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Total Skin Electron Therapy for Cutaneous T-Cell Lymphoma Using a Modern Dual-Field Rotational Technique

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Abstract

Purpose—To report our experience with rotational total skin electron irradiation (RTSEI) in cutaneous T-cell lymphoma (CTCL), and to examine response by disease stage and race.

Methods and Materials—We reviewed our outcomes for 68 CTCL patients who received RTSEI (30 Gy) from 2000 to 2013. Primary outcomes were complete clinical response (CCR), recurrence-free survival (RFS), and overall survival (OS). Using log-rank tests and Cox proportional hazards, OS and RFS were compared across tumor stages at time of RTSEI with further racial subgroup analysis.

Results—Median age at diagnosis and at time of radiation was 52 and 56 years, respectively. Median follow-up was 5.1 years, 49% were African American, and 49% were female. At time of treatment, 18, 37, and 13 patients were T stage 2, 3, and 4, respectively. At 6 weeks after RTSEI, overall CCR was 82% (88%, 83%, and 69% for T2, T3, and T4, respectively). Median RFS was 11 months for all patients and 14, 10, and 12 months for stage T2, T3, and T4, respectively. Tumor stage was not associated with RFS or CCR. Maintenance therapy after RTSEI was associated with improved RFS in both crude and multivariable analysis, controlling for T stage. Median OS was 76 months (91 and 59 months for T3 and T4, respectively). With the exception of improved OS in African Americans compared with whites at stage T2, race was not associated with CCR, RFS, or OS.

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Conclusions—These results represent the largest RTSEI clinical outcomes study in the modern era using a dual-field rotational technique. Our observed response rates match or improve upon the standard set by previous outcome studies using conventional TSEI techniques, despite a large percentage of advanced CTCL lesions in our cohort. We found that clinical response after RTSEI did not seem to be affected by T stage or race.

Introduction

Cutaneous T-cell lymphoma (CTCL) is characterized by localization of T lymphocytes to the skin. The most common subtype is mycosis fungoides (MF), with an overall incidence of 0.55 per 100,000 person-years in the United States and median age of 58 years at diagnosis (1-3). Although other types of CTCL have variable manifestations, MF typically presents with pruritic patches and plaques and may evolve to cutaneous tumors or erythroderma. The extent and nature of skin involvement (T stage), overall disease stage, and patient age are potential prognostic factors (4). African American (AA) race has been associated with worse survival, after adjusting for other demographic factors and tumor stage (3, 5). The reason for this disparity remains poorly understood (6).

Total skin electron irradiation (TSEI) is effective for T2 (ie, generalized patch or plaque) and T3 (tumor) disease (1-3). Retrospective reviews (n = 41-180) from recent decades have demonstrated the efficacy of high-dose (30 Gy) TSEI in achieving high clinical response rates (1, 4-9). The vast majority of these studies used the large-field/modified Stanford technique, in which the skin surface is irradiated in a discontinuous manner, with the patient changing position six times by 60° during one treatment fraction (10). In contrast, a rotational TSEI technique (RTSEI), in which a patient is automatically rotated at a constant speed about the vertical axis while being irradiated with single or dual fields, allowing for continuous treatment delivery, has been previously described (11). Despite its theoretical advantage in dose homogeneity compared with its large-field/modified Stanford counterpart, the RTSEI technique is less widely available, and its clinical outcomes are largely unknown. As one of the largest academic referral centers in the southeastern United States for RTSEI, we were able to conduct an RTSEI clinical outcomes study to address this gap in clinical knowledge, as well as examine the role of race in achieving clinical response after RTSEI.

Methods and Materials

Patient population

Using an institutional review board–approved protocol, 110 patients treated with RTSEI were identified from billing records from 2000 to 2013 at Emory Healthcare (Atlanta, GA). Patient electronic medical charts and an institutional review board–approved dermatology database were used to ascertain information regarding demographics, diagnosis, histology, staging, treatment regimens, RTSEI treatment specifics, clinical response, recurrence, and overall survival. Eligibility criteria for the study included histologically confirmed CTCL and a completed first course of conventional-dose (30 Gy) RTSEI. Of the original 110 patients, 35 were excluded because of a primary diagnosis of leukemia cutis or not undergoing RTSEI. An additional 7 were excluded because of RTSEI dose <30 Gy, leaving 68 eligible patients.

