JAMA Dermatology | Original Investigation

Prognostic Factors, Treatment, and Survival in Dermatofibrosarcoma Protuberans

Maressa C. Criscito, BS; Kathryn J. Martires, MD; Jennifer A. Stein, MD, PhD

IMPORTANCE There is limited information regarding the influence of patient demographics, tumor characteristics, and treatment type on the survival of patients with dermatofibrosarcoma protuberans (DFSP).

OBJECTIVE To assess prognostic factors and to evaluate the influence of treatment modality on overall survival of patients with DFSP.

DESIGN, SETTING, AND PARTICIPANTS We examined DFSP using data for 3686 patients with histologically confirmed cases of DFSP diagnosed between 1972 and 2012 from the 18 US regional registries of the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) Program, with linkage to demographic data from the US Census Bureau for median household income (MHI). The analysis was performed in February 2016.

MAIN OUTCOMES AND MEASURES The primary outcome measures were tumor characteristics, prognostic factors, and overall survival in months.

RESULTS There were 3686 cases of DFSP examined. Older age (hazard ratio [HR], 1.08; 95% CI, 1.06-1.10; $P < .001$), male sex (HR, 1.97; 95% CI, 1.09-3.55; $P = .03$), and tumor size (HR, 1.09; 95% CI, 1.01-1.18; $P = .04$) were significantly associated with poorer overall survival in a controlled analysis. Older age (odds ratio [OR], 1.01; 95% CI, 1.00-1.02; $P = .01$), male sex (OR, 1.95; 95% CI, 1.57-2.42; $P < .001$), and black race (OR, 1.78; 95% CI, 1.37-2.32; $P < .001$) were associated with larger (≥3.0 cm) tumors at presentation. Treatment modality did not influence overall survival; however, differences in patient characteristics affected the treatment received. Older age at presentation (OR, 1.02; 95% CI, 1.01-1.03; $P = .01$), black race (OR, 1.82; 95% CI, 1.13-2.92; $P = .01$), large tumor size (OR, 1.15; 95% CI, 1.09-1.21; $P < .001$), and head or neck location (OR, 4.63; 95% CI, 2.66-8.07; $P < .001$) increased the likelihood of a patient receiving surgery and radiation over surgery alone. In addition, white patients (OR, 0.51; 95% CI, 0.30-0.87; $P = .01$), women (OR, 0.53; 95% CI, 0.36-0.78; $P < .001$), and patients with a higher MHI (OR, 1.27; 95% CI, 1.11-1.46; $P < .001$) were more likely to receive Mohs micrographic surgery (MMS) over excision.

CONCLUSIONS AND RELEVANCE Age at diagnosis, male sex, and DFSP tumor size appear to be important prognostic factors. Treatment modality did not significantly influence survival; however, patient and tumor characteristics influence treatment modality.

JAMA Dermatol. 2016;152(12):1365-1371. doi:10.1001/jamadermatol.2016.1886
Published online June 4, 2016.

Supplemental content

Author Affiliations: The Ronald O. Perelman Department of Dermatology, New York University School of Medicine, New York.

Corresponding Author: Jennifer A. Stein, MD, PhD, The Ronald O. Perelman Department of Dermatology, New York University School of Medicine, 240 E 38th St, 11th Floor, New York, NY 10016 (jennifer.stein@nyumc.org).

Dermatofibrosarcoma protuberans (DFSP) is a rare, locally aggressive cutaneous soft-tissue sarcoma that carries a 2% to 5% risk of distant metastasis.[1,2] Negative surgical margins are considered the most significant prognostic factor because inadequate initial resection may result in uncontrolled local growth or metastases.[2,3] Prior studies have suggested that head or neck location, high mitotic index, increased cellularity, and fibrosarcomatous change may also worsen survival.[2,4,5] The prognostic significance of tumor size has been controversial, with most studies indicating that tumor size does not significantly influence recurrence or survival.[2-4] Studies examining this, however, have been limited by sample size.[4,6,7]

Limited information exists regarding the prognostic significance of patient demographics and clinical features. A recent study[7] revealed that increased age, black race, and male sex were associated with worse overall survival in the DFSP population; however, the analysis did not control for potential confounding factors such as tumor size and socioeconomic status (SES). Socioeconomic status portends a significant impact on health and shares a complex relationship with race.

Prior studies have explored the effectiveness of surgical modalities on local recurrence, specifically comparing Mohs micrographic surgery (MMS) to wide local excision (WLE).[8-12] Few prior studies, however, have examined the influence of these treatments on survival for patients with DFSP. As such, we sought to characterize the factors influencing treatment modality as well as evaluate the impact of treatment type on overall survival.

Key Points

Question What is the prognostic significance of patient demographics, tumor characteristics, and/or treatment modalities for patients with dermatofibrosarcoma protuberans (DFSP)?

