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Fitzpatrick skin phototype is an independent predictor of squamous cell carcinoma risk after solid organ transplantation

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Abstract

Background—Solid organ transplant recipients are at an increased risk of developing squamous cell carcinoma of the skin after transplant. In predominantly Caucasian cohorts, Fitzpatrick skin type (FST) has been reported to be a risk factor for developing post-transplant skin cancers.

Objective—Our goal was to determine if Fitzpatrick skin type is a statistically significant risk factor for the development of squamous cell carcinomas after solid organ transplant in a diverse US population of transplant recipients.

Methods—A cohort of transplant recipients completed a questionnaire of demographic factors, transplant type, Fitzpatrick skin type and skin cancer history. Univariate and multivariate analysis was performed to determine the risk factors for development of squamous cell carcinoma after transplant.

Results—As expected, male subjects had an increased risk for SCC compared to females (p=0.02), and subjects age 50 and over at the time of transplantation were more likely to develop SCC compared to those under 50 (p<0.001). The risk of SCC increased with each incremental decrease in Fitzpatrick skin type, from FST VI to FST I (linear test for trend p<0.001).

Limitations—Our questionnaire did not ask specifically about immunosuppressive medications; instead, organ transplant category was used as a proxy for level of immunosuppression.

Conclusions—Fitzpatrick skin type, a patient-reported variable, is an independent risk factor for the development of SCC in organ transplant recipients, and should be elicited from patients who have gone or will undergo organ transplantation.

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Introduction

Currently, there are approximately 140,000 organ transplant recipients in the United States. (1) The risk of systemic and cutaneous cancers is increased within this population, with the most common post-transplant neoplasm being non-melanoma skin cancers (NMSC). Most studies have shown a predominance of squamous cell carcinomas (SCC) over basal cell carcinomas (BCC) in organ transplant recipients (OTR), in contrast to the general population.(1–3) In addition to the increased incidence with which they occur, these tumors behave more aggressively in the post-transplant population, with a metastatic rate as high as 8% and three year mortality of up to 46%.(2, 4, 5) Current recommendations call for annual full body skin examination for all OTR, although the risk for skin cancer is believed to be lower for OTR with darker skin.(6)

Originally developed to assist in the determination of the minimal erythema dose in white patients undergoing light therapy, Fitzpatrick skin type has since been more broadly utilized by dermatologists as a measure of sun sensitivity and skin cancer risk.(7, 8) A six-point categorical scale is used to describe a patient's history of tanning ability and tendency to burn. Much of the data regarding post-transplant skin cancer has been obtained from cohorts of OTR in northern Europe and Australia that are predominantly or exclusively Caucasian. (5, 9, 10) Nonetheless, some analysis regarding the connection between skin color or phototype and development of skin cancer has been performed: Caucasians have been noted to have an odds ratio of 12 for SCC occurrence when compared to non-Caucasians, Fitzpatrick skin type of I or II was found to be a significant risk factor (when compared to skin type III or IV) in liver transplant patients and Irish renal transplants recipients who later developed NMSC disproportionately had type I skin.(4, 5, 11) Type II skin has been reported to be a significant risk factor for the development of skin cancers, with patients of FST III-V enjoying an 83% risk reduction.(12–14) Larger studies have revealed an increased risk of developing keratotic lesions in patients with lighter skin types, although that comparison did not utilize the Fitzpatrick phototype system and instead used descriptions such as 'medium', 'fair' and 'olive' skin types.(15)

To date, the data regarding FST and skin cancer risk has been drawn from relatively homogeneous cohorts. Previous studies have not evaluated the incremental risk of each Fitzpatrick skin type for the development of squamous cell carcinoma after transplant within a diverse, admixed American population. Due to the significant morbidity and mortality associated with skin cancer after solid organ transplantation, it is imperative to identify clinically relevant risk factors for the development of skin cancers in the transplant recipient so that appropriate monitoring and education programs can be put in place. We analyzed a cohort of American organ transplant recipients to determine whether Fitzpatrick skin type predicts the risk of squamous cell carcinoma after transplant.

Methods

Sample

694 organ transplant recipients were enrolled in the study between 2004 and 2008 via physician contact and direct patient advertisement. Patients were recruited through physician contact, magazine advertisements, a booth at the Transplant Games, and direct mailings to patients via transplant organizations. Physicians were recruited to refer patients through advertisements in transplant and dermatology journals and through direct mailings to members of professional dermatology organizations. Subjects who opted to contact the study coordinators were enrolled in person, by mail, or by telephone. All subjects provided informed consent according the procedures of approved by the University of California, San

Francisco Committee on Human Research and adherent to the Declaration of Helsinki Principles.