Treatment technique

Rotational TSEI was administered using a 21EX Varian linear accelerator (Varian Medical Systems, Palo Alto, CA) equipped with a 6-MeV high-dose total skin electron (HDTSe) mode at a dose rate of 888 monitor units (MU) per minute. Rotational TSEI used dual-angle fields at gantry angles of 241° and 299° to cover the upper and the lower halves of the patient body. In the 6-MeV HDTSe mode, our linear accelerator calibration was 2.99 cGy per MU at a maximum source to skin distance (SSD) of 100 cm.

All patients were treated using a standard method: 36 Gy delivered at 1.5 Gy per fraction, administered three times weekly, typically on a Monday-Wednesday-Friday schedule (4.5 Gy/week). Eye shields were used upon treatment initiation; fingernail/toenail shields were added after 12 Gy. A 1-week mid-treatment break was allowed after delivery of 18 Gy. Optically stimulated luminescence dose measurements at underdosed areas were taken before the mid-treatment break. For 84% of patients, these areas received additional boost dosing according to physician preference and clinical assessment of disease response at the end of RTSEI. Thus, the total RTSEI regimen required 9 weeks, followed by a 2- to 3-week boost portion. For RTSEI, the patient (Appendices E1 and E2, available online at www.redjournal.com) is placed on a rotating platform at an extended SSD (315 cm) from the gantry. Both arms are raised overhead and are positioned on the rotator vertical bars. The platform rotates at a constant speed of 4 revolutions per minute to ensure adequate surface dose build-up.

Covariates

The overall study cohort and racial subcohorts were compared across the following covariates: sex, age at diagnosis, age at RTSEI, histology, T stage at start of RTSEI, pre-RTSEI CTCL treatments (therapies received before primary RTSEI course [see Table 1 for specific agents]), maintenance therapy (systemic therapy or topical therapy started within 3-6 months after RTSEI), time from diagnosis to RTSEI, and recurrence.

Outcome measures

Key outcome measures were complete clinical response (CCR) rate, recurrence-free survival (RFS), and overall survival (OS). The CCR rate was defined as the proportion of follow-up patients with at least 90% reduction in cutaneous tumor burden. Patients considered non-complete responders included those with partial response (>50% reduction but <90%), stable disease, recurrence, progression, or death at each of 3 time points: (1) end of RTSEI treatment; (2) 6 weeks after RTSEI; and (3) 6 months after RTSEI. Patients with no previous record of recurrence, those who did not follow up, or who had no recorded clinical response at one of the time points were not included in the CCR proportion. Response rates were compared across racial categories and by T stage using χ^2 or Fisher exact tests, as appropriate.

For RFS, time to event was calculated as the number of days between start of RTSEI and the date of recurrence. For patients whose cancers did not recur, survival time was censored at the date of last follow-up or date of death. For OS, time to event was calculated as the number of days between start of RTSEI and the date of death or last known follow-up. The

RFS and OS distributions were estimated using the Kaplan-Meier method. Both RFS and OS were compared across race, T stage, and previously mentioned covariates, using log-rank tests and Cox proportional hazards models. Multivariate Cox models were fit, adjusting for T stage before RTSEI and the proportional hazards assumption was checked for all models. A Cox proportional hazards model was not presented in the OS evaluation because we chose to focus on the primary outcome of recurrence rather than OS. This decision was made to best reflect the clinical application of TSEI, which, though effective, is generally not viewed as a curative treatment for CTCL. The cutoff for statistical significance for all analyses was set at the 2-sided α error of .05.

Results

Patient characteristics

Characteristics of the patient cohort, overall and by race, are summarized in Table 1. Sixty-eight patients ($n=18$ [T2], $n=37$ [T3], $n=13$ [T4], all T stages before RTSEI) were treated with high-dose RTSEI (range, 30-36 Gy [T2, 30-36 Gy; T3, 31.5-36 Gy; T4, 30-36 Gy]) and were included in the analysis. Thirty-three patients (49%) were female, 35 were male (51%), 33 patients were AA (48.5%), 33 were white (48.5%), and 2 were unknown (3%). Median age at time of diagnosis was 52 years (range, 18-89 years). Median follow-up time was 61.4 months (overall cohort). Median time from diagnosis until RTSEI was 20 months (range, 0.2-118 months). Twenty-six patients (38%) received maintenance therapy after RTSEI. Forty-four patients (65%) recurred after RTSEI.