Findings In this population-based cohort study of 3686 DFSP cases, older age, male sex, and tumor size were significantly associated with worse overall survival in a controlled analysis. Treatment modality did not influence overall survival; however, differences in patient characteristics affected the treatment received.

Meaning Age at diagnosis, male sex, and DFSP tumor size seem to be important prognostic factors.

Methods

Study Population

New York University School of Medicine waived institutional review board approval for this study. We used the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) Registry from 1973 through 2012, including data from the 18 regions (Alaska; Atlanta, Georgia; California, excluding San Francisco/San Jose-Monterey/Los Angeles; Connecticut; Detroit, Michigan; Greater Georgia; Hawaii; Iowa; Kentucky; Los Angeles, California; Louisiana; New Jersey; New Mexico; rural Georgia; San Francisco-Oakland, San Jose-Monterey, California; Seattle, Washington; Utah).[13] The cancer incidence and survival data published by SEER-18 accounts for 27.8% of the total US population.[14]

Cases of DFSP were identified by *International Classification of Diseases for Oncology, Third Edition* (*ICD-O-3*: codes 8832/8833). Patients with histologically confirmed DFSP of the skin were included. Cases diagnosed at autopsy or via death certificate were excluded. Patients with unknown or missing information regarding race, anatomic site, and/or treatment modality were excluded.

Primary Outcome Measures

Tumor Characteristics

Anatomic site was grouped as head or neck, extremities, and trunk. Tumor size in millimeters was available as a site-specific factor for cases diagnosed after 2004. Tumor size was analyzed continuously and dichotomized as smaller than 3 cm or larger than the median tumor size of all present values (3 cm).

Treatment

Treatments included surgical excision, MMS, and radiation therapy. Types of excision included tumor excision, excisional biopsy, gross excision, wide excision, major amputation, and surgery, not otherwise specified. We combined cases of MMS and excision to comprise the "surgery" group. We compared patients receiving surgery alone with patients receiving surgery and radiation. We conducted a subgroup analysis of patients receiving surgery, comparing patients receiving MMS to those receiving excision.

Survival

We assessed overall survival in months. Patients were followed from DFSP diagnosis until study termination in 2012.

Covariates

Demographics

Age (in years) was analyzed as a continuous variable. In our regression analyses, sex was analyzed with "female" as the reference group. Race was categorized as white, black, and other. The "other" group included persons of Asian/Pacific Islander and American Indian/Alaskan native background. Race was analyzed with "white" as the reference group. This simplification was used because of the low incidence of DFSP among nonwhite and nonblack groups.

Socioeconomic Status

Socioeconomic status was defined by median household income (MHI) collected at the census tract level, a method used in prior studies.[15] The use of census-derived measures has previously been validated as an accurate indicator of socioeconomic status.[16,17] The SEER data were linked to the US Census Bureau's 2006-2010 American Community Survey 5-Year Estimates (in 2010 inflation-adjusted dollars) by county.[18] Median household income (in $10 000s) was analyzed as a continuous variable.

Statistical Analysis

We compared age at diagnosis, sex, race, and MHI to anatomic site and tumor size using *t* tests, analysis of variance with Tukey method, or Pearson correlation for continuous variables and χ^2 tests for categorical variables. We also compared age, race, sex, MHI, tumor size, and anatomic site between treatment groups (excision vs MMS; surgery vs surgery and radiation) using *t* tests and χ^2 tests. Multinomial logistic regression was performed for controlled analysis in which anatomic location was the outcome as this involved more than 2 levels. Anatomic location was analyzed with "trunk" as the reference group. In addition, multivariable logistic regressions were performed for controlled analyses in which tumor size (<3 cm or ≥3 cm) and treatment group (excision vs MMS; surgery vs surgery and radiation) served as the outcome variables. Survival analyses were conducted using Kaplan-Meier method with log-rank statistic and Cox proportional hazards modeling. Survival analyses were conducted for overall survival. Parametric measures were chosen owing to the large sample size. Significance was set at $P < .05$. The data were retrieved using SEER*Stat 6.14 (NCI) and analyzed using SPSS statistical software (version 23.0; IBM Corp).

Results

Population Characteristics

In total, 3686 patients with DSFP were included in our analysis. Summary statistics of our cohort are provided in **Table 1**. The MHI of the data set ranged from $19 351 to $103 643, with a median value of $56 439. In 2010, the MHI for the entire US population was $51 950.[18]

The median tumor size was 3.0 cm, ranging from 1.0 mm to 30.0 cm. Because tumor size was only available for cases diagnosed after 2004, our multivariate analyses were limited to 1422 patients with DFSP. Characteristics of the tumor size limited cohort did not significantly differ from the larger cohort identified in SEER (see eTable 1 in the Supplement).

