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REVIEW

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Practical recommendations for the management of radiodermatitis: on behalf of the ESTRO RTT committee

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Abstract

Background There is a substantial body of literature addressing the prevention, acute management, and follow-up care of radiation induced dermatitis (RID). The quality and application of this evidence, however, is inconsistent and its interpretation varies widely. While several national guidelines have been developed to standardise practices locally, many of these resources are not publicly available. On behalf of the European Society for Radiotherapy and Oncology (ESTRO) Radiation Therapist (RTT) Committee, an international writing group consisting of 12 experts from radiotherapy and two patient representatives composed a recommendation document for the management of RID.

Main body The consensus for these recommendations was generated based on available international guidelines, and supplemented with evidence-based review articles on the topic. These recommendations focus on the prevention and practical management of early stage RID by avoiding skin trauma and maintaining hygiene. Addressing pain and inflammation in higher grades is also covered. The current literature refutes some of the traditional recommendations, especially restricting washing as well as the use of deodorant or the potential dose build-up of lotions which has been included and rectified in recent guidelines. In addition, the importance of grading the severity, including a baseline assessment is presented. The benefit of clear, and non-contradictory communication within the multidisciplinary team as well as patient involvement (e.g. PROMs or similar) is highlighted. Furthermore, the importance of recognising different skin types and skin tones, and the impact on how RID changes these in their appearance is stressed.

Conclusion This document provides practical, actionable recommendations for the clinical management of RID, referencing the supporting literature. These recommendations have, however, identified a lack of high-level evidence, especially for agent-specific recommendations.

Keywords Radiation-induced dermatitis, Radiodermatitis, Skin, Guidelines

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Background

Up to 95% of cancer patients receiving radiotherapy will develop acute radiation-induced dermatitis (RID) in the treated area, either during or after the treatment course [1, 2]. Depending on the degree of severity, RID can lead to major consequences on quality of life, and in some cases may result in interruptions, modifications and/or, hampering of treatment intensity, thereby affecting clinical outcomes [3].

Research efforts over the years have resulted in an abundance of literature on the topic, ranging from prevention, acute management and follow-up care [3–8]. Unfortunately, the quality of this body of evidence is varied and international interpretation is heterogeneous [9]. Several national guidelines have been produced to standardize practice at a local level; however, these resources are often not publicly available.

These practical recommendations on the assessment and management of RID will synthesize existing guidelines as well as the body of evidence, to provide recommendations on the clinical assessment and medical management of RID. This document will be both practical in its advice and applicable to all professionals involved in the care of patients receiving radiotherapy.

Main body

Methodology

A multidisciplinary, international writing group was established in which members were invited to contribute based on their previous work in the field; for example, a track record of relevant publication, or involvement in establishing local guidelines. In an attempt to reduce bias, attention was paid to ensuring not only multidisciplinarity, but also country of work and languages spoken. In addition to radiation oncologists, radiation therapists (RTT), a medical physicist and a radiobiologist; two patient representatives (AC and JD) were fully integrated throughout the entire process and were also included in the writing group. Guidelines, recommendations or similar were collected in languages the writing panel was capable of working with; i.e. the Italian [10], German [11], UK (Society of Radiographers) [12], French [13], Oncology Nursing Society (ONS) [14], International Society of Nurses in Cancer Care (ISNCC) [15], Dutch [16], and Belgian [17, 18]. Additionally, a translated Danish recommendation was added [19]. These documents were accessed with the assistance of colleagues within the ESTRO RTT committee, and the consensus of these documents formed the basis of these practical recommendations.

Given some national guidelines lack an evidence review and have evolved based on local practices, to provide an evidence-based foundation for the information contained within them, a literature search was conducted. The search strategy was compiled with the assistance of a subject librarian, and full details are included in the supplementary material. The literature included was limited to capture evidence from reviews, systematic reviews and meta-analyses of randomised controlled trials (RCT). The treatment of all cancer types using radiation therapy were included, with no exclusion criteria placed on the type of treatment or fractionation used. The screening process was conducted by two reviewers independently (EF and AOD), with any disagreement resolved via consultation with a third member of the writing group (PS). A total of 40 review papers were identified which was reduced to 27 after removing duplicates and screening for relevance. The MASCC guidelines published in 2023 [8, 20], with the linked systematic reviews [21–27] including meta-analysis were outside the scope of this paper's search timeline but were subsequently added. These 29 papers were used along with the national guidelines to form the basis of the recommendations put forward by the writing group. If recommendations within several national guidelines were conflicting, this literary evidence was referred to drive consensus.

The recommendations from the guidelines were reviewed, and a minimum number of 3 guidelines giving the same recommendation was defined as an arbitrary threshold for a consensus. A summary of the recommendations of this panel deduced from these and the reviewed literature is presented in Table 1 in which the strength of the recommendation is rated in conformity with the ASTRO Clinical Practice Guideline Methodology Guide [28]. Additionally, the evidence was scored using a modified rating for the Quality of Evidence Levels (Table 2). Whenever in doubt or in case of a non-unanimous decision the next lower level was used for both scales.

Risk factors of RID

Several intrinsic and extrinsic factors have been identified to increase a patient's risk of developing RID. Although there is little evidence of genetic predisposition to increased risk of RID, some rare conditions may lead to more severe degrees of RID. For example, a mutation of the ataxia telangiectasia mutated (ATM) gene causes ataxia telangiectasia syndrome, and these patients are more sensitive to radiation due to an inhibition in DNA repair [29]. Other pre-existing auto-immune skin conditions (e.g. lupus erythematosus and psoriasis) in some patients can flare up and extend beyond the irradiated area, requiring dermatological treatment. It must be noted, however, that RID is not absolutely predictable on the basis of intrinsic sensitivity, and other contributing factors must be considered [30]. For example, general

