New Textile Technologies for the Prevention and Care of Skin Lesions Due to Radiodermatitis

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A clinical case of radiodermatitis on the neck, classified as grade 3 according to the RTOG, is presented, in which the use of therapeutic health textiles, manufactured with Regenactiv technology (chitosan and silver fibers), is associated with the rest of the care that the patient can receive at home from her caregivers. This results in a high level of empowerment, at the same time as providing relief from her dependence on primary health care services.

Keywords: radiodermatitis, textiles, Chitosan, metallic silver, radiation injuries

INTRODUCTION

The skin is made up of three well-differentiated layers, both anatomically and functionally: the epidermis, the dermis (connective tissue) and the fatty (adipose or subcutaneous) tissue[1].

The epidermis is the outermost part and consists of a poly-stratified squamous epithelium with an average thickness of between 0.1 mm (the thinnest in the upper eyelid) and 1-2 mm (palms of the hands and soles of the feet). It is the most superficial layer and is composed of approximately 85% keratinocytes that are formed by cell division from the germinative basal layer (Figures 1,2), from which they ascend in well-defined layers (basal layer, stratum spinosum, stratum granulosum and stratum corneum), gradually increasing their amount of keratin until reaching the horny layer where the process of keratinization is complete. This process of epidermopoiesis of the basal layer cells to the stratum corneum has an average duration of about 2 weeks, remaining in this layer for another 15 days until its detachment.

FIGURE 1
LAYERS OF THE SKIN

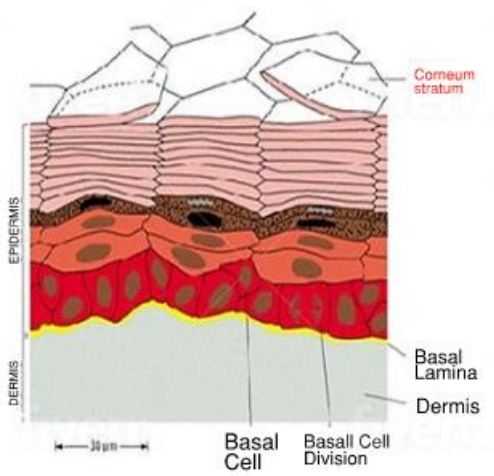
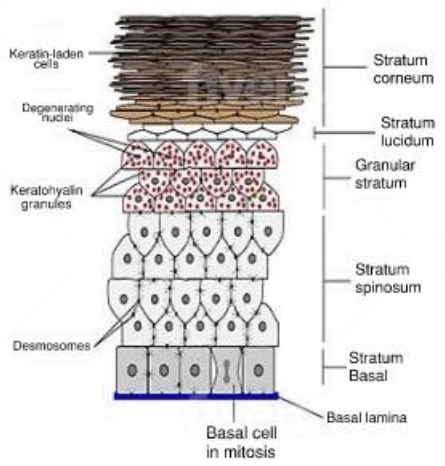
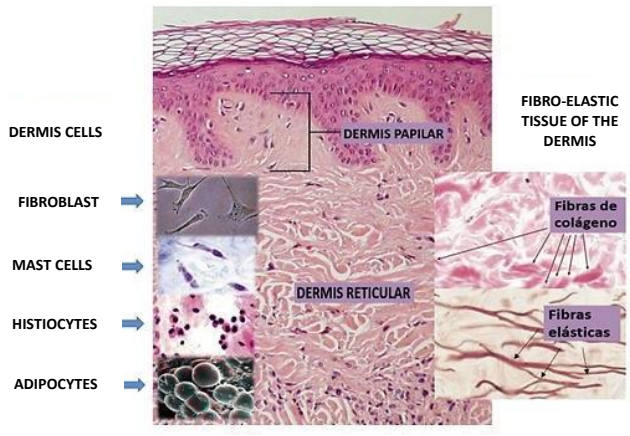


FIGURE 2
LAYERS OF THE EPIDERMIS



The dermis represents a fibroelastic tissue, consisting mainly of a network of collagen and elastic fibers. It is composed of connective tissue and comprises papillae, fibers, ground substance and cells, and contains the vascularized support of the skin. It can be divided into two parts: a thin zone which goes under the epidermis (papillary dermis), composed mainly of the dermal papillae zone which penetrates the epidermal ridges which in turn penetrate the dermis; and a thick zone going from the papillary dermis to the subcutaneous tissue (reticular dermis) where collagen fibers and elastic fibers are abundant, as well as the most important cells which synthesize them, such as fibroblasts[1] (Figure 3).

FIGURE 3
DERMIS COMPONENTS



The skin has multiple functions[1]. Among these functions, the immune function and the barrier function stand out. The barrier function prevents the entry of substances or organisms from the outside and loss from the inside, as well as acting as a filter for ultraviolet radiation. Other functions include the repair of wounds, ulcers and cell damage caused by radiation, nutritional and temperature-regulating vascular functions, sensory and communication functions, and relationship or attention functions.