Survival

A multivariable survival analysis controlling for age at diagnosis, race, sex, MHI, tumor size, and anatomic site was performed. For every additional year of age, there was an 8.0% increased risk of death (HR, 1.08; 95% CI, 1.06-1.10; $P < .001$). Compared with women, men had almost twice the risk of death (HR, 1.97; 95% CI, 1.09-3.55; $P = .03$) (**Figure**, A; **Table 2**). Tumor size was marginally associated with survival in the multivariable analysis. For every 1 cm increase in tumor size, a patient with DFSP had a 9.0% increased risk of death from all-cause mortality (HR, 1.09; 95% CI, 1.01-1.18; $P=.04$) (Figure, B; Table 2).

Race (black: HR, 0.69; 95% CI, 0.31-1.53; $P = .36$; other: HR, 0.50; 95% CI, 0.12-2.07; $P = .34$), MHI (HR, 0.96; 95% CI, 0.77-1.20; $P = .72$), and anatomic site (head/neck: HR, 1.15; 95% CI, 0.46-2.88; $P = .76$; extremities: HR, 1.74; 95% CI, 0.95-3.18; $P = .07$) were not associated with survival in both the univariate and multivariable analysis (multivariable *P* values shown). In the treatment subanalyses, there were no significant differences in survival by treatment type when evaluating patients receiving surgery vs surgery plus radiation (HR, 1.14; 95% CI, 0.50-2.62; $P = .75$), or patients receiving excision vs MMS (HR, 0.75; 95% CI, 0.23-2.47; $P = .64$) (Table 2).

Table 1. Characteristics of the 3686 Patients in the Overall Dermatofibrosarcoma Protuberans (DFSP) Cohort Included in Our Analysis, After Adjustment for Exclusion Criteria[a]

Characteristic	Value
Age at diagnosis, mean (SD), y	43.64 (16.34)
MHI, mean (SD), $	58 741.97 (13 299.80)
Tumor size, mean (SD), cm	3.57 (2.93)
Sex	
Female	2003 (54.3)
Male	1683 (45.7)
Race	
White	2675 (72.6)
Black	729 (19.8)
Other	282 (7.7)
Anatomic site	
Head/neck	483 (13.1)
Extremities	1390 (37.7)
Trunk	1813 (49.2)
Treatment	
Surgery	3494 (94.8)
Surgery and radiation	192 (5.2)
Treatment	
Excision	3381 (91.7)
MMS	305 (8.3)

Abbreviations: DFSP, dermatofibrosarcoma protuberans; MHI, median household income; MMS, Mohs micrographic surgery.

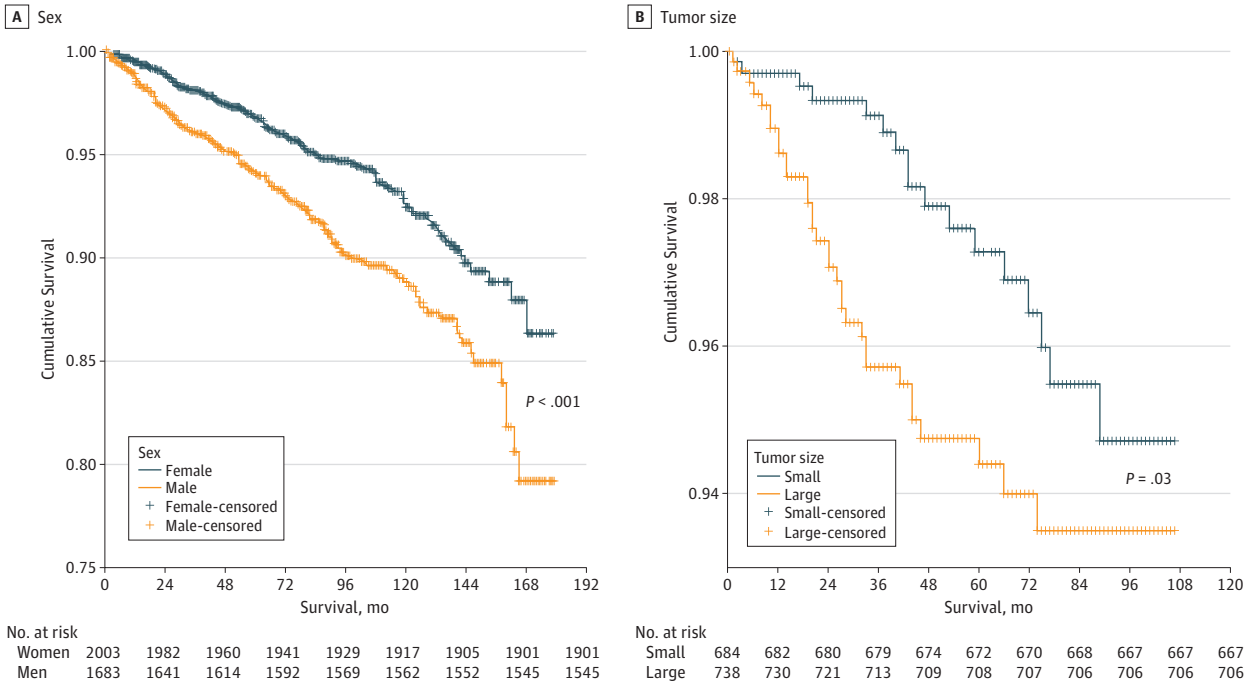
[a] Patients with DFSP with unknown or missing information on race, anatomic site, and/or treatment modality were excluded. In addition, cases diagnosed at autopsy or via death certificate were also excluded. Unless otherwise indicated, data are given as No. (%).