Table 1 Summary of recommendations

Score of RID	Assessment	Recommendations for management	Quality of evidence (QoE)	Strength of recommendation
Pre-treatment	Recording of baseline skin assessment to include any dermatological conditions within the treatment field Encourage self-assessment by patient including differences of RID presentation across skin tones	Baseline stratification of intrinsic and extrinsic risk factors is encouraged to help stratify patients at a higher risk of developing severe RID	QoE L4	Conditional recommendation
		Provide evidence-based information to patients and staff on appropriately assessing and managing RID	QoE L4	Strong recommendation
		Encourage the use of a basic moisturiser from pre-treatment to help the skin within the treatment area prepare for radiotherapy	QoE L4	Strong recommendation
General (Grade 0)	Recording of baseline skin assessment on day one of radiotherapy	Ensure good hygiene by washing the skin daily, preferably with lukewarm water and gentle drying of the treatment area	QoE L1	Strong recommendation
		The use of deodorant is allowed unless the skin is broken	QoE L1	Strong recommendation
		Avoid skin irritation due to friction and abrasion in the treatment area through the wearing of loose fitting (preferably cotton, linen, or silk) clothing, avoidance of excessive rubbing, trauma, jewellery or adhesives	QoE L2-3	Strong recommendation
		Protect the (irradiated) skin to exposure to of the sun by covering the skin. After the course of treatment has finished, a high SPF (SPF50) or sunblock is recommended	QoE L2	Strong recommendation
		Apply a moisturizing cream/lotion to hydrate the irradiated skin. The cream/lotion may be applied directly/shortly before treatment	QoE L3	Strong recommendation
		Shaving with an electric of wet razor is possible as long as the skin is still intact	QoE L4	Conditional recommendation
		Photo-biomodulation or low-level laser therapy may be used to prevent higher grades of RID	QoE L2	Conditional recommendation
		The use of corticoid creams or topical steroid can be considered (but only when the skin is not broken)	QoE L1	Strong recommendation
		The use of barrier films or (semipermeable) dressings can be considered	QoE L1	Conditional recommendation
Grade 1	For white skin tones erythema presents as pink and/or red For brown and black skin tones pigmentation can present as the treatment area becoming darker than the surrounding skin, sometimes redness or maroon or yellow/purple/grey colour changes	Continue general management/prevention with the following addition		
		The continued use of corticoid creams or topical steroid can be considered (but only when the skin is not broken)	QoE L2	Strong recommendation

Table 1 (continued)

Score of RID	Assessment	Recommendations for management	Quality of evidence (QoE)	Strength of recommendation
Grade 2	For white skin tones brisk erythema presents as bright redness For brown and black skin tones pigmentation can present as the treatment area becoming darker than the surrounding skin, sometimes redness or maroon or yellow/purple/grey colour changes Texture changes such as skin feeling tighter, warmer and harder Patchy dry desquamation and/or moist desquamation with exudate within skin creases and/or folds Moderate oedema can be seen	Same policy as grade 1 with the following additions		
		Option 1: Apply self-adhesive soft silicone dressings on the irradiated skin	QoE L1	Strong recommendation
		Option 2: Continue using moisturizing cream or use hydrogel in combination with soft absorbent dressings on areas of open skin and fix in position with bandages	QoE L3	Strong recommendation
		Prevent and be aware of infections, infections should be overseen by skin/wound care specialist	QoE L4	Strong recommendation
		Use topical antiseptics and/or antibiotics at any sign of infections	QoE L3	Strong recommendation
		Prescribe adequate analgesia if required to manage pain	QoE L4	Strong recommendation
		Ensure good hygiene by cleansing the skin daily or twice daily	QoE L4	Strong recommendation
Grade 3	Confluent moist desquamation with exudate Bleeding from abrasion	Apply soft silicone or other appropriate dressings on broken skin, fixate with soft bandages	QoE L1	Strong recommendation
		Manage exudates with absorbent dressings	QoE L4	Strong recommendation
		Prevent and be aware of infections, infections should be overseen by skin/wound care specialist	QoE L4	Strong recommendation
		Use topical antiseptics and/or antibiotics at any sign of infections	QoE L4	Strong recommendation
		Prescribe adequate analgesia if required to manage pain	QoE L4	Strong recommendation
		Needs to be overseen in a multidisciplinary team consisting of a Radiation Oncologist, Medical Oncologist, dermatologist, plastic surgeon and/or wound care specialist	QoE L4	Strong recommendation
Grade 4	Necrosis or ulceration within dermis, exudate and bleeding within area	Surgical intervention needs to be considered	QoE L4	Strong recommendation
		Interruption or discontinuation of the (systemic and) RT treatment needs to be considered	QoE L4	Strong recommendation

Table 2 Quality of evidence (QoE) modified based on American Society for Radiation Oncology (ASTRO) Clinical Practice Guideline Methodology Guide [28] and strength of recommendation conforming with the same

Level of quality of evidence (QoE)	
Level 1	Is based on a systematic review or meta-analysis of at least 2 randomised studies of good quality
Level 2	Is based on at least 2 non-randomised comparative studies
Level 3	Is based on 1 non-randomised comparative study or non-comparative study
Level 4	Is based on the opinion of experts or no evidence referenced in the respective guideline (or not clearly assignable)
Strength of recommendation	
Strong	"Benefits clearly outweigh risks and burden, or risks and burden clearly outweigh benefits" [28]
Conditional	"Benefits are finely balanced with risks and burden or appreciable uncertainty exists about the magnitude of benefits and risks." [28]

patient factors such as smoking, and malnutrition can also increase or prolong RID.

Treatment-related factors which have been identified to increase a patient's risk of experiencing a more severe degree of RID include anything which will increase the physical or biologically equivalent dose to the surface of the skin, such as higher total dose, boost dose, use of bolus, or lager treatment volume. Anatomical location of the treatment area will also influence RID risk. Due to the superficial nature of the target volumes, RID is commonly observed in patients undergoing radiotherapy with treatment volumes (and, as such dose) close to or encompassing the skin (i.e., breast, head and neck, anal, and vulvar cancer). Moreover, obesity leading to skin folds will also increase the dose to the skin in the folds, exacerbating RID risk in the area. Prolonged fractionation schedules longer than 4–5 weeks will also delay the onset of RID recovery. Finally, in addition to radiation therapy, systemic oncological treatments with chemotherapy or targeted therapy that reduce cell division or inhibit repair of DNA damage can also increase the severity or prolong the duration of RID.[7, 31–34].

Pathophysiology of RID

Anatomy and physiology of the skin

The skin consists of three layers; starting from the surface, the epidermis, the dermis and the sub-cutis (connective tissue). The deepest layer, the sub-cutis, forms a connection with the structures underneath the skin such as muscles and bones, and contains blood, lymph vessels, nerves and fat. The middle layer, the dermis, contains the hair follicles (invaginations of the epidermis), glands, blood vessels, sweat glands, and nerves. Although very thin (30–300 μm) and not containing any blood vessels or nerves, the most superficial layer, the epidermis, serves as protection and prevents moisture loss.