Data Collection and Measures

Each subject completed a questionnaire that gathered data on sex, age, age at transplantation, race, Fitzpatrick skin type (description of tendency to burn or tan), hair color, eye color, time since transplantation, type of organ transplanted, and self-reported history of any skin cancer.(7) Enrolled subjects were asked to consent to collection and review of medical records relevant to skin cancer. All reports of skin cancer diagnoses and dates of diagnoses were confirmed by review of pathology report.

Fitzpatrick skin type, the primary predictor, was measured on a six-point categorical scale according to the patient's response to the question "How does your skin react if you go outside without sunscreen?" Answer choices were: I. Always burns easily, never tans, II. Always burns easily, tans a little, III. Burns moderately, tans gradually, IV. Burns a little, always tans well, V. Rarely burns, tans profusely, VI. Never burns. Secondary predictors were measured as follows: Race (select as many as apply): White, Black/African American, Asian, Hispanic or Latino, American Indian/Alaskan Native, Hawaiian or Pacific Islander. Hair color (select one): black, brown, blonde, red. Eye color (select one): brown, hazel, blue, other (write in).

For analysis, age at transplant was dichotomized into age under 50 and 50 and over. Eye color was dichotomized into brown/hazel and blue/gray/green, and hair color was dichotomized into brown/black and red/blonde. Transplanted organ was categorized as thoracic (heart, lung, heart-lung, and heart-kidney) or abdominal (kidney, liver, and pancreas).

Statistical Analysis

Variables were analyzed with two-sided Fisher's exact test or two-sample Wilcoxon rank-sum test. We assessed correlations between all potential predictors, with correlation coefficients <|0.35| in all cases (-0.09 to 0.33).

A pathological confirmation of skin cancer history was obtained for 556 subjects (80.1%); 138 subjects either did not consent to record review or their records were unobtainable. The subjects with missing data were similar with respect to age, sex, organ transplanted, Fitzpatrick skin type, hair and eye color, and race but were older and more likely to have reported a history of skin cancer than those with complete data. We therefore generated inverse weights to address potential bias in survey response and data collection.(16, 17) Inverse weights were based on a logistic regression model of missingness on sex, age at transplant, and reported history of skin cancer. These weights were incorporated when the data were declared to be survival-time data.

We employed Cox proportional hazard models to assess the incremental impact of Fitzpatrick skin type on the risk of developing SCC. Fitzpatrick skin type was modeled as a six-level categorical variable. Variables were selected by a modified Allan-Cady backwards selection procedure. Gender and age at transplant were included in the Cox models *a priori* based on known associations with skin cancer after organ transplant.(18) Type of organ transplanted was included to adjust for level of immunosuppression (higher in thoracic transplant recipients than abdominal transplant recipients).

We next performed binary tests of interaction between all predictors, which revealed interactions between race and Fitzpatrick skin type as well as between race and organ transplanted. Further, we identified that 98% of SCC developed in white subjects. Because

of these interactions and the rarity of SCC development in non-white subjects, models were stratified by race (white/non-white).

The proportionality of hazards assumption was tested and confirmed with the Schoenfeld test. The goodness of fit of the models was confirmed by comparing a plot of the Cox-Snell residuals to the Nelson-Aalon cumulative hazard function.

The impact of hair color and eye color on Fitzpatrick skin type was measured by ordinal logistic regression.

Results

694 organ transplant recipients completed the survey, 449 male and 245 female (Table I). 587 subjects had received an abdominal organ transplant and 107 had received a thoracic organ transplant. 384 patients were transplanted before the age of 50 while 299 were transplanted after age 50. 639 subjects self-identified as white. All six Fitzpatrick skin types were represented in both white and nonwhite groups.

Among the 556 patients for whom skin cancer history confirmation was obtained, 317 (57%) had a history of squamous cell carcinoma (Table II). The mean age at the time of transplant for the subset that developed an SCC was 47.7 years, compared to 44.5 years for the unaffected group. Univariate analysis revealed a significantly increased risk in males, thoracic organ transplant recipients, those who self-identified as white, and subjects who were older than age 50 at the time of transplant. Hair color and eye color (p=0.8 and 0.08, respectively) were not univariate predictors of SCC development. The mean duration of followup was 9.9 years for subjects with SCC and 10 years for subjects with no history of SCC (p=0.6)

The final multivariate model included Fitzpatrick skin type adjusted for sex, age at transplant, and organ transplanted (Table III). The risk of SCC increased with each incremental decrease in Fitzpatrick skin type (linear test for trend p<0.001), such that subjects with Type I skin had a 1.7-fold increased risk for SCC over those with Type IV skin (HR 1.67, 95% CI 1.07–2.62, p=0.02) and a 3.5-fold increased risk over those with Type VI skin (HR 3.47, 95% CI 1.46–8.28, p=0.005) (Figure 1).

