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Reducing Radiation Dermatitis Using a Film-forming Silicone Gel During Breast Radiotherapy: A Pilot Randomized-controlled Trial

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Abstract. *Background/Aim: To evaluate whether topical use of a film-forming silicone gel (StrataXRT®) could reduce radiation dermatitis compared to a moisturizing cream (X-derm®) in patients receiving whole breast radiotherapy. Patients and Methods: A total of 56 patients with breast cancer were randomized to use StrataXRT or X-derm. The severity of radiation dermatitis was graded using physiological skin parameters, clinician-assessed visual rating scales and patient-reported symptoms. Changes in these parameters from baseline to 4 weeks post-radiotherapy were evaluated every two weeks. Results: Two-way repeated-measures ANOVA revealed different patterns of changes in the erythema index (F=3.609, p=0.008) and melanin index (F=3.475, p=0.015). The post hoc analysis demonstrated a significantly lower erythema index and melanin index in the patients allocated to the StrataXRT group. Conclusion: The use of StrataXRT can reduce radiation dermatitis with respect to objectively measured physiological skin parameters. The results of the present study will support the feasibility of conducting a larger randomized controlled trial.*

Radiation dermatitis (RD) is the most common adverse side effect of radiation therapy (RT), appearing in almost every patient with breast cancer who receives RT (1-3). The symptoms of RD generally include erythema, edema, dryness, hair loss, hyperpigmentation, and most seriously, moist desquamation, ulcers, and skin necrosis, which can cause discomfort in patients and disruption to RT (4-6). Traditionally, RD has been evaluated and graded using visual rating scales, such as the Common Terminology Criteria for Adverse Events (CTCAE) and Radiation Therapy Oncology Group (RTOG) criteria (7, 8). An additional scoring system, the modified 10-point Catterall skin scoring profile (CSSP), has been used to better evaluate RD (9, 10). However, due to the inherent subjectivity of these scales, a number of alternative methods have been developed to objectively quantify the changes in physiological skin parameters, such as electrochemical, reflectance spectrophotometer (erythema index (EI) and melanin index (MI)), trans-epidermal water loss (TEWL), and laser Doppler flowmetry (LDF) methods (11-15).

The management of RD, as an inevitable part of RT, is directed toward the palliation of skin symptoms (16). Several agents such as steroids, hyaluronic acid, aloe vera, sucralfate, and adrenergic vasoconstrictors have been used to prevent or reduce the severity of RD (10, 17-22). However, there are no clear guidelines or a consensus supporting the application of any topical agent as a standard of care for RD.

Recently, silicone-based barrier-forming products have been used for the management of RD (23, 24). The silicone-based film dressing provides mechanical protection from skin damage and TEWL, and may prevent moist desquamation and reduce the severity of RD. Despite these advantages, this silicone-based film dressing may have limitations, such as small bolus effects, easy detachment particularly when bathing or perspiring, and the need for frequent replacement at least twice a week. Topical applications of a silicone gel have been shown to be effective

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Key Words: Film-forming silicone gel, StrataXRT, radiation dermatitis, breast cancer.