Within the epidermis, is the regeneration layer or stratum basale, which contains the stem cells that serve as a reservoir. Within the layers of the epidermis, specifically the horn forming layer and the horny layer (stratum corneum), the keratinocyte stem cells are transformed stepwise to horn cells. The horn cells are eventually lost [35]. Depending on the thickness of the skin, a cell from the epidermis takes between 12 and 48 days to migrate from the basal cell layer to the surface; referred to as the 'transit time' [36]. As a result of this 'transit time', it takes on average 30 days for the epidermis to be completely renewed. Acute radiotherapy skin reactions have their origin in the epidermis, whereas late effects are related mostly to changes in the vascular structures of the dermis, and can occur several months or years following treatment completion. Changes in pigmentation are correlated with acute reactions and, whist hypo- or hyperpigmentation may resolve over time, telangiectasia is permanent [37]. Other chronic events that involve the skin include radiation-induced morphea; a rare inflammatory condition caused by abnormal deposition of collagen. Radiation induced skin cancers can also occur as a result of vascular damage of the dermis; however, in the case of squamous cell carcinoma, the latency period can be as much as 20 years [38].

Radiobiology RID

Several studies examined the effects of fractionated radiotherapy on human skin in patients treated for prostate [39] and breast cancer [40, 41] with external beam radiotherapy. This work identified that early skin reactions are not the result of massive cell death (apoptosis) in the epidermis, but rather the consequence of continuing physiological loss of cells in the epidermis horn layer without the timely replacement of these cells from the basal layer due to radiation-induced cell cycle blockade [39]. This can be considered as a survival response to the radiation, as during cell division the stem cells are more susceptible to cell death from the radiation. These studies further identified differences between the repair capacity for late telangiectasia and that for erythema and desquamation [40]. These changes could be attributed to a modification

in the immune and cell cycle pathways related to senescence [41].

In addition to the loss of epithelial cells, an inflammatory response develops in the skin that can cause soreness, swelling and erythema [42]. It is important to note that the term 'erythema' presents differently across different skin tones and can be misleading [43]. The British Association of Dermatology [44] states that erythema can be easy to miss in brown and black skin as the change in colouration can present as the skin becoming darker than the surrounding area. For some people with brown and black skin, the skin changes can present through pink, red, maroon, yellow, grey or purple skin colour changes [43]. It is important to understand the patient's skin tone at baseline.

With increasing skin dose and/or time, complete denudation of the horn layer may occur, resulting in moist desquamation. The epidermis recovers through proliferation of cells from the stem cell compartment. The true stem cells are found in the bulge compartment of the hair follicle [45, 46]. From here, the stem cells can migrate down to the root of the hair follicle, or to the epidermis, the derivative stem cells in Fig. 1a. When moist desquamation starts to heal, the skin regenerates from the hair follicles with small islands of new skin that extend and coalesce (Fig. 1b). In the case of an imbalance of pro-inflammatory and profibrotic cytokines, chronic RID can manifest. This irreversible condition is characterised by a change in vascularity, pigmentation, and fibrous tissue [38].

As detailed by Bennado et al. [38] other, rare chronic events have also been linked to RID. Only occurring in approximately 6% of patients previously treated with radiotherapy, radiation recall is a phenomenon which is poorly understood. Whilst the exact pathogenesis remains unknown, it has been postulated that radiation induced changes to the stem cells, along with DNA damage and oxidative stress are likely to trigger an acute inflammatory response at the original radiation site when a drug is administered months or years after the original treatment. The clinical manifestation of radiation recall is similar to that acute RID, and may include desquamation and pruitis.

Scoring RID

Grading and clinical assessment

Over the years several different systems have been developed to assign a grade reflecting the level of normal tissue damage, both in the acute and late setting [47–49]. Despite international efforts in standardization across all disciplines in oncology, we still see a range of scoring systems across Europe being used for the assessment of RID.

The Common Terminology Criteria for Adverse Events (CTCAE), current version 5, 2017 [50] includes both acute and late effects from treatment. Within the grades, specifically Grade 2 and 3, the impact on "activities of daily living" (ADL) is also considered, reflecting the patients' quality of life. Whilst the CTCAE is the system adopted in the Dutch guidelines [16], the French [13] and Italian [10] guidelines have employed a slightly edited version; motivated by the need to consider the synergistic effects of combined therapies and the occurrence of "bioradiation dermatitis"; e.g. experienced with the concurrent use of cetuximab [51, 52].

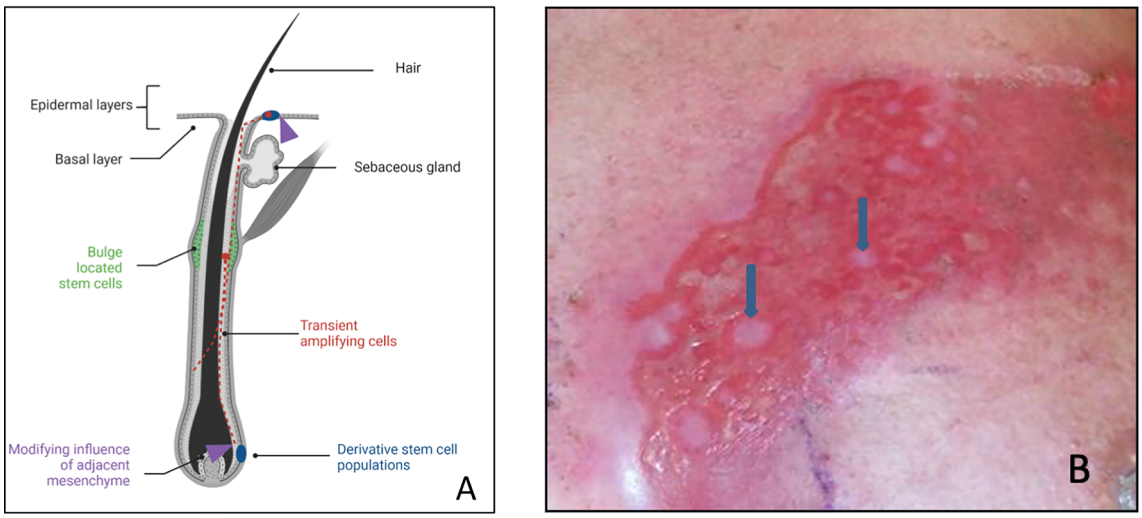


Fig. 1 **a** Position of multipotent stem cells in the bulge compartment in the hair follicle root sheath. Derived lineages migrate to the skin surface to regenerate epidermal cells. **b** Regeneration of the epidermis in an area of epidermolysis. Islands of regrowth (arrows) derived from the stem cells of the hair follicles gradually coalesce

An alternative system is that of the EORTC/RTOG [49], recognized for use in both the Italian and UK guidelines [10, 12]. Although limited to targeting acute toxicity only, this system has been shown to have high rates of inter-observer variability when compared with other established systems [53]. Table 3 presents a comparison of these systems for RID.