African American patients were significantly younger at diagnosis (mean 48.1 years, $P=.01$) and at time of RTSEI (mean 52.4 years, $P=.02$) compared with white patients (mean age at diagnosis 60.5 years; mean age at RTSEI 59.6 years). African American patients also had a significantly ($P=.01$) longer time to RTSEI (median 28.4 months) compared with their white counterparts (median 16.6 months). Whites also had a significantly ($P<.001$) higher number of non-MF CTCL subtypes. The distributions of T stage before RTSEI differed significantly between the 2 racial groups. There were no significant differences between AA and white subcohorts in regard to sex, treatment before RTSEI (topical, systemic antineoplastic, systemic dermatologic, and phototherapies), maintenance therapy, follow-up time, or proportion that recurred after RTSEI.

Clinical response rates

Table 2 summarizes CCR rates for the entire cohort and by race. Overall, 93% had a CCR (100%, 92%, and 85% for stages T2, T3, and T4, respectively) immediately after RTSEI. At 6-week follow-up the overall CCR rate was 82% (88%, 83%, and 69% for T2, T3, and T4, respectively), and at 6 months it was 44% (42%, 47%, and 38% for T2, T3, and T4, respectively). Caucasians had a CCR of 97%, 81%, and 41% at the end of RTSEI, 6-week follow-up, and 6-month follow-up, respectively. African Americans had a CCR rate of 88%, 81%, and 43% at the end of RTSEI, 6-week follow-up, and 6-month follow-up, respectively. Table 2 presents CCR rates broken down by stage within each racial subgroup. Chi-square and Fisher exact tests revealed no significant differences in CCR rate between races after end of RTSEI ($P=.355$), at 6 weeks after RTSEI ($P=.951$), and at 6 months after RTSEI ($P=$

879). Further comparisons between racial groups across respective T stages also showed no significance difference in CCR. Complete clinical response at end of RTSEI was not associated with T stage at time of RTSEI ($P=.298$). Although there seems to be a qualitative dose–response relationship by T stage for CCR at end of RTSEI, the result of a Cochrane–Armitage exact test examining this trend was not significant ($P=.166$). The corresponding P value at 6 weeks of follow-up was $P=.47$ for T stage at time of RTSEI, and at 6 months of follow-up was $P=.85$.

Recurrence-free survival

As seen in Table 3, the overall cohort had a median RFS of 11.3 months (14.3, 9.9, and 12.1 months for T2, T3, and T4, respectively, with no difference across stages, $P=.86$). Kaplan–Meier RFS curves stratified by race and by T stage are shown in Figure 1.

As shown in Table 4, longer RFS was associated with maintenance therapy after RTSEI in crude (hazard ratio 2.17, 95% confidence interval 1.14–4.14, $P=.016$) and multivariate (hazard ratio 2.56, 95% confidence interval 1.22–5.37, $P=.013$) analyses when controlling for T stage. Race ($P=.274$), sex ($P=.891$), T stage ($P=.857$), histology (MF vs non-MF, $P=.42$), age at diagnosis ($P=.598$), and time from diagnosis to start of RTSEI ($P=.202$) were not significantly associated with RFS in crude or multivariate analyses.

Overall survival

As shown in Table 3, median OS estimates were 75.8 months for the overall cohort, 90.7 months for T3 stage, and 59.3 months for T4 stage. Median OS could not be calculated for T2 stage because more than 50% of patients with this stage survived to the end of follow-up. When comparing racial groups, median OS was 74.5 months for whites and 127.5 months for AA patients ($P=.04$). When stratified by T stage, AAs had significantly higher OS than whites at T2 stage ($P=.03$).

Other treatment outcomes

After RTSEI, 79% of patients reported complete symptom relief (ie, burning, pain, pruritus). Common acute adverse reactions to treatment were transient edema (32%), pain (28%), and fatigue (27%); all were grade 1. Six patients (8.8%) developed secondary cancers: 4 (5.9%) were diagnosed with nonmelanoma skin cancer, 1 (1.5%) with melanoma, and 1 (1.5%) with lymphoma.

Discussion

We examined the clinical response of CTCL patients treated to a conventional (>30 Gy) dose using a dual-beam RTSEI technique at our institution. In theory, RTSEI provides greater dose homogeneity compared with other stationary or dynamic TSEI techniques. Our data show that conventional-dose, dual-field RTSEI is an effective, well-tolerated modality, regardless of disease stage and race. These results represent the largest RTSEI clinical outcomes study in the modern era using a dual-field rotational technique.

