Research Article

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Tissue Adhesives, Wound Closures, and Radiation Penetration

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Abstract

Introduction: *Keloid scars often occur due to skin trauma, such as ear piercing. These benign fibrous growths are difficult to treat, and recurrence adversely affects patients. Multimodal therapies such as surgical removal and low-dose superficial radiation therapy (SRT) have yielded positive results; however, several factors may impede the amount of radiation absorbed at the surgical site.*

Material and Method: *This feasibility study aimed to determine differences in the absorption of SRT in skin tissue in three simulated post-surgical wound scenarios versus a control group.*

Results: *The analysis of the results revealed that the layering process, as in the case when combining multiple wound closure techniques postoperatively, directly reduced the underlying wound's amount of radiation exposure and possible absorption at the incision site.*

Conclusion: *Treating clinicians should consider wound closure techniques and their role in post-surgical outcomes when treating keloid scars.*

Keywords: Keloid, Superficial Radiation Therapy, Wound

Introduction

Benign fibrous growths or keloids have adversely affected patients, and their resistance to effective treatments has perplexed physicians for millennia. For patients, these unsightly and often painful scars result from trauma to the skin, which triggers an overgrowth of collagen when injured. Clinically, they present as hard to the touch with a loss of skin texture and hair growth and are often smooth. Keloids are more common in specific races, specifically those with darker-pigmented skin [1].

There is no universally accepted treatment for these scars. Numerous unimodal treatments such as pressure therapy, cryotherapy, radiation, intralesional injections, topical silicone, and surgery are often unsuccessful [2, 3]. Surgical intervention is the gold standard for treating keloids, followed by wound care basics, including rapid primary closure utilizing tension-free techniques to induce epithelialization, minimizing scarring [4].

Current research supports that multimodal therapies have better outcomes when treating keloids [5, 6]. In particular, the combination of surgical excision followed by low-dose superficial radiation therapy (SRT) has yielded positive results in treating nonmelanoma skin cancers and keloids [5, 7, 8]. Having been developed over 100 years ago, SRT is considered a safe and effective method for treating dermatological conditions [9, 10]. In recent years, advanced device development and commercial availability have promoted use in the private practice setting (SRT-100TM; Sensus Healthcare, Boca Raton, Florida). SRT provides an ideal depth of penetration of 5mm, combined with the utilization of custom-tailored lead shields which target the intended areas avoiding exposure to deeper tissue. Studies examining SRT in treating keloids have shown low recurrence rates and a significant reduction in itching and pain, which are often problematic and difficult to manage [11-13].

An essential consideration in managing post-surgical keloids is wound closure. The surgeon decides which method is best suited for the type and location of the surgical wound. In the treatment of keloids, depending upon size, incisions can be closed using sutures, staples, wound closure strips, and tissue adhesives [14, 15]. The closure of the wound using sutures allows for precision; however, reactivity may occur that necessitates removal and the potential for further injury to the skin, increasing the probability of recurrence. Wound closure strips, which are ideal for areas of the body that are highly contoured, offer both tensile support and can contribute to the prevention of skin maceration. Typically, closure strips are made of a porous, non-woven backing reinforced with polymer filaments for strength and coated with a hypoallergenic adhesive. Traditional Steri-strips® are a thinner, paper-based wound closure system. They consist of a combination of polyurethane pads and polymeric strips coated with a non-latex pressure-sensitive, hypoallergenic skin adhesive that provides greater adhesiveness and ease of skin approximation. Tissue adhesives that have primarily been favored in emergency room settings, such as Dermabond® and Skin Stich®, classified as cyanoacrylates, have become increasingly popular among plastic surgeons for the closure of wounds. These products are considered histotoxic when applied below the dermal layer of skin; however, they are highly effective for superficial wound closure [16]. Skin adhesives can be used in the painless treatment of minor cuts, scrapes, burns, and minor irritations of the skin and helps protect them from infection. Regardless of the method of wound closure, an essential consideration in the treatment and application of radiation therapy is the degree of penetration in the targeted area and how this may influence post-surgical outcomes.

Methods

This feasibility study aimed to determine differences in the absorption of SRT in skin tissue in three simulated post-surgical wound scenarios versus a control group. To perform this study, a Thermoluminescence Dosimeter (TLD) badge (Mirion Genesis Ultra ® TLD) was used to record radiation dose. The TLD is a passive radiation detection device used for personal dose monitoring or to measure patient exposure to a specific amount. The TLD dose range for the badge is 1 mrem-1000 rad (0.01 mSv-10 Gy). A control group was included in the study to strengthen the ability to draw conclusions and to decrease the possibility of formulating potentially erroneous assumptions in this study. The three experimental groups included (1) TLD and wound closure strip (Steristrip ®), (2) TLD and tissue adhesive (Skinstitch ® glue), and (3) TLD and tissue adhesive (Skinstitch ® glue) plus wound closure strip (Steristrip ®).