The use of photographs in the clinical environment may also provide useful supplementary information to monitor progression and/or response to interventions when needed, and their use is recommended by the panel. Figure 2 shows examples of the different grades of RID.

Whilst it is apparent that several different scoring systems are used in routine clinical care across Europe, consistent use of one single system amongst the multidisciplinary team within individual institutions is critical. Timing of the assessment should also be standardized; a point which is currently lacking in most guideline documents. In this regard, the UK guidelines recommend weekly assessment and grading [12]. Assessment of adverse events should also include reporting at baseline (i.e., prior to treatment commencing). Assigning a grade at this point is particularly important in specific clinical scenarios; for example, in the post-operative setting, or where reconstructive procedures have been undertaken, such as skin flaps or skin grafts. Furthermore, reporting at baseline also allows for responsible monitoring and appreciation of the progression of RID throughout the treatment course. At baseline assessment, it is important to evaluate intrinsic and extrinsic risk factors that may influence the frequency, severity, and duration of skin reactions. Professionals should be aware of altered skin reactions that may develop or be exacerbated by other therapies; for example, if patients receive concomitant chemo- or immunotherapy [54, 55] as well as the potential of a recall skin dermatitis [56]. Based on intrinsic factors, it is possible to stratify patients with a low, medium, or high risk of developing severe skin reactions, allowing

Table 3 Comparison of WHO, EORTC/RTOG, CTCAE v5.0, and CTCAE (modified) for the scoring of skin toxicity

Score	Scoring system			
	WHO	**EORTC/RTOG**	**CTCAE v5.0**	**Modified CTCAE**
0	No change	No change from baseline		
1	Erythema	Follicular, faint, or dull erythema epilation Dry desquamation Decreased sweating	Faint erythema Dry desquamation	Faint erythema Dry desquamation Lesions due to bio-treatment which may or may not be associated with symptoms of pruritus or tenderness
2	Dry desquamation Blister Itching	Tender or bright erythema Patchy moist desquamation Moderate oedema	Moderate to brisk erythema Patchy moist desquamation, mostly confined to skin folds and creases Moderate oedema	Moderate to brisk erythema Patchy moist desquamation, mostly confined to skin folds and creases Lesions due to bio-treatment mostly confined to < 50% of radiation area Bleeding lesions with friction of trauma
3	Moist desquamation Ulceration	Confluent, moist desquamation other than skin folds Pitting oedema	Moist desquamation in areas other than skin folds and creases Bleeding induced by minor trauma or abrasion	Moist desquamation in areas other than skin folds and creases Bleeding induced by minor trauma or abrasion Extensive (> 50% of involved field) confluent lesions due to bio-treatment
4	Exfoliative dermatitis Necrosis that requires surgical intervention	Ulceration Bleeding Necrosis	Life-threatening consequences Skin necrosis or ulceration of full thickness dermis Spontaneous bleeding from involved site Skin graft indicated	Life-threatening consequences Skin necrosis or ulceration of full thickness dermis Spontaneous bleeding from involved site Extensive (> 50% of involved field) confluent lesions due to bio-treatment Systemic inflammation response syndrome (SIRS)
5			Death	

WHO, World Health Organization; EORTC, European organization for research and treatment of cancer; RTOG, Radiation therapy oncology group; CTCAE, Common terminology criteria for adverse events

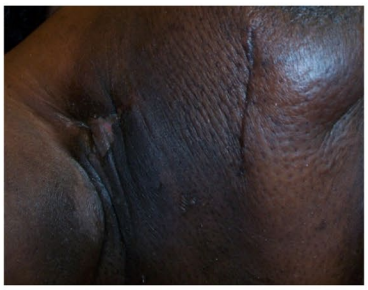
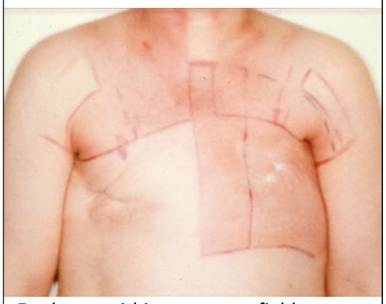
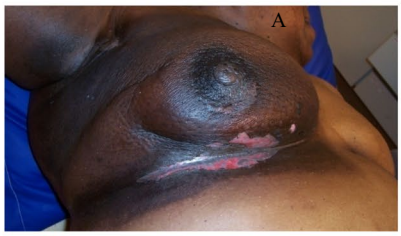
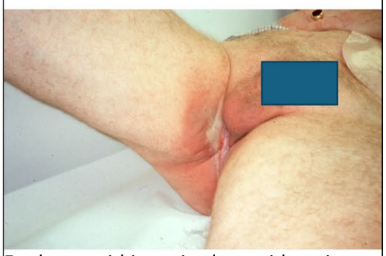
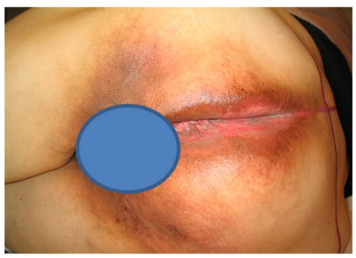
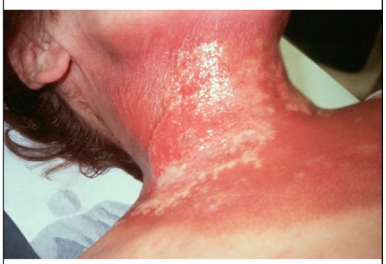
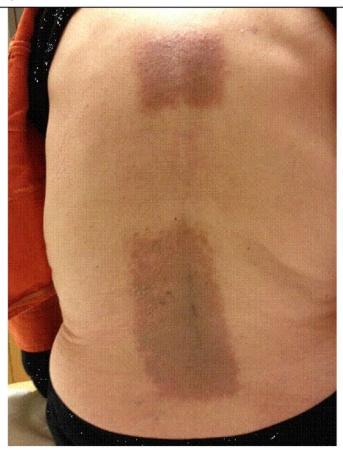
Grade of Reaction	Patient Example	
1	 Hyperpigmentation over the lateral chest and axilla on a patient with darker skin	 Erythema within treatment field on a patient with lighter skin
2	 Chest and axilla hyperpigmentation along with moist desquamation within the inframammary fold	 Erythema within groin along with moist desquamation in skin fold
3	 Erythema and hyperpigmentation within groin along with moist desquamation in the natal cleft	 Erythema along with confluent moist desquamation across the chest and neck
Post-Treatment	 Hyperpigmentation within two treatment fields on a patient with lighter skin tone following radiotherapy treatment to the spine	

Fig. 2 Examples of the different grades of radiodermatitis

for prompt intervention where required. Whilst there is a lack of high-quality evidence to inform risk stratification [7], machine learning methods are now being used to develop more eloquent predictive models for RID [57–59].