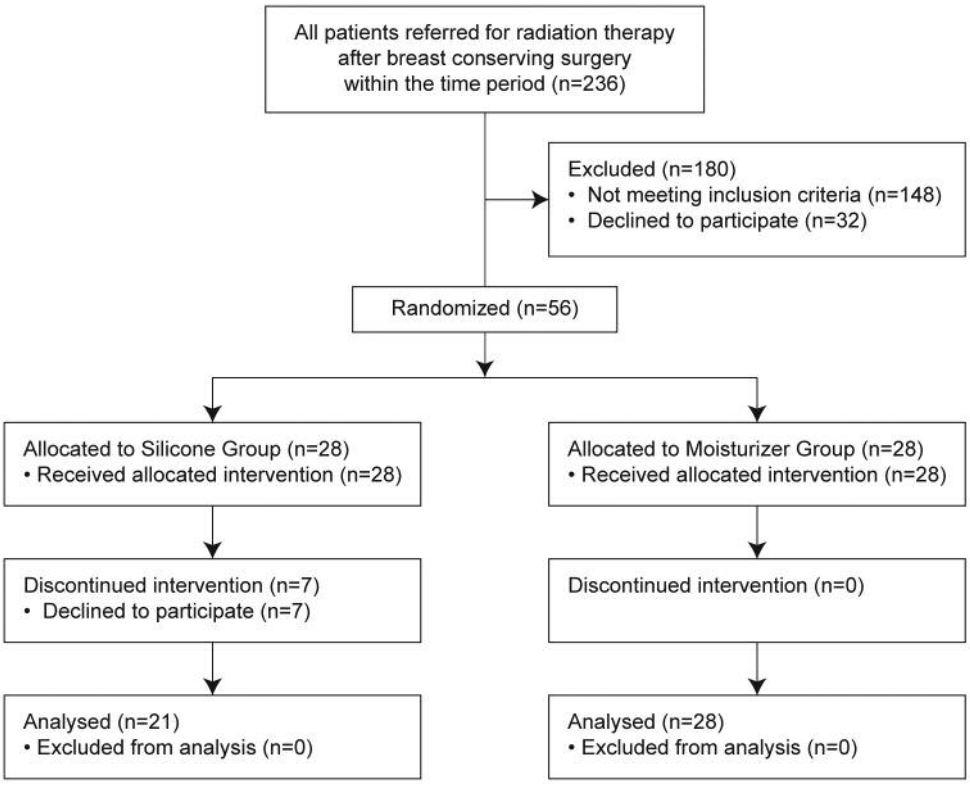

Figure 1. *CONSORT flow diagram showing participant flow through each stage of the randomized controlled trial (enrolment, intervention allocation, follow-up, and data analysis).*

in promoting accelerated epithelialization, reducing the inflammatory response (25, 26). StrataXRT® (Stratpharma AG, Basel, Switzerland) is a film-forming silicone gel designed to promote a moist wound-healing environment. When applied topicaly, StrataXRT dries to form a thin, flexible, protective layer that is gas permeable and waterproof. This environment leads to rapid wound healing and faster skin recovery. Studies have raised the possibility that topical use of StrataXRT might be effective in reducing various types of radiation-induced skin reactions (27, 28). A recently published randomized controlled trial has demonstrated the effectiveness of StrataXRT in preventing, delaying and reducing the severity of RD in patients with head and neck cancer (29).

The primary aim of this pilot randomized controlled trial was to compare the effectiveness of a film-forming silicone gel (StrataXRT®) and a moisturizing cream (X-derm®, Pharmbio Korea Inc., Republic of Korea) in reducing RD in patients receiving RT for breast cancer. The secondary aim was to correlate three physiological skin parameters (EI, MI, and TEWL) with changes in clinician-assessed visual rating scales (CSSP, RTOG, and CTCAE criteria) and patient-reported symptoms (dryness, itchiness, burning sensation, and pain).

Patients and Methods

Trial protocol. This was a single-centre, unblinded, randomized-controlled parallel study that included patients with breast cancer who had been referred for adjuvant breast RT after breast conserving surgery. Female patients aged 20-60 years with stage pTis, pT1-2, pN0, M0 were recruited between May 2017 and January 2019 at Gachon University Gil Medical Center in Incheon, Republic of Korea. The exclusion criteria were previous ipsilateral breast RT, any skin disease, any skin allergy to usual topical creams, and inability to consent or comply with instructions or skin care. Participants were randomly assigned to the silicone (StrataXRT®) *versus* moisturizer (X-derm®) groups using a random number generator (Figure 1).

All study participants provided written informed consent with respect to the use of topical agents and clinical data management for research purposes. This trial was designed and conducted in accordance with the principles outlined in the Declaration of Helsinki and within the guidelines of Good Clinical Practices. This trial received ethics approval from the Institutional Review Board, Gachon University Gil Medical Center (IRB number: GAIRB2017-127) and was retrospectively registered on Clinical Research Information Service (identifier KCT0002695).

Radiotherapy. A computed tomography (CT) simulation was performed in the supine position on a breast board with the ipsilateral arm up. The target volumes and organ-at-risk volumes

Table I. *Visual rating scales for radiation dermatitis*.