Tumor Characteristics

Association of Black Race, Female Sex, and Large Tumor Size With Truncal Location

Dermatofibrosarcoma protuberans tumors were most frequently located on the trunk (1813 [49.2%]), followed by the extremities (1390 [37.7%]) and then the head or neck (483 [13.1%]) (Table 1). In a multivariable analysis, which controlled for age, race, sex, MHI, and tumor size (see eTable 2 in the Supplement), we found that compared with whites, blacks more commonly had tumors of the trunk than of the head or neck (odds ratio [OR], 0.46; 95% CI, 0.28-0.74; $P < .001$). There was no difference with regards to race and having tumors of the extremities (OR, 0.89; 95% CI, 0.67-1.16; $P = .38$). Compared with women, men had greater odds of presenting with a head or neck tumor (OR, 1.44; 95% CI. 1.02-2.02; $P = .04$) or a tumor of the extremities (OR, 1.27; 95% CI, 1.01-1.61; $P = .04$) than a truncal tumor. There was a marginally significant difference in tumor size with regards to anatomic site, as truncal tumors were larger at presentation than tumors of the head or neck (OR, 0.93; 95% CI, 0.87-1.00; $P = .04$) or extremities (OR, 0.95; 95% CI, 0.91-0.99; $P = .01$).

Figure. Kaplan-Meier Curves of Prognostic Factors in Patients With Dermatofibrosarcoma Protuberans (DFSP)



A, As demonstrated in a Kaplan-Meier analysis with log-rank statistic, male patients had significantly worse survival than female patients. A controlled multivariable analysis also revealed that when compared with women, men with DFSP had almost twice the risk of death (hazard ratio [HR], 1.97; 95% CI, 1.09-3.55; $P = .03$). B, As demonstrated in a Kaplan-Meier analysis with log-rank statistic, patients with small (<3.0 cm) DFSP tumors had greater survival than those with large (≥3.0 cm) tumors. A controlled multivariable analysis demonstrated that for every 1-cm increase in tumor size, a patient with DFSP had a 9.0% increased risk of death from all-cause mortality (HR, 1.09; 95% CI, 1.01-1.18; $P = .04$).

Association of Older Age, Male Sex, and Black Race With Larger Tumor Size

In the multivariable analysis controlling for age, race, sex, MHI, and anatomic site (**Table 3**), we found that for every additional year of age, there was a 1.0% greater likelihood of presenting with a larger tumor (OR, 1.01; 95% CI, 1.00-1.02; $P = .01$). Black patients with DFSP were 1.78 times as likely as white patients to present with large tumors (OR, 1.78; 95% CI, 1.37-2.32; $P < .001$). Compared with women, men were more likely to present with large tumors (OR, 1.95; 95% CI, 1.57-2.42; $P < .001$).

Treatment

Association of Age, Black Race, Tumor Size, and Head or Neck Tumors With Combined Surgery and Radiation (vs Surgery Alone)

In the multivariable analysis, adjusting for age, race, sex, MHI, tumor size, and anatomic site (**Table 4**), we found that for every additional year of age, there was a 2.0% greater likelihood of receiving surgery and radiation vs surgery alone (OR, 1.02; 95% CI, 1.01-1.03; $P = .01$). Black patients with DFSP had 82.0% greater odds of receiving surgery and radiation than white patients (OR, 1.82; 95% CI, 1.13-2.92; $P = .01$). In addition, for every 1 cm increase in tumor size, there was a 15.0% greater odds of receiving combined surgery and radiation vs surgery alone (OR, 1.15; 95% CI, 1.09-1.21; $P < .001$). Compared with DFSP patients with truncal tumors, those with tumors of the head or neck had 4.63 greater odds of receiving surgery and radiation (OR, 4.63; 95% CI, 2.66-8.07; $P < .001$). Median house income (OR, 0.85; 95% CI, 0.72-1.00; $P = .06$) was not significantly associated with odds of receiving combined surgery and radiation.