Patient involvement and self-assessment

Whilst these established scoring systems are useful, when scoring side effects that are often subjective, there is the potential to undervalue the impact on patients' quality of life. In addition, there is a recognized lack of concordance between the grade assigned by the health care practitioner and that of the patient [60]. To overcome these concerns, separate quality of life scoring systems, such as the European Organisation for Research and Treatment of Cancer Core Quality of Life Questionnaire (EORTC QLQ-C30) [61], and patient reported outcome measures (PROMs) have been developed [62, 63]. Specific to RID (Table 4), the Radiation Induced Skin Reaction Assessment Scale (RISRAS) and the Skin Toxicity Assessment Tool (STAT) are commonly used [64]. Unique to these scales is the hybrid of both a PROMs component as well as a scale for scoring by the health care professional; thereby capturing both the objective and subjective domains, combined in a total score. Whilst the Italian [10] and Belgium [17, 18] guidelines do not mandate the use of the RISRAS, the value of this system, when used in combination with other classification systems, is recognised. Conversely, the Italian guidelines [10] refer to STAT as a valid tool to be used [65]. Another alternative tool is the Dermatology Life Quality Index (DLQI) [66]. This questionnaire measures the impact of skin disease on the patient's quality of life, where each of the ten questions considers the impact over the previous week. This tool may also be supplemented with an additional illustrative version [67]; yet despite being validated, neither appear in many of the guidelines reviewed. Similar to the DLQI [66], the Skindex-16 rates skin conditions that have occurred in the previous week, with a 16-item patient completed form using numerical analogues scales and 3 subscales (14).

The panel recommends involving the patient and evaluate the different options available [68] to incorporate patient reported skin reactions, during and after radiation therapy.

Prevention and management of RID

Prevention and general skin care management

Prevention of RID comprises the reduction of irritants and trauma to the skin, taking care during washing, with the application of topical agents during radiotherapy, as well as taking care during sun exposure and activities such as swimming. The overall recommendations based on the majority of guidelines and systematic reviews for general skin care management are listed in Table 5. As highlighted in the Dutch [16], UK [12] and Belgian [17, 18] guidelines, healthcare professionals need to be provided with clear instruction and

Table 4 Assessment tools for radiation induced dermatitis (RID), evaluating patient-reported outcomes measures

Assessment tool	Type of CRO included	Scale	Type of PRO included	Scale	Other domains evaluated
RISRAS	Erythema	0–4	Tenderness, discomfort, pain	0 to 4	–
	Dry desquamation		Itching		
	Moist desquamation		Burning sensation		
	Necrosis		Impact on daily activities		
STAT	Erythema	Area (cm × cm)	Burning	0 to 5	Skin care treatment, assessment time
	Dry desquamation		Itchiness		
	Moist desquamation		Pulling		
	Exudate		Tenderness		
			Other		
DLQI	NA	–	Itchiness	0 to 3	Symptoms and feelings, daily activities, leisure, work and school, treatment
			Soreness		
			Pain		
			Stinging		
Skindex-16	NA	–	Itching	0 to 6	Emotional and functional subscales (frustration, embarrassment, depression, personal relationships, daily activities)
			Burning or stinging		
			Hurting		
			Irritation		

CRO, Clinician-reported outcome; PRO, Patient-reported outcome; STAT, Skin toxicity assessment tool; RISRAS, Radiation Induced Skin Reaction Assessment Scale; DLQI, Dermatology life quality index; NA, Not available

Table 5 Summary of management recommendations outlined in the (national) guidelines reviewed

Recommendations	Supporting guidelines/ literature			
	QoE L1	QoE L2	QoE L3	QoE L4
General management/prevention				
To ensure good hygiene the skins should be washed daily, preferably with lukewarm water and gently drying of the treatment area	MASCC (2013); Rosenthal et al. [3]; Iacovelli et al. [6]; Russi et al. [54]; Kumar et al. [72]; McQuestion et al. [73]; Spasic et al. [77]; Bolderston et al. [81]; Chan et al. [94];	DE; NL; UK; Gutierrez et al. [55]; Chan et al. [95]	Butcher et al. [96]	BE; DK; FR; IT; ONS; Siddiqui et al. [69]; Radvansky et al. [88]
The use of deodorant is allowed unless the skin is broken	MASCC (2013); MASCC(2023); Salvestrini et al. [26] (breast cancer only); Chan et al. [95]	DE; NL; ONS; UK; McQuestion et al. [73]; Spasic et al. [77];	Butcher et al. [96]	BE; IT; Ramseier et al. [76];
Skin irritation due to friction and abrasion in the treatment area should be avoided through the wearing of loose fitting (preferably cotton, linen, or silk) clothing, avoidance of excessive rubbing, trauma, jewellery or adhesives		UK		BE; DE; FR; IT; NL; MASCC (2013); Iacovelli et al. [6]; Russi et al. [54]; Ramseier et al. [76]; Siddiqui et al. [69]; Spasic et al. [77]; Abreu et al. [97]
Sun exposure in the treated area should be avoided. Protect the (irradiated) skin from exposure to the sun by covering the skin. After treatment a high SPF (SPF50) or sunblock is recommended				BE; FR; IT; NL; ONS; UK, Iacovelli et al. [6]; Russi et al. [54]; Ramseier et al. [76]; Spasic et al. [77]; Radvansky et al. [88] Abreu et al. [97];
Apply moisturizing cream/lotion to hydrate the irradiated skin. Application of cream/lotion directly/shortly before treatment is acceptable			BE; Bruch et al. [98]	DE; DK; IT; MX; UK; Gutierrez et al. [55]; Naylor et al. [86]; Bolderston et al. [81];
Management of Grade 1 RID				
Continue general management/ prevention				BE; FR; IT; NL; UK; Gutierrez et al. [55]
Apply moisturizing cream/lotion to hydrate the irradiated skin. Application of cream/lotion directly/shortly before treatment is acceptable				BE; DE; DK; IT; MX; NL; UK; Bolderston et al. [81];
The continued use of corticoid creams or topical steroid can be considered (but only when the skin is not broken)		DE; ISNCC; MASCC (2013); ONS; Rosenthal et al. [3]; Siddiqui et al. [69]; Chan et al. [95]	Spasic et al. [77]; Bolderston et al. [81]; Naylor et al. [86]; Abreu et al. [97]	BE; NL; DK; FR; MX; Gutierrez et al. [55]; Ramseier et al. [76];
Management of Grade 2 RID				
Continue general management/ prevention				BE; FR; NL; UK; Gutierrez et al.; [55]
Treat areas with intact skin same policy as grade 1				BE; DK; NL