Reactions	Severity	CSSP	RTOG	CTCAE
No reaction		1	0	0
Erythema	Light, Tender	2	1	1
	Moderate, Bright	3		
	Severe	4		
Dry desquamation	<50%	5		
	>50%	6		
Blistering		7		
Edema	Moderate		2	2
Moist desquamation	<50%, Patchy	8		
	>50%, Confluent, Skin fold / Crease	9		
	Other than skin fold		3	3
Edema	Pitting			
Bleeding	Induced by trauma/abrasion		4	
	Spontaneous			4
Ulceration Necrosis		10		

CSSP: The modified 10-point Catterall skin scoring profile; RTOG: the Radiation Therapy Oncology Group; CTCAE: the Common Terminology Criteria for Adverse Events.

were delineated under the recommendations of the European Society for Radiotherapy and Oncology consensus guidelines (30). All patients underwent a standardized adjuvant RT protocol of 50 Gy to the whole breast delivered by a pair of wedged tangential fields (6-MV photon beams) in daily fractions of 2 Gy 5 days per week, followed by a 10 Gy electron boost to the tumor bed in daily fractions of 2 Gy.

Study procedure and measurements. Participants were instructed to apply the allocated agent to the designated treatment site at least twice daily, starting on the first day of RT and for 4 weeks after completion of RT. All patients were advised to comply with the institutional skin care guideline: wear soft, loose cotton clothes and bras; avoid using soap and water; avoid sunlight exposure to the treatment area; and avoid using topical agents other than the allocated agents. If the patients allocated to the moisturizer group developed moist desquamation within the RT field, they were asked to discontinue applying X-derm® cream and to initiate wound dressings as per usual institutional practice. Because StrataXRT® can be used as a film-forming wound dressing for moist desquamation, the patients randomized to the silicone group were instructed to continue with the study protocol regardless of developing moist desquamation around the irradiated area.

The severity of RD was graded using physiological skin parameters, clinician-assessed visual rating scales, and patient-reported symptoms. Changes in these parameters from baseline to 4 weeks post-RT were evaluated every two weeks (a total of approximately 10 weeks).

Physiological skin parameters. Skin toxicities induced by irradiation were assessed objectively using physiological skin parameters, including the EI, MI, and TEWL. These three physiological skin parameters were measured at the surface of the skin of the upper outer quadrant of the breast, at the midpoint between the axilla and nipple. This point was marked to ensure a consistent measurement location during the study period. Two experienced dermatologists performed measurements blinded to the arm allocation as well as to the results of other scoring criteria. The EI and MI were measured using a reflectance spectrophotometer (Mexameter® MX 18, Courage+Khazaka electronic GmbH, Cologne, Germany) and were expressed as arbitrary Mexameter® units on a scale from 0 to 999 (11). The TEWL was measured using the Tewameter® TM 300 (Courage+Khazaka electronic GmbH, Cologne, Germany).

Visual rating scales and patient-reported symptoms. One radiation oncology nurse independently assessed the grade of RD using three visual rating scales, including the CSSP, RTOG, and CTCAE criteria, and the descriptions for each scale are summarized in Table I. Meanwhile, the patient-reported symptoms of dryness, itchiness, burning sensation, and pain in the treatment area were assessed using a 5-point scale questionnaire.

Statistical analysis. Statistical analysis was performed using R Statistical Software (version 3.6.1; R Foundation for Statistical Computing, Vienna, Austria). The student's t-test for continuous variables and Chi-square test for categorical variables were used to compare the differences in the data between groups according to their demographics and baseline variables. Continuous variables are reported as mean±standard deviation. Between-group differences in the changes of outcome variables were analysed using two-way repeated measures analysis of variance (ANOVA) with Greenhouse–Geisser correction, which were expressed as F-statistic and *p*-value. We also conducted Bonferroni's correction to account for multiple testing (a total of six tests, therefore the α level was adjusted to 0.05/6=0.0083). The correlations among the different physiological skin parameters and changes in clinician-assessed scoring criteria and patient-reported symptoms following RT were determined using Spearman's correlation test. A correlation coefficient, ϱ>0.6 was considered to indicate a strong correlation, and ϱ=0.3–0.6 a moderate correlation. All the statistical tests were two-tailed and a significance level of 0.05 was accepted.

Results

A total of 56 patients were randomized during a 21-month recruitment period. Seven patients did not complete any of the post-RT assessments. Among them, five patients did not attend the 2 weeks post-RT assessment and two patients were lost to the final assessment. Thus, data for 49 patients (21 patients in the silicone group and 28 in the moisturizer group) were included in the analysis (Figure 1). The two groups were well-balanced in terms of clinical characteristics, except human epidermal growth factor receptor 2 (HER2) status and the use of trastuzumab (Table II). No differences in the results of baseline assessments were found between the groups.