Clinical response performance

A summary of previous TSEI clinical outcome studies (Table 5) shows that our observed CCR rates match or improve upon those achieved elsewhere. Our overall CCR rate at 6 weeks after RTSEI of 83% surpasses the 63% reported in the largest TSEI study (n=180), conducted by Navi et al using the Stanford technique (1). After a 4- to 6-week follow-up, the Stanford study reported CCR estimates of 75% for T2 and 47% for T3 cutaneous disease; lower than the corresponding stage-specific CCR rates of 88% and 83% at 6 weeks of follow-up in our study (1). In contrast to the Navi study, we also analyzed the data for T4 disease and observed a CCR rate of 69% at 6 weeks after TSEI. As shown in Table 5, this surpasses other published studies reporting CCR at similar follow-up for T4 lesions (4, 9, 12). Our results are also more favorable than those reported by Freedman et al (9) in the only other RTSEI (single beam) outcome study (n=44), which had an overall CCR rate of 73% (91% [T2], 71% [T3], 58% [T4]) at an unknown follow-up time. In addition to showing strong CCR rates overall, the present study indicates that effectiveness of conventional-dose RTSEI is similar across all presenting T stages, regardless of follow-up duration. Other studies have reported a loss of efficacy with TSEI treatment with higher T stages and have questioned the efficacy for TSEI in treating T4 disease (1, 8, 9). The more favorable T3 and T4 clinical response in our study may be due to increased depth of penetration and greater uniformity of the dose distribution with RTSEI.

Recurrence-free survival performance

Although our median RFS values were comparable to those in previous TSEI cohorts (1, 4, 9), Figure 1 shows that a large proportion of patients with CTCL still recurred within a year. Similar to CCR rates, RFS in our study did not differ across T stages. This seems to be in disagreement with findings in previous studies. In the Navi et al study (1), T2 patients had fewer and more delayed recurrences than those with T3 disease. Part of the difference, or lack thereof in RFS, is likely due to small numbers. Though not significant, on simple observation, T4s seemed to have better RFS than T3s (12.1 vs 9.9 months), suggesting that it may be difficult to distinguish an advanced/heavily pretreated T3 from a T4, in some cases. Additionally, T4s may have been more aggressively managed compared with T3s. Future studies with larger numbers could test this hypothesis.

Another important finding of our study is the clear benefit of maintenance therapy. This observation is in accordance with some (13, 14) but not all (1, 15, 16) previous reports. In a previous study, the lack of improvement due to maintenance therapy was attributed to the relatively small number of pretreatments and short duration of adjuvant nitrogen mustard (1). Although we did not record the total number of different treatments before the first course of RTSEI, no particular class of pretreatment (dermatologic, antineoplastic, phototherapy, or topical agents) in our study was associated with RFS.

Overall survival performance

In total, our cohort had a 5-year OS of 61.2%, comparable to previous studies by Navi (5-year OS 63%) and Wagner (5-year OS 58%) (1, 7). Our study included a higher number of T4 stage patients (n=13). Yseabert et al (8) reported 5-year OS of 90%; however, in this study, OS was calculated from time of diagnosis rather than time of TSEI, and this study

included only patients with T1-2 stage disease. When stratified by T stage, T3 had a median OS of 7.6 years, and T4 had a median OS of 4.9 years. These values far exceed previous OS median values for T3 disease (4.9 years [1], 1.3 years [9], 2.1 years [4]) and T4 disease (1.9 years [9], 3.8 years [4]). In our study, we also found no significant difference in OS between T stages, which differs from previous studies that found a significant decrease in OS between T stages (1, 4, 8, 9).

RTSEI outcomes by race

Consistent with epidemiologic data (17), the AA CTCL patients in our study were significantly younger than their white counterparts. Notably, nearly one-third (30%) of the AA patients had T4 disease at the time of RTSEI, compared with only 9% among whites. This difference may be explained by racial disparities in disease aggressiveness (18), inequalities in access to care (treatment delay), or both.

We found no racial differences in RFS within each T-stage category. The 6-week CCR rates in both white (80.7%) and AA (81.3%) patients were higher than the rates reported in the only other TSEI study that looked at response and relapse by race with similar follow-up (12). The CCR estimates after a standard Stanford TSEI technique in that study were 38% for whites and 59% for AA patients, but the racial difference was not significant (12). Hinds et al (12) suggested a possible interaction between gender and race for outcomes, but we found no significant interaction between race and sex on multivariate analysis, controlling for T stage, for RFS ($P=.428$) and OS ($P=.658$).