Table 5 (continued)

Recommendations	Supporting guidelines/ literature			
	QoE L1	**QoE L2**	**QoE L3**	**QoE L4**
Option 1: Apply self-adhesive soft silicone dressings on the irradiated skin		MASCC (2023)	ISNCC; Iacovelli et al. [6]	BE; DK; FR; IT; NL; Ramseier et al. [76]; Spasic et al. [77]
Option 2: Continue using moisturizing cream or use hydrogel in combination with soft absorbent dressings on areas of open skin (and fix in position with bandages)			NL	BE; DK; FR; IT; UK; MX
The continued use of corticoid creams or topical steroid can be considered (but only when the skin is not broken)		DE; ISNCC; MASCC (2013); ONS; Rosenthal et al. [3]; Siddiqui et al. [69]; Chan et al. [95]	Gutierrez et al. [55]; Spasic et al. [77]; Bolderston et al. [81]; Naylor et al. [86]; Abreu et al. [97]	BE; DK; NL; MX; UK; Ramseier et al. [76];
Prevent and be aware of infections, infections should be overseen by a clinician				DK; IT; UK; NL; Gutierrez et al. [55]
At any sign of infection: the use of topical antiseptics and/or antibiotics is advised			NL	DK; IT; MASCC (2013); Russi et al. [54]; Gutierrez et al. [55]; Radvansky et al. [88]; Spasic et al. [77]
Ensure adequate analgesia is prescribed for the patient if required				DK; NL; UK; Gutierrez et al. [55]
Management of Grade 3 RID				
Ensure good hygiene care by daily or twice daily cleansing				BE; FR; IT; NL
Apply soft silicone or other appropriate dressings on broken skin, fixate with soft bandages		MASCC (2023)	NL; UK; Naylor et al. [86]	BE; DE; DK; FR; IT; Russi et al. [54]; Ramseier et al. [76]; Spasic et al. [77]; Radvansky et al. [88]
Manage exudates with absorbent dressings				FR; IT; NL; ONS; Russi et al. [54]
Prevent and be aware of infections, should be overseen by a clinician				DK; IT; NL; UK
At any sign of infection: use of topical antiseptics and/or antibiotics is advised			NL	BE; IT; MASCC (2013); Russi et al. [54]; Gutierrez et al. [55]; Spasic et al. [77]; Radvansky et al. [88]
Ensure adequate analgesia is prescribed for the patient if needed				DK; NL; UK; Gutierrez et al., [55]

Supporting literary evidence also cited. BE = Belgium [17, 18]; DK = Denmark [19]; FR = France [13]; DE = Germany [11]; IT = Italy [10]; NL = The Netherlands [16]; UK = The United Kingdom [12], MX = Mexico [83], ONS = Oncology Nursing Society [14], ISNCC = International Society of Nurses in Cancer Care [15], MASCC = Multinational Association for Supportive Care in Cancer (2013) [5], MASCC (2023) [8, 20]

adequate education to ensure skin care management is appropriate. Prior to RID becoming apparent, baseline assessment and stratification of risk factors is also encouraged. The UK [12] and Belgian [17, 18] guidelines also stress the importance of clear documentation of skin reactions and the skin care regimen to facilitate communication within the multidisciplinary team.

In most of the guidelines listed in Table 5, evidence-based recommendations are provided to reduce skin irritation from the beginning of radiotherapy; for example, limiting friction and abrasion in the treatment area. According to the majority of guidelines, hair removal treatments like waxing or laser should be avoided during treatment. On the other hand, shaving with either an electric razor or wet is allowed if the skin is still intact according to the Dutch [16] and Italian [10] guidelines, which is supported by the published literature [9, 54, 69–71].

All guidelines reviewed support basic hygiene practices consisting of daily washing with soap, as evidence shows it has been proven to reduce skin reactions and prevent infection [3, 5, 9, 54, 55, 69, 72–75]. Regarding basic hygiene, the use of a mild, unscented, pH neutral soap is advised in the French [13], Belgian [17, 18] and Danish [19] guidelines, highlighting the aim of reducing additional irritants [3, 6, 54, 55, 72, 73, 76, 77]. On the contrary, this is not specifically mentioned in either the UK [12] or Dutch [16] guidelines. There is also a lack of consensus regarding the use of cosmetic products containing alcohol, menthol, perfumes, perseverative or allergenic substances, owing to the lack of high-level evidence regarding these products. Whilst the use of intranasal mupirocin and chlorhexidine body cleanser for bacterial decolonization was shown to be effective in a recent RCT by Kost et al. [78], the results were only clinically significant in preventing moist desquamation for patients with breast cancer, and the authors call for more research across institutions and cancer sites. The panel could not find evidence supporting a specific recommendation apart from generally supporting basic hygiene practices.

In the majority of guidelines, the preferred use of alcohol-free deodorant is advised (Table 5); however, due to the emerging evidence that the use of deodorant does not affect the severity of RID, regardless the ingredients of different products, this advice should be re-considered [9, 26, 75, 79, 80]. In light of this recent evidence, the panel does not recommend specifically avoiding the use of deodorants during radiotherapy.

Regarding treating the brain, only the UK guidelines [12] advise to wash hair gently with regular shampoo, but not to use a hairdryer [81]. In contrast, many authors recommend a milder baby shampoo [4–6, 72].

The Italian [10], German [11] and Belgian [17, 18] guidelines advise limiting or avoiding swimming in chlorinated or salt water. On the other hand, the UK [12] and Dutch [16] guidelines allow swimming, with the stipulation that the skin is intact and the patient shower directly afterwards to wash off residual chlorine. The panel could not find sufficient evidence or consistency in the reviewed guidelines to deduce recommendations regarding swimming. In line with McQuestion et al. [73], avoiding extremes of temperature, such as saunas and solariums is also recommended in a number of the guidelines [10, 11, 17, 18] but is allowed in according to the Dutch [16] guidelines provided the skin shows no reaction.