Physiological skin parameters. The EI, measured using the Mexameter® MX 18, followed the same trajectory in both groups with a peak at the completion of RT (Figure 2A). There was a significant difference (p=0.001) between groups when comparing the highest EI during the study period, with a

Table II. *Clinical characteristics of patients*.

Characteristics	Silicone[a] (N=21)	Moisturizer[b] (N=28)	*p*-Value
Median age (range)	46 years (40-56)	49 years (29-60)	0.135
BMI (kg/m^2)			0.587
<25	15 (71.4%)	23 (82.1%)	
25-29	6 (28.6%)	5 (17.9%)	
≥30	0	0	
Breast volume (cm^3)	650.7±204.7	559.5±242.9	0.171
Boost volume (cm^3)	56.2±29.8	50.0±25.4	0.437
Hypertension			0.216
No	20 (95.2%)	22 (78.6%)	
Yes	1 (4.8%)	6 (21.4%)	
Diabetes mellitus			1.000
No	21 (100.0%)	27 (96.4%)	
Yes	0	1 (3.6%)	
Laterality			0.650
Left	12 (57.1%)	13 (46.4%)	
Right	9 (42.9%)	15 (53.6%)	
Breast cancer stage			0.173
0	1 (4.8%)	6 (21.4%)	
I	11 (52.4%)	15 (53.6%)	
II	9 (42.9%)	7 (25.0%)	
Estrogen receptor			0.790
Negative	3 (14.3%)	6 (21.4%)	
Positive	18 (85.7%)	22 (78.6%)	
Progesterone receptor			0.692
Negative	8 (38.1%)	8 (28.6%)	
Positive	13 (61.9%)	20 (71.4%)	
HER2 status			0.021*
Negative	13 (61.9%)	26 (92.9%)	
Positive	8 (38.1%)	2 (7.1%)	
Chemotherapy			0.269
No	7 (33.3%)	18 (64.3%)	
CMF	4 (19.0%)	3 (10.7%)	
AC-T	6 (28.6%)	5 (17.9%)	
AC	1 (4.8%)	1 (3.6%)	
TC	3 (14.3%)	1 (3.6%)	
Hormone therapy			1.000
No	3 (14.3%)	5 (17.9%)	
Yes	18 (85.7%)	23 (82.1%)	
Trastuzumab			0.010*
No	15 (71.4%)	28 (100.0%)	
Yes	6 (28.6%)	0	

BMI: Body mass index; HER2: human epidermal growth factor receptor 2; CMF: cyclophosphamide methotrexate and fluorouracil; AC-T: doxorubicin and cyclophosphamide followed by paclitaxel; AC: doxorubicin and cyclophosphamide; TC: taxotere and cyclophosphamide. [a]Film-forming silicone gel (StrataXRT®) group; [b]Moisturizing cream (X-derm®) group; *p<0.05.

Table III. *Highest values of studied parameters during the study period*.

Parameter	Silicone[a] (N=21)	Moisturizer[b] (N=28)	*p*-Value
Physiological skin parameters			
Erythema index[c]	453.4±61.6	531.7±82.2	0.001**
Melanin index[c]	241.8±83.8	314.0±85.5	0.005**
TEWL (g/h/m^2)	15.3±10.2	18.4±13.1	0.374
Visual rating scales			
CSSP			0.650
3	2 (9.5%)	2 (7.1%)	
4	0 (0.0%)	2 (7.1%)	
5	18 (85.7%)	23 (82.1%)	
6	1 (4.8%)	1 (3.6%)	
RTOG			-
1	21 (100.0%)	28 (100.0%)	
CTCAE			-
1	21 (100.0%)	28 (100.0%)	
Patient-reported symptoms			
Dryness			0.188
0	6 (28.6%)	11 (39.3%)	
1	0	6 (21.4%)	
2	5 (23.8%)	3 (10.7%)	
3	7 (33.3%)	5 (17.9%)	
4	2 (9.5%)	2 (7.1%)	
5	1 (4.8%)	1 (3.6%)	
Itching			0.463
0	5 (23.8%)	5 (17.9%)	
1	5 (23.8%)	5 (17.9%)	
2	2 (9.5%)	9 (32.1%)	
3	7 (33.3%)	6 (21.4%)	
4	2 (9.5%)	2 (7.1%)	
5	0	1 (3.6%)	
Burning			0.094
0	5 (23.8%)	9 (32.1%)	
1	2 (9.5%)	7 (25%)	
2	9 (42.9%)	5 (17.9%)	
3	4 (19%)	3 (10.7%)	
4	0	4 (14.3%)	
5	1 (4.8%)	0	
Pain			0.262
0	4 (19.0%)	5 (17.9%)	
1	3 (14.3%)	5 (17.9%)	
2	2 (9.5%)	8 (28.6%)	
3	7 (33.3%)	3 (10.7%)	
4	5 (23.8%)	7 (25.0%)	
5	0	0	