Association of White Race, Female Sex, and Higher MHI With Increased Likelihood of Receiving MMS

In the multivariable analysis, we found that women had 47.0% greater odds of receiving MMS compared with men (OR, 0.53; 95% CI, 0.36-0.78; $P < .001$) (Table 4). Compared with white patients with DFSP, blacks had 49.0% lesser odds of receiving MMS for the treatment of DFSP (OR, 0.51; 95% CI, 0.30-0.87; $P = .01$). For every $10 000 increase in MHI, there was a 27.0% higher odds of a patient receiving MMS for the treatment of DFSP (OR, 1.27; 95% CI, 1.11-1.46; $P < .001$). Age (OR, 1.00; 95% CI, 0.99-1.01; $P = .72$), tumor size (OR, 0.96; 95% CI, 0.90-1.04; $P = .35$), and anatomic site (head/neck: OR, 1.37; 95% CI, 0.80-2.35; $P = .26$; extremities: OR, 1.20; 95% CI, 0.81-1.78; $P = .36$) were not significantly associated with odds of receiving MMS.

Discussion

Our study provides a comprehensive survival analysis for patients with DFSP by uniquely linking SEER registry data with the US Census tract to examine prognostic factors. Of the vari-

Table 2. Multivariable Survival Analysis of Dermatofibrosarcoma Protuberans (DFSP)

Characteristic	HR (95% CI)	*P* Value[a]
Age at diagnosis, y	1.08 (1.06-1.10)	**<.001**
Race		.44
White	1 [Reference]	
Black	0.69 (0.31-1.53)	.36
Other	0.50 (0.12-2.07)	.34
Sex		
Female	1 [Reference]	
Male	1.97 (1.09-3.55)	**.03**
MHI, $	0.96 (0.77-1.20)	.72
Tumor size, cm	1.09 (1.01-1.18)	**.04**
Anatomic site		.19
Trunk	1 [Reference]	
Head/neck	1.15 (0.46-2.88)	.76
Extremities	1.74 (0.95-3.18)	.07
Multivariable survival analysis of DFSP, also controlling for treatment modalities		
Surgery vs surgery/radiation[b]		
Surgery	1 [Reference]	
Surgery and radiation	1.14 (0.50-2.62)	.75
Excision vs MMS[c]		
Excision	1 [Reference]	
MMS	0.75 (0.23-2.47)	.64

Abbreviations: DFSP, dermatofibrosarcoma protuberans; HR, hazard ratio; MHI, median household income; MMS, Mohs micrographic surgery.

[a] Bold typeface indicates statistical significance.

[b] When comparing surgery vs surgery and radiation, surgery served as the reference value.

[c] When comparing excision vs MMS, excision served as the reference value.

Table 3. Multivariable Analysis Evaluating Factors Influencing Tumor Size[a]

Characteristic	Tumor Size, OR (95% CI)	*P* Value
Age at diagnosis, y	1.01 (1.00-1.02)	.01
Race		<.001
White	1 [Reference]	
Black	1.78 (1.37-2.32)	<.001
Other	1.31 (0.89-1.92)	.17
Sex		
Female	1 [Reference]	
Male	1.95 (1.57-2.42)	<.001
MHI, $	0.93 (0.85-1.01)	.07
Anatomic site		.04
Trunk	1 [Reference]	
Head/neck	0.82 (0.58-1.15)	.24
Extremities	0.74 (0.58-0.93)	.01

Abbreviations: MHI, median household income; OR, odds ratio.

[a] Tumor size (in centimeters) was analyzed as a dichotomized value, .0 cm vs ≥3.0 cm, based on the median value of 3.0 cm, with "small (<3.0 cm)" as the reference group.

ables assessed, older age at diagnosis, male sex, and large tumor size were identified as negative predictors of survival. Patients with DFSP who were male or black were more likely to present with large tumors. However, race was not significantly associated with worse survival. Furthermore, we examined differences in clinical characteristics and treatment modalities. Interestingly, while differences in clinical characteristics and treatment modalities were elicited, treatment type did not influence overall survival. Older age at diagnosis, black race, large tumor size, and head or neck location increased the likelihood of receiving combined surgery and radiation. In addition, patients with DFSP who were female, white, or had a higher MHI were more likely to receive MMS compared with WLE. Because treatment for rare tumors such as DFSP may lack standardization, we provide an important examination of factors affecting choice of treatment, and the impact of treatment modality on survival.

In a recent population-based study of DFSP, Kreicher et al[7] used data from the 18 SEER registries, the same data set used in our study, to evaluate potential prognostic factors. Kreicher et al[7] noted that increased age, black race, male sex, and anatomic location of the limbs and head were associated with worse survival. This study,[7] however, did not account for tumor size and socioeconomic status. We demonstrated their findings, and also controlled for the important factors of tumor size and MHI. In our model, we found that race and anatomic site were no longer associated with worse overall survival, highlighting the importance of controlling for these additional factors. Increased age, male sex, and large tumor size were the only negative predictors of survival in our study.