The majority of guidelines in Table 5 encourage skin hydration in the treatment area from Day 1 of treatment through the use of various topical agents. Although, in both the literature and the guidelines, a variety of products is recommended, there is a paucity of RCTs to support the use of one moisturising agent over another. Similarly, Fatima et al. [22] could not find a benefit from topical non steroid agents for the prevention of RID with the exception of Biafine, a moisturizing cream. Recognising this lack of evidence, the UK [12] and Dutch [16] guidelines do not recommend a specific product. Considering results from the randomized control trial conducted by Pommier et al. [82] demonstrated calendula cream may reduce the occurrence of Grade 2 or higher skin toxicity, the recommended prophylactic use of such is now recommended in the Italian [10], and Mexican [83] guidelines. Yet despite also being recommended in the wider literature [3, 6, 77], still insufficient evidence [5, 14] or possible allergic reactions are highlighted (i.e., German guideline [11]) to justify no or limited recommendation for the use of calendula. Furthermore, Ginex et al. [84] and Robijns et al. [25], highlight conflicting evidence for the use of calendula containing products with the metanalysis performed by Robijns et al. [25] indicating ineffectiveness of calendula. Similarly, the evidence for the use of aloe vera containing products is conflicting [25, 84]. While anecdotally it may be common in clinical practice, its use is not recommended by the UK [12], MASCC [8, 20], or ONS guidelines [14], and is even advised against in the ISNCC guidelines [15].

Given this background, the panel recommends the use of moisturizing agents in the prevention of RID; however, can not recommend with certainty the use of natural agents due to the lack of evidence regarding their efficacy.

Photo-biomodulation therapy or low-level-laser therapy (LLT) is mentioned as an emerging option with limited data in the literature [70] by the German [11], UK [12] and Mexican guideline [83]. The UK [12] and French guidelines [13] also highlight ongoing research evaluating

LLT. In a recent systematic review and meta-analysis Gobbo et al. [23] report that the available data suggest that LLT may have a role in prevention of higher Grade RID and should be started early on. The MASCC conclude (based on a literature review [8] and backed up by a Delphi consensus [20]) that LLT shows promising results and recommend its utilisation for breast cancer patient, with this group being most researched (4 out of 5 randomised controlled trials [23]).

According to the 2023 MASCC guideline [8] the lack of evidence and conflicting data does not allow recommendations based on the currently published literature. However, for patients considered at a higher risk of radiation dermatitis, they recommend the use of topical corticoids (mometasone furoate and betamethasone), silicone-based polyurethane or polyurethane films (Mepitel Film and Hydrofilm), photo-biomodulation (low level laser) therapy, as well as topical olive oil to prevent RID or associated symptoms, as these show potential positive effects [8, 23–25] and were agreed upon in an associated Delphi study [20].

Management of RID

Once a skin reaction has been established, appropriate management includes limiting pain and discomfort. Depending on the severity of the reaction, this will typically involve the use of topical agents and dressings. In Table 5 the overall recommendations based on the majority of guidelines and best available evidence for the management of different grades of RID is listed.

In the case of Grade 1 RID most guidelines recommend either continuing general skin care as per the general recommendations. To prevent RID progressing many also recommend keeping the irritated area clean to avoid infections, keeping the skin moisturized and nourished, managing pruritus, and avoiding additional irritations or damage due to friction (Table 5). In the case of pruritis, cooling measures like moist compresses could be considered, as per the Dutch [16] and German [11] guidelines. In addition, the French [13], Italian [10], and Mexican [83] guidelines mention the use of creams containing hyaluronic acid as it has been shown to accelerate the skin healing [77, 85]. In contrast, this practice is not advised in the German [11] and the MASCC guidelines [5, 8]; owing to insufficient evidence and the limited statistical power of the current evidence on the topic [9, 22, 73].

When the RID progresses to Grade 2 most of the guidelines advocate the use of soft silicone wound dressings or similar dressings to reduce the potential impact of friction, especially for areas in the early stages of desquamation (Table 5). Similarly, the potential of semipermeable dressings or barrier films has been highlighted in several systematic reviews on the topic [6, 14, 76, 77]. While the UK guideline [12] reports insufficient evidence for the use of such, Finkelstein et al., [9] report that there are recommendations for the use of silicone-based dressings. The lack of evidence is also highlighted in the MASCC guideline [8], however stating that polyurethane film (Hydrofilm) and silicone-based polyurethane film (Mepitel Film) showed the most potential to effectively reduce RID severity. Furthermore, the MASCC group report some evidence [8] and a consensus [20] recommending the use of foam dressings (Mepilex Lite) to manage RID. There is, however, a wide range of dressings available in clinical practice, and there is little evidence to aid in the choice of which dressing to use. The panel does, however, recommend staff are aware of patient sensitivity to the adhesive materials that may result in an inflammatory skin reaction. To prevent potential adverse reactions, the panel recommend confirming the patient allergy status, possible via a spot test prior to use. As recommended in the Dutch [16], Belgian [17, 18] and French [13] guidelines, the dressings, and bandages fixated with soft and non-adhesive materials, should be removed before treatment. Ultra-thin films or semi-permeable dressings can be maintained during treatment [86, 87].

Similar to G1 RID, the aim at this stage is to keep the skin clean and moisturized while avoiding additional irritation. Care must be taken to prevent infection and avoid additional damage at the affected site being mindful of the reduced barrier function of the intact skin, or areas in the early stage of (moist) desquamation. If infections do appear, the use of topical antiseptics and/or antibiotics (e.g., silver sulphadiazine cream) are recommended in the majority of the guidelines reviewed (Table 5); a point which is again further supported by the evidence base [9, 55, 69, 88]. Patients should be educated to be aware of infections, and if they occur the patient should preferably be reviewed by a Radiation Oncologist, skin/wound care specialist, or RTT working in an advanced practice role [89]. Specifically, the Dutch [16] guidelines advise patients to measure their temperature in case of cold chills or feeling sick, and to contact the department if their body temperature is > 38 °C, as this may indicate infection. In addition to some guidelines reported by Finklestein et al. [9], the Dutch [16], the UK [12] and the Danish [19] guidelines recommend prescribing analgesia for pain, if needed.