TEWL: Trans-epidermal water loss. [a]Film-forming silicone gel (StrataXRT®) group; [b]Moisturizing cream (X-derm®) group; [c]Arbitrary Mexameter® units (on a scale from 0 to 999); **p<0.01.

higher EI in the moisturizer group than in the silicone group (Table III). This difference was verified by two-way repeated measures ANOVA, which showed significance (F=3.609, p=0.008) in the interaction between time and group for the EI measurement (Figure 2A and Table IV). The *post hoc* analysis also demonstrated that the higher EI in the moisturizer group at 6 weeks (completion of RT) was statistically highly significant (p<0.001, Table IV).

The MI in both groups increased from baseline to 2 weeks after completion of RT and then decreased (Figure 2B). The highest MI during the study period in the moisturizer group was significantly higher than that in the silicone group

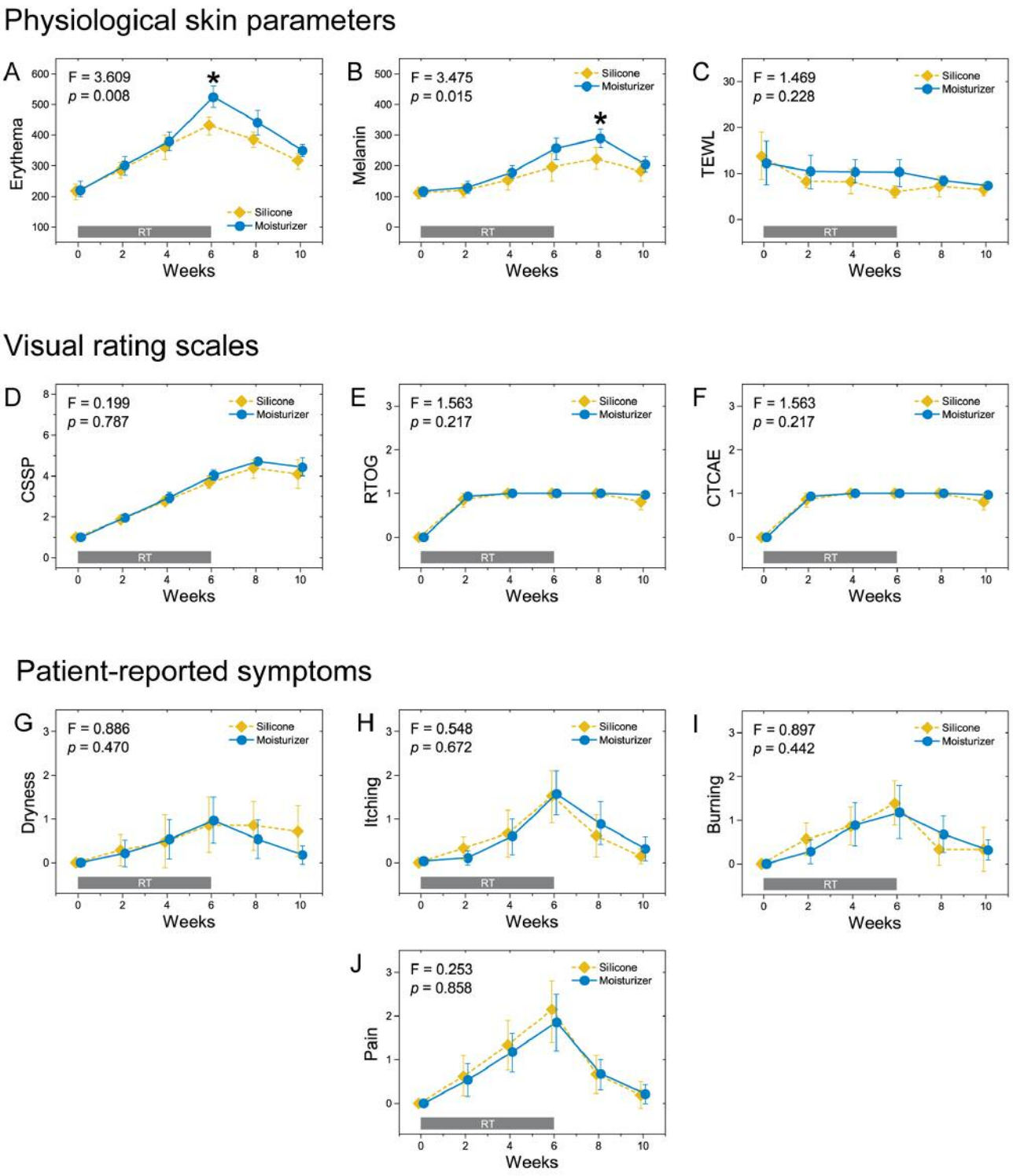

Figure 2. *Changes in the severity of radiation dermatitis in the Silicone group (StrataXRT®) and the Moisturizer group (X-derm®). Data are expressed as means (95% confidence intervals). Two-way repeated measures ANOVA with Greenhouse–Geisser correction followed by Bonferroni's post hoc test were used to verify the statistical significance of interaction between time and group factors, which were expressed as F-statistic and p-value. A: Erythema index (arbitrary Mexameter® units on a scale from 0 to 999). B: Melanin index (arbitrary Mexameter® units on a scale from 0 to 999). C: Trans-epidermal water loss (TEWL, g/h/m^2). D: Modified 10-point Catterall skin scoring profile. E: Radiation Therapy Oncology Group (RTOG) criteria. F: Common Terminology Criteria for Adverse Events. G: Dryness. H: Itching. I: Burning sensation. J: Pain. *p*<0.0083, Bonferroni's *post hoc* test for multiple comparisons.