Although multiple Surveillance, Epidemiology, and End Results database studies have showed poor overall survival of AA (19, 20) patients even when controlling for demographic factors and tumor stage (18), there was no significant difference between white and AA patients in our study. In fact, when stratified by T stage before RTSEI, AAs had significantly improved OS compared with whites at stage T2 ($P=.03$), suggesting that earlier use of RTSEI may actually be more effective in AAs than in their non-AA counterparts. However, a firm conclusion should be approached cautiously given the small sample size when stratified by stage. Larger studies are needed to confirm this effect.

Limitations

This retrospective cohort, though one of the largest among TSEI clinical experiences (and the largest using the rotational method), is still limited by the small sample size. For this reason, a more definitive interpretation of some of the analyses (particularly those that used stratification) is difficult owing to unstable and imprecise estimates. It is important to note that our RFS model was thought to be stable because it included 44 events for 2 independent predictors (ie, maintenance therapy and T stage), which exceeds the general rule of having at least 10 outcome events per independent predictor for a Cox model (21). Although we found a significant positive effect of maintenance therapy on RFS, the analyses included all treatment modalities. The limited sample size precluded a more detailed examination of the data by specific type of maintenance therapy. Because biopsies were rarely performed on the suspected areas of recurrence, we sometimes relied on the clinical judgment of a radiation oncologist or dermatologist to ascertain RFS. Censoring in CCR ratios was also a potentially

limiting factor. When a patient did not follow up or did not have a recorded clinical response at one of the time points with no previous record of recurrence, they were not included in the CCR calculations. Without complete follow-up, the direction of bias, if any, remains unclear. Finally, given the chance for changes in technology and management of CTCL over time, we confirmed that there were no changes in technique of RTSEI during our study period. Additionally, dichotomizing the cohort by year of RTSEI (“2000-2006” and “2007-2013”) had no significant impact on RFS or OS on crude and multivariate analyses.

Strengths and conclusions

Overall, our clinical outcomes for CCR, RFS, and OS compare favorably to past conventional-dose TSEI clinical experience studies, even when accounting for the relatively large percentage of advanced-stage patients in our cohort. Not only was this the first modern outcomes study examining dual-field RTSEI technique, our study includes a relatively large number of CTCL patients, a relatively large percentage of AA patients, and more advanced-stage patients than included in several prior reports. This study was also unique in terms of documenting clinical response across multiple time points. Because this was a single-institution experience, every patient underwent radiation treatment using the same technique, with minimal variability in regimens and dosage schedules. This uniformity proved valuable for comparisons made between racial groups and different disease stages. Finally, no serious acute side effects from treatment were observed. Long-term secondary cancer development was also small (n=6 [8.8%]), with nonmelanoma skin cancer constituting two-thirds of these cases. This may or may not have been attributed to the radiation: baseline age risk and other therapies (ie ultraviolet therapy) also predispose these patients to the development of skin cancers.

Even with our encouraging results, recurrence after RTSEI remains frequent, and maintenance therapy and/or better consolidation therapy should be considered. Future studies should focus on the benefit of these specific therapies while also evaluating patterns of recurrence, quality of life, toxicity metrics, and the role of a second course of RTSEI in the maintenance setting or in the retreatment setting.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Summary

This study reports the first single-institutional outcomes after conventional-dose, dual-beam rotational total skin electron irradiation (RTSEI). Complete clinical response rates and recurrence-free and overall survival outcomes were compared across pretreatment tumor stage categories and by race. This study represents one of the largest, most diverse RTSEI cohorts in terms of overall number of patients and proportion of African Americans.