Radiodermatitis (RD) is defined as the result of damage to the skin, with alterations in cellular DNA (direct effect or formation of free radicals), as a consequence of exposure to high-energy therapeutic ionizing radiation, which in its different modalities is one of the fundamental pillars in the treatment of different types of cancer[2].

Considering the severity of the clinical effects, their importance for the body and the time of development (immediate or delayed), the following are considered determinants: The type of ionizing radiation, the radiation dose (dose effect) and its power (dose / power effect), the nature of the exposure (external or internal, general, or local, single or fractionated) and the radiosensitivity of tissues, organs and systems.

The skin, due to its high capacity for renewal, is considered an early response tissue. With the first sessions of radiotherapy, the basal cells (more radiosensitive) are destroyed in a high percentage, which leads to the alteration of the balance between the normal production of cells of the basal layer and the destruction of the cells of the skin surface.

Although skin changes occur from the beginning of exposure, reactions in their acute form are usually visible between the second and third week, reaching their peak at the end of treatment. They are manifested as erythematous, scaly, erosive, or ulcerative lesions whose associated symptoms are mainly pain and pruritus.

The RTOG/EORTC classification is the most commonly used, and classifies lesions into the following stages:

- **Grade 0:** No symptoms. Skin without clinical signs of dermatitis
- **Grade 1:** Slight erythema or dry peeling.
- **Grade 2:** Moderate erythema or patchy moist peeling, mainly confined to wrinkles and skin folds. Moderate edema.
- **Grade 3:** Confluent moist peeling, diameter greater than or equal to 1.5 cm, not confined to skin folds. Edema with pitting.
- **Grade 4:** Cutaneous necrosis or ulceration of the entire thickness of the dermis. It may include hemorrhage not induced by trauma or minor abrasion.

Erythema is caused by dilation of the dermis capillaries accompanied by edema due to increased vascularization and obstruction of the capillaries.

Dry dermatitis occurs due to decreased ability of the basal cells to replace the superficial layers and decreased functioning of the sebaceous and sweat glands; this appears after 2-3 weeks of treatment. It appears with a cumulative dose of 20 Gy.

Moist dermatitis is caused by damage to the extracapillary cells with increased blood flow, hyperemia, and edema, depending on the accumulation of radiotherapy sessions, exposing the dermis, which produces abundant exudate and crusting. It appears after accumulated doses of 40-60 Gy.

Skin ulceration and necrosis can occur when the total dose exceeds 60-70 Gy, resulting in the death of all cells of the stratum basale, leaving permanent atrophic scars.

Normal tissue repair is the result of a self-regulatory mechanism with re-epithelialization, proliferation and differentiation of cells from the basement membrane, and migration of epithelial cells from the untreated skin at the periphery of the treatment area; this process usually begins after 15 days, but its total duration depends on age and other personal factors, as well as possible complications due to lesion infection; its total resolution may be prolonged beyond 2 months. In addition, there are a series of factors which influence the risk and resolution of skin toxicity due to radiotherapy, such as high treatment doses, concomitant chemotherapy, fractionation of sessions, as well as others related to the patient, such as the treatment area having thinner skin (breast, armpit, and neck), previous skin condition, nutritional status, comorbidities such as diabetes or renal insufficiency.

The general care of radiodermatitis is aimed at protecting and preserving the skin's integrity (balanced hydration and nutrition, daily hygiene with mild products, environmental protection, clothes made of natural fibers). The topical treatment mostly recommended is based on the use of emollients (urea, pantothenic acid, oatmeal), hydrogels and hydrocolloids, barrier protectors (zinc, silicones), hyaluronic acid and collagen, or topical corticosteroids (in cases with high inflammatory response)[3].

The use of chitin/chitosan (Qi/Qo) textiles applied to wounds and skin stems from the studies of the 1st International Qi/Qo Conference in 1978, where Balassa and Prudden showed evidence that Qi/Qo dressings can accelerate wound healing by up to 75%[4]. Its applications studied are multiple, ranging from its use in dressings and hemostatic bandages marketed by HemCon Medical Technologies INC (Oregon, USA)[5,6], to its use in the design of smart fabrics.

Its zero toxicity on epithelial cells (melanocytes, fibroblasts, keratinocytes) has been documented[6]. Recently, Chen et al[7] have investigated its use in topical wound treatment, confirming that it can be used in the treatment of wounds:

a) It promotes skin wound contraction,
b) It accelerates skin reepithelialization and keratinocyte proliferation,
c) It decreases excessive inflammation of skin wounds.