Table IV. *Changes in physiological skin parameters and the results of two-way repeated-measures ANOVA with Greenhouse-Geisser correction for the interaction between time and group factors.*

Parameter	Silicone[a]	Moisturizer[b]	F-Statistic	*p*-Value
Erythema Index[c]			3.609	0.008
Baseline	217.2±60.5	220.5±63.4		
2 weeks	285.5±52.3	301.1±81.8		
4 weeks	361.0±89.2	380.1±70.2		
6 weeks	432.9±64.6	525.0±80.7		(<0.001*)
8 weeks	386.8±58.9	441.6±104.4		
10 weeks	316.7±54.0	350.6±56.6		
Melanin Index[c]			3.475	0.015
Baseline	111.6±40.9	117.4±41.0		
2 weeks	118.5±47.3	129.1±48.0		
4 weeks	153.3±65.4	179.0±60.9		
6 weeks	196.4±93.6	257.5±85.7		
8 weeks	221.9±78.0	290.1±85.9		(0.006*)
10 weeks	183.0±65.6	204.3±66.9		
Trans-Epidermal Water Loss (g/h/m^2)			1.469	0.228
Baseline	14.8±11.6	12.4±12.3		
2 weeks	8.2±3.1	10.7±10.0		
4 weeks	10.1±6.2	11.2±7.3		
6 weeks	6.4±2.9	11.3±8.8		
8 weeks	7.4±5.3	9.0±3.9		
10 weeks	6.7±3.1	7.9±2.3		

[a]Film-forming silicone gel (StrataXRT®) group; [b]Moisturizing cream (X-derm®) group; [c]Arbitrary Mexameter® units (on a scale from 0 to 999); *p<0.0083, Bonferroni's post hoc test for multiple comparisons implemented, and an α value less than 0.0083 was required for statistical significance.

(p=0.005, Table III). A significant interaction between time and group in the changes in the MI (F=3.475, p=0.015) was observed based on two-way repeated measures ANOVA (Figure 2B and Table IV). The *post hoc* analysis demonstrated a significantly higher MI in the moisturizer group compared with that in the silicone group 2 weeks after completion of RT (p<0.001, Table IV).