The association between age and overall survival may be partly attributed to our use of all-cause mortality instead of disease-specific survival—that is, older patients have additional comorbidities making death more likely. However, older age is commonly a risk factor for many skin cancers, including melanoma.[19,20] In addition, the association between age and death from DFSP has been discussed previously, with increased age being recognized as an independent risk factor.[1,5,7]

According to our data, male patients with DFSP had almost twice the risk of death compared with female patients. This finding is consistent with results from Kreicher et al,[7] who noted that men with DFSP were at 1.5 times higher risk for all-cause death than women. While the reason for this is not known, men in our study were more likely to present with tumors of the head or neck or extremities than women, who were more likely to present with truncal tumors. Our study did not demonstrate an impact of anatomic site on overall survival. However, prior studies have suggested that head or neck location is a poor prognostic factor.[2,21,22] Tumors of the head and neck likely present challenges for surgeons to achieve adequate margins because of their cosmetically and functionally sensitive anatomic locations. Furthermore, men in our study also demonstrated larger tumors than women, consistent with findings in other skin cancers, including melanoma.[23,24] Multiple studies have demonstrated sex differences in health-seeking and health-utilization behavior, with women pursuing preventive and diagnostic services more frequently than men.[25] This sex-specific difference may explain why women present earlier for diagnosis and, thus, may have smaller DFSP tumors at presentation and, therefore, better prognosis.

Table 4. Multivariable Analysis Examining Factors Affecting Treatment Modalities

Characteristic	OR (95% CI) Surgery vs Surgery and Radiation[a]	*P* Value	Excision vs MMS[b]	*P* Value
Age at diagnosis, y	1.02 (1.01-1.03)	.01	1.00 (0.99-1.01)	.72
Race		.05		.04
White	1 [Reference]		1 [Reference]	
Black	1.82 (1.13-2.92)	.01	0.51 (0.30-0.87)	.01
Other	1.10 (0.48-2.54)	.83	1.12 (0.64-1.98)	.69
Sex				
Female	1 [Reference]		1 [Reference]	
Male	1.01 (0.66-1.57)	.95	0.53 (0.36-0.78)	<.001
MHI, $	0.85 (0.72-1.00)	.06	1.27 (1.11-1.46)	<.001
Tumor size, cm	1.15 (1.09-1.21)	<.001	0.96 (0.90-1.04)	.35
Anatomic site		<.001		.44
Trunk	1 [Reference]		1 [Reference]	
Head/neck	4.63 (2.66-8.07)	<.001	1.37 (0.80-2.35)	.26
Extremities	1.54 (0.94-2.53)	.09	1.20 (0.81-1.78)	.36

Abbreviations: MHI, median household income; MMS, Mohs micrographic surgery; OR, odds ratio.

[a] When comparing surgery vs surgery and radiation, "surgery" was the reference group.

[b] When comparing excision vs MMS, "excision" was the reference group.

Indeed, we identified larger tumor size as a potential negative predictor of overall survival. Few prior studies have examined this. In a small study by Park et al,[26] tumor size (>10 cm) was a significant prognostic factor in univariate analysis but did not influence overall survival in the multivariate analysis. In addition, in a retrospective examination of 32 DFSP cases, Gayner et al[6] demonstrated that tumor size was not associated with DFSP recurrence. While it may seem intuitive that larger tumors would portend worse prognosis, further research is necessary to examine this.

Although Kreicher et al[7] found that black patients had 1.7 times the risk of death than whites, when we controlled for size, race was no longer an independent prognostic factor. In our study, race significantly influenced tumor size, as black patients with DFSP presented with larger tumors compared with whites. One possible explanation for the discrepancy in tumor size with regard to race may lie in delay in diagnosis. The pigmented variant of DFSP occurs predominantly in black patients.[27] Clinically, this variant may resemble a keloid and, thus, may be misdiagnosed in blacks who are keloid-prone.[27] Furthermore, the lack of clinical familiarity of skin cancer in individuals with darker skin types among the public and physicians may also contribute to a delay in diagnosis.[10,28]

Interestingly, differences in the clinical characteristics of patients with DFSP receiving each type of treatment were also noted. The mainstay of DFSP treatment is surgical, with tumor size and anatomic site being recognized as important factors influencing choice of surgical modality (excision vs MMS) and adjuvant radiation. Radiation is usually reserved for large or recurrent DFSP tumors and is most effective in reducing the rate of recurrence after surgery on large tumors.[9,10] In addition, adjuvant radiation therapy is most often used in cases where resection is limited due to anatomic site, such as the head or neck.[8,29] Our study findings are consistent with this, as older age, black race, large tumor size, and head or neck location increased the likelihood of receiving surgery and radiation compared with surgery alone. Receipt of adjuvant radiation, however, did not influence overall survival in our study.