This study did not use human subjects and was deemed exempt from the institutional review board. The analysis was performed in a radiation suite. The source of radiation used for this experiment is the SRT-100 TM machine. The badge was placed on a hard plastic surface in the radiation suite. In this study, a 10x10 cm applicator was used and exposed to radiation of 70 KV at 1.24 minutes. The calculated radiation dose delivered for this experiment would be used as the control.

The first experiment involved placing TLD on a hard plastic surface; a ½ inch Steristrip was placed horizontally across the mid-section of the TLD. It was then exposed to 70KV of radiation for 1.24 minutes. In the second experiment, a thin layer of surgical adhesive was placed horizontally across the mid-section of the TLD. The TLD was placed on a hard plastic surface. It, too, was covered with a 10x10cm applicator. A dose of 70KV, was delivered to the badge at 1.24 minutes. In the final experiment, a thin layer of surgical glue was applied horizontally across the length of the TLD. This was followed by a ½ inch wound closure strip placed on top of the glue, and a finger was used to ensure that the glue had evenly adhered to the TLD. The TLD badge was sent to Mirion Technologies ®, Dosimetry Services, for reading.

Results

This study aimed to evaluate whether the amount of SRT radiation delivered and absorbed varied utilizing differing post-surgical treatment modalities. The analysis of the results revealed that the process of layering, as is in the case when combining multiple wound closure techniques postoperatively, directly reduced the underlying wounds' amount of radiation exposure and possible absorption at the incision site.

The outcome of this experiment determined that there was a reduction in the absorption of radiation dose with the increase in the number of wound closure products placed on top of the TLD, which was considered the targeted pseudo-incision. The results of this study may be partly attributed to the fact that the radiation beam's intensity decreases as it passes through matter [17]. The reduction of the X-ray photons results initially from the absorption and subsequent scattering and is directly dependent on the beam's intensity and the area being irradiated. SRT uses a monochromatic beam of photons, meaning they are all the same energy. During the process of SRT, X-ray photons scatter and are ejected from the primary beam of radiation [8]. This occurs due to different interactions with the orbital electrons of the absorber atoms. In the case of SRT, there are three other mechanisms, Coherent scattering, Compton Scattering, and Photoelectric effect [18]. The reduction of the intensity of the X-ray beam is predictable. Still, it also depends on the physical characteristics of the beam and the targeted absorber, in this case, the wound closure strip and the surgical adhesive. When the primary beam of radiation passes through each one of these, the beam is attenuated as it passes through each unit of thickness of the absorbing material. The absorption of the beam depends on the thickness of the absorbing material and the beam's energy. In this case, to maintain uniformity between all the experiments, the energy remained constant for all the experiments. The wound closure strip with the surgical adhesive absorbed the most as it was the thickest absorption layer of all the experiments. The resulting beam is absorbed less with the addition of each successive layer of material. The dosimetry results are listed in Table 1.

Discussion

The effective treatment of keloid scars is complex, often employing several treatment modalities. The surgical incision is generally followed by wound closure utilizing sutures, surgical adhesives, wound closure strips or some combination of these techniques [15]. An adjuvant treatment that has gained favor over time is SRT, and serval studies have demonstrated effectiveness in the prevention of the recurrence of keloids [12, 19, 20]. A critical factor in keloids' successful outcome is the targeted radiation dose using postoperative SRT. This study sought to explore differences in radiation absorption when implementing different wound closure methods and the effect of layering on absorption. Results of this study found that radiation absorption utilizing surgical tape versus surgical adhesive alone had almost no significant difference in the rate of SRT absorption; however, the combination of surgical adhesive and wound closure strip was moderately lower. These results demonstrate that possible differences in the amount of radiation absorbed exist. A limitation of this study is that it was not carried out in a real-world scenario, but rather a simulation and further research should be conducted utilizing a traditional randomized control trial. Treating clinicians should consider wound closure and its role in post-surgical outcomes when treating keloid scars.

Table 1: Dosimetry Report Results

	Experiment	Millirem (mrem)
1	Control	285,053 mrem
2	(TLD and wound closure strip)	264,427 mrem
3	(TLD and surgical adhesive)	264,408 mrem
4	(TLD, surgical adhesive and wound closure strip)	257,067 mrem

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