Fig. 1. Recurrence-free and overall survival curves by T stage and race

Table 1
Characteristics and descriptive statistics for RTSEI study cohort and by race

Covariate	Entire cohort (n=68)	White (n=33)	AA (n=33)	P
Race				
White	33 (48.5)	33 (100)	0	-
AA	33 (48.5)	0	33 (100)	
Other	2 (3)	0	0	
Sex				
Female	33 (48.5)	14 (42.4)	18 (54.6)	.325
Male	35 (51.5)	19 (57.6)	15 (45.4)	
Age at diagnosis (y)				
Median	51.7	60.5	44.8	.008 *
Mean	53.1	57.8	48.1	
Age at start of RTSEI (y)				
Median	55.5	62.3	50	.02 *
Mean	55.5	59.6	52.37	
Time from diagnosis to RTSEI (mo)				
Median	20.2	16.6	28.4	.01 *
Mean	28.9	21.2	37.9	
Pre-RTSEI tumor (T) stage				
T2 (patches/plaques >10% body surface)	18 (26.5)	7 (21.2)	11 (33.3)	.017 *
T3 (1+ tumor >1 cm in diameter)	37 (54.4)	23 (69.7)	12 (36.4)	
T4 (erythema >80% of body surface)	13 (19.1)	3 (9.1)	10 (30.3)	
Histology				
MF	53 (77.9)	20 (60.6)	32 (97)	<.001 *
Non-MF subtype	15 (22.1)	13 (39.4)	1 (3)	
Pre-RTSEI CTCL treatment				
Topical agents (nitrogen mustard, steroids)				
No	30 (44.1)	16 (48.5)	14 (42.4)	.621
Yes	38 (55.9)	17 (51.5)	19 (57.6)	
Systemic antineoplastic agents (bexarotene, interferon, vorinostat, denileukin diftitox, chemotherapy, etc)				
No	33 (48.5)	14 (42.4)	17 (51.5)	.495
Yes	35 (51.5)	19 (57.6)	16 (48.5)	
Systemic dermatologic agents (soriatane, steroids, etc)				
No	55 (80.9)	28 (84.9)	25 (75.8)	.353
Yes	13 (19.1)	5 (15.1)	8 (24.2)	
Phototherapy ([P]UVA, UVB, photopheresis)				
No	35 (51.5)	20 (60.6)	14 (42.4)	.139
Yes	33 (48.5)	13 (39.4)	19 (57.6)	
Maintenance therapy after RTSEI				
No	42 (61.8)	21 (63.6)	20 (60.6)	.8

Covariate	Entire cohort (n=68)	White (n=33)	AA (n=33)	P
Yes	26 (38.2)	12 (36.4)	13 (39.4)	
Recurrence after RTSEI				
No/unknown	24 (35.3)	12 (36.4)	11 (33.3)	.796
Yes	44 (64.7)	21 (63.6)	22 (66.7)	

Abbreviations: AA = African American; CTCL = cutaneous T-cell lymphoma; MF = mycosis fungoides; RTSEI = rotational total skin electron irradiation; [P]UVA = Psoralen plus Ultraviolet A Light Therapy; UVB = Ultraviolet B Light Therapy.
Values are number (percentage) unless otherwise noted.

*
 $P < .05$.

Table 2

Complete clinical response rates by T stage and stratified by race

T stage before RTSEI	Follow-up period														
	End of RTSEI					6 wk after RTSEI					6 mo after RTSEI				
	Entire cohort		By race			Entire cohort		By race			Entire cohort		By race		
	n (%)	P	White, n (%)	AA, n (%)	P	n (%)	P	White, n (%)	AA, n (%)	P	n (%)	P	White, n (%)	AA, n (%)	P
All	63 (93)	-	32 (97)	29 (88)	.36	53 (82)	-	25 (81)	26 (81)	.95	27 (44)	-	12 (41)	13 (43)	.88
T2	18 (100)	.298	7 (100)	11 (100)	1	15 (88)	.473	5 (83)	10 (90)	1	5 (42)	.845	1 (33)	4 (44)	1
T3	34 (92)		22 (96)	10 (83)	.27	29 (83)		18 (82)	9 (82)	1	17 (47)		10 (43)	5 (45)	1
T4	11 (85)		3 (100)	8 (80)	1	9 (69)		2 (67)	7 (70)	1	5 (38)		1 (33)	4 (40)	1

Abbreviations as in Table 1.

If patient did not follow up/did not have a recorded clinical response at time point (with no previous record of recurrence), they were not included in the portion. *P* values calculated using Fisher exact tests. Significance was assessed at the .05 level.