TEWL decreased continuously during the study period (Figure 2C). There were no significant differences between the groups in the TEWL measurements (Table IV).

Visual rating scales. Most patients developed mild RD, and no patient experienced edema or moist desquamation. When the CSSP was used, the majority of patients were scored as grade 5 (Table III). All patients were scored as grade 1 using the RTOG and CTCAE criteria (Table III). There were no between-group differences in the changes in clinician-assessed visual rating scales during the study period (Figure 2D-F).

Patient-reported symptoms. The progression of patient-reported symptoms evaluated using the 5-point Likert scale showed a similar trajectory (Figure 2G-J). These scores representing dryness, itchiness, burning sensation, and pain gradually increased during RT, reached a peak at the end of RT, and decreased thereafter. No statistically significant differences between the groups were observed in the patient-reported symptoms.

Correlation of physiological skin parameters with visual rating scales and patient-reported symptoms. When analysing the correlations among the three different physiological skin parameters, we found a strong correlation between EI and MI (Table V). TEWL showed no significant correlation with other physiological skin parameters.

Regarding the clinician-assessed visual rating scales, CSSP revealed strong correlations with EI and MI (Table V). The RTOG and CTCAE criteria correlated moderately with EI and MI. TEWL showed no significant correlation with visual rating scales. There were no strong correlations between physiological skin parameters and patient-reported symptoms.

Discussion

In the present study, we prospectively evaluated the clinical efficacy of a film-forming silicone gel on the prevention of RD in comparison with a moisturizing cream. Our results demonstrated significant decreases in EI and MI in the patients allocated to the StrataXRT group. To our knowledge, this is the first randomized trial demonstrating the superiority of a film-forming silicone gel in reducing

Table V. *Correlations among physiological skin parameters, clinician-assessed visual rating scales, and patient-reported symptoms.*

Parameter	EI	MI	TEWL
Physiological skin parameters			
EI[a]		0.63***	–0.14*
MI[a]	0.63***		–0.10
TEWL (g/h/m^2)	–0.14*	–0.10	
Visual Rating Scales			
CSSP	0.61***	0.56***	–0.20***
RTOG	0.56***	0.38***	–0.22***
CTCAE	0.56***	0.38***	–0.22***
Patient-reported symptoms			
Dryness	0.18**	0.07	0.05
Itching	0.45***	0.24***	–0.07
Burning sensation	0.32***	0.05	–0.04
Pain	0.38***	0.15*	0.05

EI: Erythema index; MI: melanin index; TEWL: trans-epidermal water loss; CSSP: the modified 10-point Catterall skin scoring profile; RTOG: the Radiation Therapy Oncology Group scale; CTCAE: the Common Terminology Criteria for Adverse Events scale. [a]Arbitrary Mexameter® units (on a scale from 0 to 999); *$p<0.05$, **$p<0.01$, ***$p<0.001$.

RD during breast RT based on objectively measured physiological skin parameters.

Despite decades of investigations, no clear evidence of the superiority of any single topical agent in the prevention of RD has emerged (10, 17-22, 24). Although steroids have been proven to be potent topical agents in reducing RD (31, 32), the use of steroids requires a doctor's prescription and is not free of criticism. Regardless of the type of topical agents, previous studies have evaluated the severity of RD using clinician-assessed scales or patient-reported symptom scores. Consistent with previous studies, our study also demonstrated that there were no differences between study groups in the severity of RD assessed by three visual rating scales and four patient-reported symptoms. These subjective scales have many drawbacks, which can compromise the accuracy and reliability of detecting radiation-induced skin changes. Many studies have pointed out such drawbacks, including inter- and intra-observer variations and the lack of objectivity (14, 33).

In this context, the need for more objective measurements of the severity of RD have emerged. Advances in technology have allowed many physiological skin parameters to be measured non-invasively (11-15). As an example, LDF has been proposed to assess RD by measuring cutaneous blood flow and has shown promising results in detecting radiation-induced changes even before the clinical manifestation of RD became evident, such as grade 0 dermatitis (15). In our study cohort, no patient experienced moist desquamation, and most patients developed CSSP grade 5 radiation dermatitis, which corresponds to grade 1 on the RTOG and CTCAE criteria (Table III). Similar to the results of the LDF measurement, we found that the quantitatively measured EI and MI can distinguish the difference in radiation-induced changes between study groups, even in patients experiencing very low-grade RD.