While MMS is the most effective treatment of nonmelanoma skin cancers, such as basal and squamous cell carcinomas, its use in the treatment of rare cutaneous tumors is controversial. Evidence supports MMS as the treatment of choice for DFSP owing to its precise margin control and maximal conservation of tissue.[8,11] Mohs micrographic surgery is indicated for the treatment of locally aggressive tumors at high risk of recurrence and is considered superior to excision for the treatment of DFSP.[11,12] Patients with DFSP in our study who were female, white, or had a higher MHI were more likely to receive MMS. Our study found no difference in overall survival for tumors treated with excision vs MMS; however, we did not assess recurrence rates because SEER does not include that information. While anatomic site did not significantly differ between the sexes, women were more likely to present with smaller tumors than men. Thus, the greater likelihood of women receiving MMS may also be due to aesthetic considerations. Higher SES is associated with increased utilization of specialized services, such as MMS.[30] Most Mohs surgery practices (90%) are located in urban and suburban geographic areas, with few surgeons practicing in rural, low-income areas.[31] Because a higher proportion of blacks live in lower SES areas,[32] their access to Mohs surgeons may be limited. Importantly, MHI did not influence overall survival in our DFSP cohort.

While the SEER registry provides a large, comprehensive resource, case-specific detail is limited. In addition, tumor size was available only for patients diagnosed after 2004, reducing our cohort from 3686 to 1422 in the multivariate analyses. Tumor extension and infiltration were also not addressed in this study. We were also unable to evaluate local recurrence, which is the major source of morbidity for patients with DFSP, because information for this may not be accurately obtainable from SEER. Furthermore, we could not examine the influence of imatinib, which was approved in 2006 for the treatment of locally advanced and metastatic DFSP,[33] because SEER lacks data on medications.

Conclusions

The rarity of DFSP has made the identification of prognostic factors and evaluation of treatment modalities difficult. In this large population-based study, we demonstrate that older age, male sex, and large tumor size may be important predictors of survival, and that treatment modality may be influenced by sex, race, and SES.

ARTICLE INFORMATION

Accepted for Publication: April 29, 2016.

Published Online: June 4, 2016. doi:10.1001/jamadermatol.2016.1886

Author Contributions: Drs Martires and Stein had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: All authors.
Acquisition, analysis, or interpretation of data: Criscito, Martires.
Drafting of the manuscript: Criscito.
Critical revision of the manuscript for important intellectual content: All authors.
Statistical analysis: Criscito, Martires.
Administrative, technical, or material support: Stein.
Study supervision: Martires, Stein.

Conflict of Interest Disclosures: None reported.

Funding/Support: Dr Stein was supported by the Irwin I. Lubowe Fellowship in Dermatology.

Role of the Funder/Sponsor: The funder had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

REFERENCES

1. Criscione VD, Weinstock MA. Descriptive epidemiology of dermatofibrosarcoma protuberans in the United States, 1973 to 2002. *J Am Acad Dermatol*. 2007;56(6):968-973.

2. Gloster HM Jr. Dermatofibrosarcoma protuberans. *J Am Acad Dermatol*. 1996;35(3, pt 1):355-374.

3. Roses DF, Valensi Q, LaTrenta G, Harris MN. Surgical treatment of dermatofibrosarcoma protuberans. *Surg Gynecol Obstet*. 1986;162(5):449-452.

4. Bowne WB, Antonescu CR, Leung DH, et al. Dermatofibrosarcoma protuberans: a clinicopathologic analysis of patients treated and followed at a single institution. *Cancer*. 2000;88(12):2711-2720.

5. Lemm D, Mügge LO, Mentzel T, Höffken K. Current treatment options in dermatofibrosarcoma protuberans. *J Cancer Res Clin Oncol*. 2009;135(5):653-665.

6. Gayner SM, Lewis JE, McCaffrey TV. Effect of resection margins on dermatofibrosarcoma protuberans of the head and neck. *Arch Otolaryngol Head Neck Surg*. 1997;123(4):430-433.

7. Kreicher KL, Kurlander DE, Gittleman HR, Barnholtz-Sloan JS, Bordeaux JS. Incidence and survival of primary dermatofibrosarcoma protuberans in the United States. *Dermatol Surg*. 2016;42(suppl 1):S24-S31.

8. Llombart B, Serra-Guillén C, Monteagudo C, López Guerrero JA, Sanmartín O. Dermatofibrosarcoma protuberans: a comprehensive review and update on diagnosis and management. *Semin Diagn Pathol*. 2013;30(1):13-28.

9. Haas RL, Keus RB, Loftus BM, Rutgers EJ, van Coevorden F, Bartelink H; Soft Tissue Tumours Working Group. The role of radiotherapy in the local management of dermatofibrosarcoma protuberans. *Eur J Cancer*. 1997;33(7):1055-1060.

10. Sun LM, Wang CJ, Huang CC, et al. Dermatofibrosarcoma protuberans: treatment results of 35 cases. *Radiother Oncol*. 2000;57(2):175-181.

