plast Reconstr Surg*. 2022;149(1):79e–94e. doi:10.1097/PRS.0000000000008667
5. Liu EK, Cohen RF, Chiu ES. Radiation therapy modalities for keloid management: a critical review. *J Plast Reconstr Aesthet Surg*. 2022;75(8):2455–2465. doi:10.1016/j.bjps.2022.04.099
6. Ogawa R, Yoshitatsu S, Yoshida K, Miyashita T. Is radiation therapy for keloids acceptable? The risk of radiation-induced carcinogenesis. *Plast Reconstr Surg*. 2009;124(4):1196–1201. doi:10.1097/PRS.0b013e3181b5a3ae
7. Han XM, Jiang SQ, Hu CX, Du M, Zhao L. Triple surgical technique for the repair of auricular keloids: achieving perfect restoration of the ear contour. *Aesthetic Plast Surg*. 2024;48(20):4086–4094. doi:10.1007/s00266-024-04306-5
8. Hoang D, Reznik R, Orgel M, Li Q, Mirhadi A, Kulber DA. Surgical excision and adjuvant brachytherapy vs external beam radiation for the effective treatment of keloids: 10-year institutional retrospective analysis. *Aesthet Surg J*. 2017;37(2):212–225. doi:10.1093/asj/sjw124
9. Zhou W, Li B, Yin Y, et al. Treatment outcomes of surgery followed by short-course every other day radiotherapy in keloid. *Radiat Oncol*. 2024;19(1):91. doi:10.1186/s13014-024-02488-5
10. van Leeuwen MCE, Stokmans SC, Bulstra AJ, Meijer OWM, van Leeuwen PAM, Niessen FB. High-dose-rate brachytherapy for the treatment of recalcitrant keloids: a unique, effective treatment protocol. *Plast Reconstr Surg*. 2014;134(3):527–534. doi:10.1097/prs.0000000000000415
11. Shen J, Lian X, Sun Y, et al. Hypofractionated electron-beam radiation therapy for keloids: retrospective study of 568 cases with 834 lesions. *J Radiat Res*. 2015;56(5):811–817. doi:10.1093/jrr/rrv031
12. Han SH, Ha B, Chang CH, Park TH. Efficacy of immediate postoperative single fractional 10 Gy radiotherapy for earlobe keloids. *J Craniofac Surg*. 2024;35(3):e257–61. doi:10.1097/scs.0000000000010002
13. Ha B, Kim SJ, Lee YJ, Im S, Park TH. Early outcomes of complete excision followed by immediate postoperative single fractional 10 Gy for anterior chest keloids: a preliminary results. *Int Wound J*. 2023;20(5):1418–1425. doi:10.1111/iwj.13996
14. Ständer S. Atopic Dermatitis. *N Engl J Med*. 2021;384(12):1136–1143. doi:10.1056/NEJMra2023911
15. Wang V, Boguniewicz J, Boguniewicz M, Ong PY. The infectious complications of atopic dermatitis. *Ann Allergy Asthma Immunol*. 2021;126(1):3–12. doi:10.1016/j.anai.2020.08.002
16. Sharma RK, Parashar A. The management of perineal wounds. *Indian J Plast Surg*. 2012;45(2):352–363. doi:10.4103/0970-0358.101318
17. Sakamoto T, Oya N, Shibuya K, Nagata Y, Hiraoka M. Dose-response relationship and dose optimization in radiotherapy of postoperative keloids. *Radiother Oncol*. 2009;91(2):271–276. doi:10.1016/j.radonc.2008.12.018
18. Xu J, Yang E, Yu NZ, Long X. Radiation therapy in keloids treatment: history, strategy, effectiveness, and complication. *Chin Med J*. 2017;130(14):1715–1721. doi:10.4103/0366-6999.209896
19. Kal HB, Veen RE. Biologically effective doses of postoperative radiotherapy in the prevention of keloids: dose-effect relationship. *Strahlenther Onkol*. 2005;181(11):717–723. doi:10.1007/s00066-005-1407-6
20. Rödel F, Fournier C, Wiedemann J, et al. Basics of radiation biology when treating hyperproliferative benign diseases. *Front Immunol*. 2017;8:519. doi:10.3389/fimmu.2017.00519
21. Peng Q, Lu Y, Huang R, Chen R. Should we do postoperative radiotherapy after keloid excision as soon as possible? A systematic review and meta-analysis. *Aesthetic Plast Surg*. 2025;1–2. doi:10.1007/s00266-025-04869-x
22. van de Kar AL, Kreulen M, van Zuijlen PPM, Oldenburger F. The results of surgical excision and adjuvant irradiation for therapy-resistant keloids: a prospective clinical outcome study. *Plast Reconstr Surg*. 2007;119(7):2248–2254. doi:10.1097/01.prs.0000260751.20217.28
23. Ma QY, Yang YT, Chen ZA, et al. Laser combined with radiotherapy for keloid treatment: a novel and efficient comprehensive therapy with a lower recurrence rate. *Plast Reconstr Surg*. 2023;152(6):1022e–1029e. doi:10.1097/prs.0000000000010376
24. Swanson T, Ousey K, Haesler E, et al. IWII wound infection in clinical practice consensus document: 2022 update. *J Wound Care*. 2022;31(Sup12):S10–s21. doi:10.12968/jowc.2022.31.Sup12.S10

25. Gieringer M, Gosepath J, Naim R. Radiotherapy and wound healing: principles, management and prospects (review). *Oncol Rep*. 2011;26 (2):299–307. doi:10.3892/or.2011.1319
26. Haubner F, Ohmann E, Pohl F, Strutz J, Gassner HG. Wound healing after radiation therapy: review of the literature. *Radiat Oncol*. 2012;7:162. doi:10.1186/1748-717x-7-162
27. Kantor R, Silverberg JI. Environmental risk factors and their role in the management of atopic dermatitis. *Expert Rev Clin Immunol*. 2017;13 (1):15–26. doi:10.1080/1744666x.2016.1212660
28. Ung CY, Warwick A, Onoufriadis A, et al. Comorbidities of keloid and hypertrophic scars among participants in UK Biobank. *JAMA Dermatol*. 2023;159(2):172–181. doi:10.1001/jamadermatol.2022.5607
29. Lu YY, Lu CC, Yu WW, et al. Keloid risk in patients with atopic dermatitis: a nationwide retrospective cohort study in Taiwan. *BMJ Open*. 2018;8 (7):e022865. doi:10.1136/bmjopen-2018-022865
30. Zhou B, Zhou N, Liu Y, et al. Identification and validation of CCR5 linking keloid with atopic dermatitis through comprehensive bioinformatics analysis and machine learning. *Front Immunol*. 2024;15:1309992. doi:10.3389/fimmu.2024.1309992
31. Wound infection in clinical practice. An international consensus. *Int Wound J*. 2008;5(Suppl 3):iii–11. doi:10.1111/j.1742-481X.2008.00488.x
32. Nuutila K, Eriksson E. Moist wound healing with commonly available dressings. *Adv Wound Care*. 2021;10(12):685–698. doi:10.1089/wound.2020.1232
33. McQuestion M. Evidence-based skin care management in radiation therapy: clinical update. *Semin Oncol Nurs*. 2011;27(2):e1–17. doi:10.1016/j.soncn.2011.02.009