Previous studies have shown that impaired epidermal function induced by RT leads to an increase in TEWL (34). As shown in Figure 2C, TEWL values continued to decline throughout the study period. This was an unexpected finding and may be due to the fact that various topical agents can alter the results of TEWL measurement regardless of skin condition (35, 36). The continuous use of topical agents in accordance with study instructions may maintain a moist skin environment, leading to a decrease in TEWL.

Although numerous physiological skin parameters have been introduced to quantify radiation-induced skin changes, various subjective criteria such as clinician- and patient-assessed scales are widely used as the most common standard tools to evaluate the severity of RD. For this reason, there is a need to identify the concordance among these different parameters. Previously, various objective parameters including pigmentation, hydration, and pH of the skin, were tested in patients receiving breast RT, and only cutaneous blood flow measured by LDF has shown a strong correlation with the RTOG and CTCAE criteria (14, 15). Skin pigmentation have also been found to be moderately correlated with clinician-assessed scales. The results of the present study demonstrated that objectively measured EI and MI showed a moderate correlation with clinician-assessed visual rating scales, confirming previous results. On the other hand, we found that EI strongly correlated with the CSSP, which was considered a more sophisticated version with the 10-point grading scale.

RD is a series of processes that undergo development, deterioration, and recovery. To evaluate these processes, we should repeatedly measure the outcome variables associated with skin changes over time. Such data repeatedly measured from the same individuals are referred to as longitudinal data (37). Appropriate analysis of the longitudinal data requires specific statistical attention. Nevertheless, most studies have used the maximum peak scores or the number of patients experiencing severe RD as an endpoint of statistical analyses (10, 19, 22, 24). Survival analysis dealing with the time of diagnosis of a certain grade of skin toxicity have also been conducted (29). However, these summary statistic approaches, in which all individual measurements are condensed in a single parameter, can lose a substantial amount of information (38), such as changes in the recovery period. In the present study, repeatedly measured skin parameters were analysed by using two-way repeated measures ANOVA (37, 39). Using this technique, analysis of the interactions between time effects, group effects, and time and group factors enabled comprehensive interpretation of

longitudinal data, and finally, identification of differences between groups in reducing RD.

In our study design, the data measuring radiation-induced skin changes were collected at two-week intervals during RT. Post-RT assessments were also conducted every two weeks to account for our routine follow-up interval of four weeks. In general, the severity of RD reached its maximum value around 5–7 weeks from baseline. Previous studies have revealed that the severity of RD shows a peak one week after completion of RT (10). We have no data collected at that period, and the assessment schedule of the two-week interval may lead to a decrease in the maximum value of the parameters examined in this study.

The present study has limitations. First, this randomized controlled trial with small patient numbers was unblinded, and some bias cannot be excluded. However, physiological skin parameters and clinician-assessed symptoms were assessed independently by each researcher blinded to the results of other scoring systems. Participants also completed the questionnaire without any information about the assessment results. Thus, this limitation would have minimal impact on the outcome measurements of this trial. Second, physiological skin parameters were measured only using the EI, MI and TEWL. Although numerous techniques have been used for the objective measurement of quantitative skin parameters, there is no gold standard for diagnosing and grading the severity of RD. Therefore, various skin parameters should be evaluated in terms of clinical correlation and concordance between the techniques. Finally, no patients experienced moist desquamation, unlike the incidences in previously published reports. This study should be reproduced to confirm the efficacy of StrataXRT in more severe cases of RD.

Conclusion

This pilot study showed that topical use of a film-forming silicone gel (StrataXRT) can reduce RD with respect to objectively measured physiological skin parameters. The outcomes of this trial support the feasibility of conducting a larger randomized controlled trial.

Conflicts of Interest

The Authors declare that they have no competing interests regarding this study.

Authors' Contributions

SA provided ideas. SA and KS drafted the manuscript. SA, KS, JSK, and SKL conducted patient examinations and participated in data collection. SA, KS, and YEC collected patient data and performed the statistical analysis. KS, HJK, YEC, and YKL were responsible for patient treatment and radiation therapy planning. JYR, HJK, and YEC supervised the analysis and interpretation of the data and reviewed the manuscript. All Authors read and approved the final manuscript.

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