11. Gloster HM Jr, Harris KR, Roenigk RK. A comparison between Mohs micrographic surgery and wide surgical excision for the treatment of dermatofibrosarcoma protuberans. *J Am Acad Dermatol*. 1996;35(1):82-87.

12. Paradisi A, Abeni D, Rusciani A, et al. Dermatofibrosarcoma protuberans: wide local excision vs. Mohs micrographic surgery. *Cancer Treat Rev*. 2008;34(8):728-736.

13. National Cancer Institute Surveillance, Epidemiology, and End Results Program. SEER*Stat software, version 8.2.1. http://seer.cancer.gov/seerstat/. Accessed August 19, 2015.

14. National Cancer Institute Surveillance, Epidemiology, and End Results Program. Number of persons by race and Hispanic ethnicity for SEER participants (2010 census data). http://seer.cancer.gov/registries/data.html. Accessed November 28, 2015.

15. Reyes-Ortiz CA, Goodwin JS, Freeman JL, Kuo YF. Socioeconomic status and survival in older patients with melanoma. *J Am Geriatr Soc*. 2006;54(11):1758-1764.

16. Krieger N, Chen JT, Waterman PD, Soobader MJ, Subramanian SV, Carson R. Choosing area based socioeconomic measures to monitor social inequalities in low birth weight and childhood lead poisoning: the Public Health Disparities Geocoding Project (US). *J Epidemiol Community Health*. 2003;57(3):186-199.

17. Hofer TP, Wolfe RA, Tedeschi PJ, McMahon LF, Griffith JR. Use of community versus individual socioeconomic data in predicting variation in hospital use. *Health Serv Res*. 1998;33(2 Pt 1):243-259.

18. US Census Bureau American FactFinder. Median household income in the past 12 months (in 2010 inflation-adjusted dollars). http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_10_5YR_B19013&prodType=table. Accessed September 20, 2015.

19. Banerjee M, Lao CD, Wancata LM, Muenz DG, Haymart MR, Wong SL. Implications of age and conditional survival estimates for patients with melanoma. *Melanoma Res*. 2016;26(1):77-82.

20. Merrill RM, Bateman S. Conditional melanoma cancer survival in the United States. *Cancers (Basel)*. 2016;8(2):E20.

21. Barnes L, Coleman JA Jr, Johnson JT. Dermatofibrosarcoma protuberans of the head and neck. *Arch Otolaryngol*. 1984;110(6):398-404.

22. Mark RJ, Bailet JW, Tran LM, Poen J, Fu YS, Calcaterra TC. Dermatofibrosarcoma protuberans of the head and neck. A report of 16 cases. *Arch Otolaryngol Head Neck Surg*. 1993;119(8):891-896.

23. Lee KC, Higgins HW II, Linden O, Cruz AP. Gender differences in tumor and patient characteristics in those undergoing Mohs surgery. *Dermatol Surg*. 2014;40(6):686-690.

24. Scoggins CR, Ross MI, Reintgen DS, et al; Sunbelt Melanoma Trial. Gender-related differences in outcome for melanoma patients. *Ann Surg*. 2006;243(5):693-698.

25. Bertakis KD, Azari R, Helms LJ, Callahan EJ, Robbins JA. Gender differences in the utilization of health care services. *J Fam Pract*. 2000;49(2):147-152.

26. Park JT, Roh JL, Kim SO, et al. Prognostic factors and oncological outcomes of 122 head and neck soft tissue sarcoma patients treated at a single institution. *Ann Surg Oncol*. 2015;22(1):248-255.

27. Agbai ON, Buster K, Sanchez M, et al. Skin cancer and photoprotection in people of color: a review and recommendations for physicians and the public. *J Am Acad Dermatol*. 2014;70(4):748-762.

28. Gloster HM Jr, Neal K. Skin cancer in skin of color. *J Am Acad Dermatol*. 2006;55(5):741-760.

29. Williams N, Morris CG, Kirwan JM, Dagan R, Mendenhall WM. Radiotherapy for dermatofibrosarcoma protuberans. *Am J Clin Oncol*. 2014;37(5):430-432.

30. Starfield B. Commentary: how does "insurance" improve equity in health? *Int J Epidemiol*. 2009;38(6):1551-1553.

31. Campbell RM, Perlis CS, Malik MK, Dufresne RG Jr. Characteristics of Mohs practices in the United States: a recall survey of ACMS surgeons. *Dermatol Surg*. 2007;33(12):1413-1418.

32. Freeman HP. Poverty, culture, and social injustice: determinants of cancer disparities. *CA Cancer J Clin*. 2004;54(2):72-77.

33. US Food and Drug Administration. FDA approves imatinib mesylate (Gleevec) as a single agent for the treatment of multiple indications. http://www.fda.gov/AboutFDA/CentersOffices/OfficeofMedicalProductsandTobacco/CDER/ucm094941.htm. Accessed September 20, 2015.