In the case of the use of silver in different skin wounds, it has been known since ancient times. Currently its use has become universal: for the cauterization of haemorrhages, elimination of granulation tissue, prophylaxis of dermal burns, as an antiseptic in situations of local infection of ulcers, and above all in dressings of textile fibers (alginates, hydrofibers, foams, etc.)[8].

The Regenactiv® fabric is made up of CH viscose fibers (viscose with chitin/chitosan additives), silver polyamide (ionic silver adsorbed on polyamide), and elastane. Approximately 15 years ago, the company MLS Textiles 1992 S.L., in collaboration with the Instituto Tecnológico Textil (AITEX) developed a fabric called Regenactiv® with which different textile garments are manufactured. Initially used in sock format, it was presented at IPSO WINTER 09 (Munich). During the same period, a trial was conducted at the Fundación de Investigación del Hospital General Universitario de Valencia to evaluate the effectiveness of the fabric in sheets for bedridden patients and in fabric dressings for wound treatment[9].

As part of the development of new garments, we have recently completed the trial of the use of garments in top format, in collaboration with the biomedical group Ascires, for use in breast radiotherapy, with very satisfactory results, which were presented at the 4th Breast Congress in Madrid[10].

The differential fact to highlight is that the Regenactiv® (MUVU) fabric is a reusable textile fabric, which has been tested in more than 135 washing cycles by AITEX laboratories. The trials carried out validated that the textile retains its absorption properties, that viscose and polyamide fibers have not been detached, and that the antibacterial and antifungal properties of chitosan and silver are maintained during this long period of time, with proper use of the garment.

CLINICAL CASE DEVELOPMENT

Background

Woman, 78 years old, diagnosed with adenosquamous carcinoma in 2012, surgically treated. Recurrence in 2018, considered a recurrence of tongue epidermoid carcinoma, approximately 1 cm in diameter, without palpable indurations, treated with surgery.

Current, November 2019, new nodule in the same area, which is treated with radiotherapy. She started radiotherapy in the last week of November (35 sessions, which in principle should have been daily), but due to a certain number of public holidays in December and January, her final session was on January 17th.

The first symptoms of radiodermatitis appeared on January 10, but it was decided to continue because it did not seem serious and there were few sessions remaining. The patient was treated with 12-hourly dressings with Rym healing cream and gauze, to be followed by home care and primary care.

Screening

Injury description: injury in total right lateral aspect with involvement of the reticular dermis of about 20 days of evolution with abundant exudate requiring more frequent changes than those prescribed with gauze compresses and presenting EVA 8 pain during the dressings (Figure 4).

Diagnosis

CIE: L58.0 “Acute radiodermatitis”; L59.8 “Other specified radiation-related skin and subcutaneous tissue disorders”; L59.9 “Unspecified radiation-related skin and subcutaneous tissue disorders”.

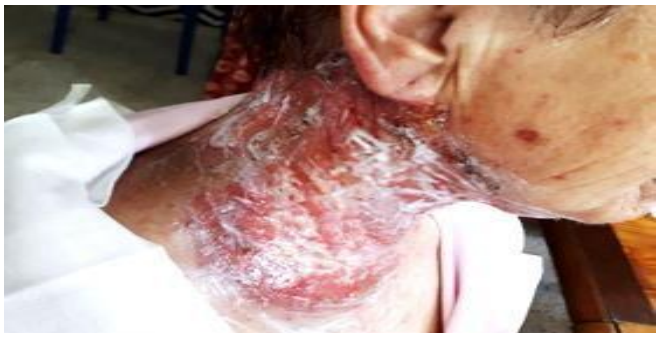
NANDA-I: Impairment of skin integrity 00046, related to ionizing radiation, manifested by a highly exudative lesion on the lateral aspect of the neck affecting the entire skin.

RTOG/EORTC classification: Grade 3: Confluent moist peeling, diameter greater than or equal to 1.5 cm, not confined to skin folds. Edema with pitting.

Care Plan and Evolution

Start: Rym healing and cover with Regenactiv® Muvu tissue, Dressing / Every 12h (Figure 4). The fabric samples used were provided by the manufacturer and washed by the patient’s family for reuse.

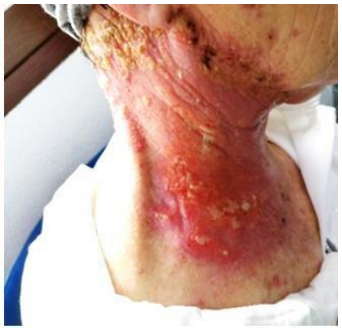
FIGURE 4
JANUARY 29, 2020. RYM HEALING AND COVER WITH REGENACTIV® MUVU FABRIC, DRESSING / EVERY 12H



February 3: dressed with Prontosan® gel support, Rym healing and covered with a double layer of Regenactiv®/ Muvu fabric /Every 12 h. (Images 5 and 6)