The management of Grade 3 RID is focused on the relief of inflammatory and painful symptoms, to treat the skin lesions, to control bleeding, to protect the skin from further trauma, and to prevent infections (Table 5). The guidelines and literature trend more toward the use of appropriate dressings/products; for example, soft silicon dressings, hydrogel sheets, hydrocolloids or hydro-active

dressings to treat the broken skin [8, 9, 54, 76, 77, 86, 88]. Although in the Dutch guidelines [16] the use of water-based cream or hydrogel in combination with soft absorbent dressing is also suggested as an option to treat moist desquamation, which is particularly useful in skin folds where flat dressings are difficult to apply. In case of infections, the same policy as for Grade 2 is advised; however, as stated in the Dutch [16] and Belgian [17, 18] guidelines, in Grade 3 RID, performing a wound swab culture should be considered to identify the infections agent [88].

Due to the extent of skin care required in cases of Grade 2 and 3 RID, in addition to the RTT, it is recommended the patient is also assessed by a skin/wound care specialist on treatment days. To ensure proper skincare on non-treatment days and/or after treatment, engaging with district nurses, community/home care or general practitioners is recommended in the Dutch [16], Danish [19], and UK guidelines [12]; however, prescriber rights of these professionals do vary between countries.

Due to the low incidence of Grade 4 RID, only few of the guidelines address management of this grade. As stated in the French [13], Dutch [16], and Italian [10] guidelines, Grade 4 RID should be managed in a multidisciplinary team consisting of a Radiation Oncologist, Medical Oncologist, dermatologist, plastic surgeon and/or wound care specialist, and often requires surgical intervention [54]. The interruption or discontinuation of the (systemic and radiotherapy) treatment should be considered [6, 54, 55, 76].

Communication and patient education

Many guidelines highlight the importance of clear communication and written instructions for patients in relation to skincare advice during radiotherapy, as well as providing advice on general preventative measures. This is important to highlight possible discomfort and to encourage patients to be proactive in their own skincare management in close association with their radiotherapy team. In the UK, the Netherlands, and Belgium, patients are encouraged to self-monitor skin changes during treatment and to discuss these with the wider radiotherapy team as they arise [12, 16–18]. In terms of being proactive in the management of RID, the 2013 MASCC guidelines [5] stress the importance of providing validated and practical advice to patients using simple language (sixth grade). These should, if possible, include specific brands to buy, along with pictures where appropriate, and highlight behaviours to avoid. The UK guidelines [12], however, advise against the use of specific products. They also stipulate the importance of communication at the end of treatment in relation to patients being aware that skin reactions will worsen up to 10–14 days after the last treatment [12]. The Dutch [16] and UK guidelines [12] further advise preparing the patient for possible discomfort by discussing the likelihood of acute RID and that permanent radiotherapy-related side effects of the skin should be considered. In this regard, the 2013 MASCC guidelines [5] also recommend providing patients with concrete examples of when they should contact their doctor regarding RID.

Discussion/limitations

These recommendations are predominately based on a limited number of guidelines available to the writing group. Although additional material was included by searching for evidence in review papers, a systematic review was not conducted to fully evaluate and include the available evidence on the prevention and management of RID. Furthermore, many of the guidelines or review articles highlight that the available evidence on management and prevention of RID is limited in scope and quality, and actively call for further research being necessary for several agents or methods. As a result of an extensive systematic review, the MASCC guideline [8] even conclude that no clear recommendations can be deduced from the current evidence, however highlighting agents or methods showing promising results across multiple studies. Relying on randomised controlled trials to assess the safety and efficacy of each individual agent is cost-prohibitive and arguably impractical. As such responsible, prospective data collection in clinical departments may serve to supplement the evidence based in this regard. There is an abundance of emerging supportive agents and methodologies that have been investigated in the literature, and we invite the reader to refer to the recent systematic reviews and meta-analyses which highlight and discuss each individually [8, 20, 90].

Whilst these practical recommendations serve to provide a frame of reference regarding assessment tools and management interventions for RID, the clinical staff responsible for these tasks must be adequately educated. The treatment of cancer continues to develop at a rapid pace, and now includes more combined treatments, such as immunotherapy. Similarly, the more frequent use of hypo fractionated schemes shortens the time patients are in contact with radiotherapy professionals, novel approaches for follow up such as telemedicine [91] but also patient-reported outcome measurements, and utilising mobile applications could be options to screen for side effects after radiotherapy [92]. As professionals we must keep abreast of these developments and anticipate the potential impact on radiodermatitis. Regular assessment of the progression of RID is also paramount ensuring prompt action is taken when needed. The RTT is perfectly positioned for this role given their daily interactions with individual patients. Furthermore, RTTs

are well placed in the multidisciplinary team and can facilitate clear communication with both colleagues and patients, hence mitigating the risk of conflicting information being circulated. Whilst professional autonomy for RTTs varies globally, through advanced practice roles, there is the opportunity to introduce RTT-led treatment review clinics [93]. In doing so, we will leverage the full potential of a highly skilled workforce to provide optimal care of our patients [89].

Conclusion

Despite the ongoing research efforts, including outcomes from RCTs, translating these findings into a change in clinical practice and establishing a standard of care remains a key challenge. Based on guidelines from eight countries, three societies, and supported by the literature, these practical recommendations are defined to provide guidance and considerations on the clinical assessment and medical management of RID, as demonstrated in Table 1. The panel calls for continued research allowing for more concrete recommendations, in particular where the current evidence is conflicting.

Abbreviations

ADL	Activities of daily living
ASTRO	American Society for Radiation Oncology
CTCAE	Common terminology criteria for adverse events
DLQI	Dermatology life quality index
EORTC QLQ-C30	European Organisation for Research and Treatment of Cancer Core Quality of Life Questionnaire
ESTRO	European Society for Radiotherapy and Oncology
ISNCC	International Society of Nurses in Cancer Care
LLT	Low-level-laser therapy
MASCC	Multinational Association of Supportive Care in Cancer
ONS	Oncology Nursing Society
PROMS	Patient reported outcome measures
RCT	Randomised control trial
RID	Radiation-induced dermatitis
RISRAS	Radiation Induced Skin Reaction Assessment Scale
RTT	Radiation therapist
RTTC	Radiation Therapists Committee
STAT	Skin toxicity assessment tool
UK	United Kingdom

Supplementary Information

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Additional file 1.

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EF and AOD searched and screened the literature. PS approved list of included studies. PS scored the quality of evidence. All authors were involved in assigning the strength of recommendations. All authors listed were involved in the study design, interpretation of the evidence base, and preparation of the manuscript.

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