Table 3
Summary recurrence-free survival (RFS) and overall survival (OS), by T stage before RTSEI and stratified by race

T stage before RTSEI	Median RFS (mo)				Median OS (mo)			
	Entire cohort		By race		Entire cohort		By race	
	Months	P	White	AA	Months	P	White	AA
All	11.3	-	11.4	11.0	75.8	-	74.5	127.5
T2	14.3	.86	19.1	6.0	55.1 [*]	.39	57.8	63.8 [*]
T3	9.9		9.2	9.7	90.7		103.3	75.8
T4	12.1		4.8	13.2	59.3		56.8	59.3

Abbreviations as in Table 1.

RFS: Time to event = no. of days between start of RTSEI and documented recurrence. For patients whose cancers did not recur, survival time was censored at the date of last follow-up or date of death. OS: Time to event = no. of days between start of RTSEI and the date of death or last known follow up. *P* values calculated using log-rank tests. Significance assessed at .05.

^{*} Kaplan-Meier OS median value not reached for entire cohort or AA at T2 stage. Median value recorded is median of survival times for events only.

[†] *P* < .05.

Table 4
Recurrence-free survival, univariate and multivariate analyses

Covariate	Hazard ratio	95% Confidence interval	P
Univariate analysis			
Race			
White	0.71	0.38-1.32	.27
AA	-		
Sex			
Female	1.04	0.57-1.90	.89
Male	-		
Pre-RTSEI T stage			
T2	1.05	0.43-2.54	.86
T3	0.87	0.40-1.88	
T4	-		
Histology			
Non-MF subtype	0.73	0.34-1.58	.42
MF	-		
Diagnosis to RTSEI time (mo)	1.01	1.00-1.02	.2
Age at diagnosis (y)	1.00	0.98-1.01	.6
Pre-RTSEI CTCL therapies			
Topical agents			
No treatment	1.34	0.74-2.45	.34
Treatment	-		
Systemic antineoplastic agents			
No treatment	0.94	0.52-1.70	.84
Treatment	-		
Systemic dermatologic agents			
No treatment	0.8	0.39-1.63	.54
Treatment	-		
Phototherapy			
Photopheresis	0.92	0.27-3.20	.89
(P)UVA/UVB	-		
Maintenance therapy after RTSEI			
No treatment	2.17	1.14-4.14	.02 [*]
Treatment	-		
Multivariate analysis			
Maintenance therapy after RTSEI			
No treatment	2.56	1.22-5.37	.01 ^{*,†}
Treatment	-		

Abbreviations as in Table 1.

Significance assessed at the .05 level.

^{*} $P < .05$.

[†]Controlling for Pre-RTSEI T stage.

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Table 5
Mycosis fungoides/CTCL TSEI comparative outcomes of institutional clinical experiences

Author	Year	Institution	N	Technique	Follow-up	Complete clinical response rates (%)				Pre-TSEI tumor (T) stage				Median OS (mo)			
						All				All				All			
						T2	T3	T4	T4	T2	T3	T4	T4	T2	T3	T4	T4
Heumann	2014	Emory, GA	68	Dual-beam rotational	6 wk	82	88	83	69	11.3	14.3	9.9	12.1	75.8	55.1*	90.7	59.3
Morris	2013	St. John, UK	41	Modified Stanford	1-3 mo	51	59	47	33	12	18	9	9	35	56	25	46
Hinds	2013	Johns Hopkins, MD	77	Modified Stanford	4-6 wk	43	45	42	12	-	-	-	-	-	-	-	-
Wagner	2013	Utah, UT	41	Modified Stanford	1 mo	56	-	-	-	-	-	-	-	-	-	-	-
Navi	2011	Stanford, CA	180	Modified Stanford	4-6 wk	63	75	47	-	-	29	9	-	-	130.8	56.4	-
Parida	2009	New Delhi, India	4	Modified Stanford	-	-	-	-	-	-	-	-	-	-	-	-	-
Funk	2008	Heidelberg, Germany	18	Modified Stanford	-	50	-	-	-	-	-	-	-	12	-	-	-
Parida	2005	New Delhi, India	7	Modified Stanford	6 wk	86	-	-	-	-	-	-	-	-	-	-	-
Ysebaert	2004	Dijon, France	57	Mobile couch	3 mo	86	85	-	-	12	-	-	-	-	-	-	-
Freeman	1992	McGill, Canada	44	Single-beam rotational	-	73	91	71	68	5	19	4	-	43	63	16	23

Abbreviations as in Tables 1 and 3.

All = total cohort (all T stages together).

* Kaplan-Meier OS median value not reached for entire cohort at T2 stage. Median value recorded is median of survival times for events only.