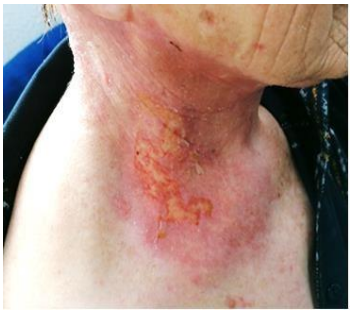
FIGURES 5
APPEARANCE OF THE INJURY AFTER 5 DAYS (02/03/2020)

FIGURES 6
APPEARANCE OF THE INJURY AFTER 5 DAYS (02/03/2020)

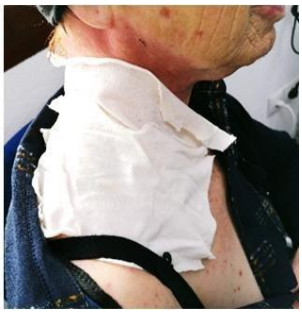


February 10: Change of the Rym healing by hyperoxygenated fatty acids (HOFA). 12-hourly application of a double layer of Regenactiv®/Muvu fabric. (Images 7 and 8)

FIGURES 7
APPEARANCE OF THE INJURY 11 DAYS LATER (02/10/2020)

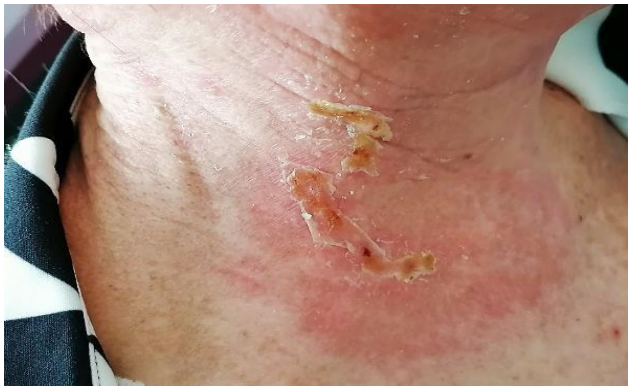


FIGURES 8
APPEARANCE OF THE INJURY 11 DAYS LATER (02/10/2020)



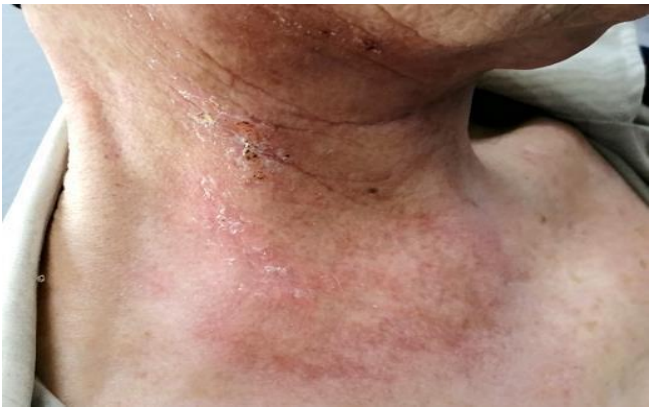
February 14: Treatment continued with HOFA and only one coat of Regenactiv®/Muvu with dressing changes every 24 hours. (Figure 9)

FIGURE 9
APPEARANCE OF THE INJURY 15 DAYS LATER (02/14/2020)



February 21: Regenactiv® fabric continues to be used until skin appearance normalizes. (Figure 10)

FIGURE 10
APPEARANCE OF THE INJURY 3 WEEKS LATER (02/21/2020)



RESULTS

The evolution has been positively assessed by the patient and her caregiver, highlighting that it has allowed them to perform daily dressings comfortably at home following the indications of the primary care nurses, and going only twice a week to the doctor's office for control. Furthermore, the decrease in pain during treatment and the prompt resolution of the injury have been highlighted, considering the degree of involvement of the entire dermis, as well as the appearance of the new formed skin.

DISCUSSION AND CONCLUSIONS

Considering the case evolution and its resolution in a relatively short period of time, we understand that the complementary use of re-usable textiles opens new paths for nursing care in complex wound care and skin care, allowing for sustainable cost-efficient treatments with a high usability index for the average patient, over long periods of time.

Textile medical devices have long been used for the treatment of difficult-to-heal wounds in the form of single-use products, made both from natural (e.g., alginates, hydrofibers) as well as synthetic (e.g., polyacrylate, polyvinyl) fibers. The research carried out by AITEX and other innovative projects, in the incorporation of new materials (chitosan, nanocrystalline silver, copper, zinc, cobalt, etc.) to textiles of standard use, is making it possible to modify the paradigm of skin care, allowing patients greater independence in the care of their lesions from radiotherapy, and achieving the added value represented by the re-use of textile fabric in the field of circular economy and sustainability.

ENDNOTES

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