The overall 5-, 10-, and 15-year cumulative incidence of SCC after transplant was 20%, 45%, and 59% (Table IV). Fair skin types had a higher incidence of SCC than the overall population, while darker skin types had a lower incidence. The cumulative incidence of SCC at 10 years ranged from 51% in patients with Type I skin to 8% in subjects with type VI skin.

Male subjects had a 1.3-fold increased risk for SCC compared to females (HR 1.33, 95% CI 1.04–1.71, p=0.02), and subjects age 50 and over at the time of transplantation had a 4.3-fold increased risk for SCC compared to those under 50 (HR 4.34, 95%CI 3.23–5.83, p<0.001). There was a trend towards higher risk in thoracic organ transplant recipients compared to abdominal organ transplant recipients, but this did not achieve statistical significance (HR 1.32, 95% CI 0.95–1.83, p=0.09). As pancreatic transplant recipients receive higher levels of immunosuppression than other abdominal transplant recipients, we ran a sensitivity analysis of the model in which the 21 patients with pancreas transplants were reclassified as thoracic. There were no qualitative changes in the model results, but the observed hazard ratio for thoracic/pancreas compared to kidney/liver was 1.43 (99% CI 1.05–1.94, p=0.022).

Hair color and eye color were not associated with risk for SCC on univariate analysis and were removed from the final multivariate model during backwards selection. Both hair color and eye color were predictive of Fitzpatrick skin type by ordinal logistic regression (p<0.001 for hair color; p=0.001 for eye color), suggesting an association of these variables with tanning ability. Notably, this finding was driven by white subjects in the population, as hair and eye color did not predict Fitzpatrick skin type in the nonwhite subgroup (p=0.9 for hair color; p=0.2 for eye color).

Discussion

The objective of this study was to determine if Fitzpatrick skin type is an independent risk factor for the development of squamous cell carcinoma after solid organ transplantation in a diverse US population. The development of squamous cell carcinoma was a common occurrence in our cohort of transplant recipients. Approximately 43% of subjects developed an SCC by 10 years after transplantation. Notably, 72% of patients who received a thoracic organ transplant developed an SCC by 10 years after transplant, a markedly higher rate than reported in previous studies.(5)

Fitzpatrick skin type (FST) was an important predictor of SCC development in our cohort, particularly when comparing patients with skin types I, II, or III to those of skin type VI. Early studies on the predictive effect of FST in non-melanoma skin cancer found that among PUVA-treated patients, the risk of non-melanoma skin cancer was significantly higher in skin types I and II compared with patients with skin type IV. However, that cohort was comprised of psoriasis patients receiving UV therapy and included a 4-point, rather than the full 6-point, FST scale.(19) Previous studies looking at the relationship of skin color or FST with skin cancer in the transplant recipient have been limited by the fact that their cohorts were drawn from more homogeneous populations in Europe and Australia.[5–7] Few studies have had cohorts that include all six Fitzpatrick photoypes, and those that do have few patients with skin type V or VI.(14, 20) Other studies that have looked at the predictive value of phenotypic characteristics on risk of skin cancer found an association only in populations with red hair, blue eyes, and highly freckled skin.(21) Interestingly, in our cohort, hair color and eye color were not significant risk factors for SCC development in multivariate analysis, although they did predict FST in the subset of white patients (p<0.001 and p=0.001 respectively). Our results also confirm data from previous studies on risk for SCC after transplantation. Male sex and advanced age at time of transplant were found to be significant risk factors as well, with males more likely to develop SCCs than females and with patients 50 years of age or older at the time of transplant developing SCCs at a higher rate than younger transplant recipients. These had previously been described as risk factors within the northern European and Australian cohorts studied.(10, 12–14, 20, 22) The increased risk with advancing age may be attributable to increased cumulative sun exposure prior to transplant.(12) UV radiation is thought to play a major role in the pathogenesis of non-melanoma skin cancer, and in post-transplant patients the vast majority of NMSC are seen in sun-exposed sites.(4, 11) Many previous studies have noted an increased risk of SCC in thoracic transplant recipients. In our cohort, a trend toward higher risk of SCC in thoracic organ recipients when compared to abdominal organ recipients was noted, but significance was not achieved. We performed a power calculation to assess whether our inability to achieve statistical significance between thoracic and abdominal subjects was due to small sample size. Given the event rate of 0.57 in our study, we would need a sample size of 715 patients to detect the observed hazard ratio of 1.32 between thoracic and abdominal subjects. Therefore we are likely underpowered to achieve statistical significance in our study. It is possible that the inclusion of pancreatic transplant recipients in the abdominal organ group biases the hazard ratio towards the mean, as these patients typically require higher levels of immunosuppression than kidney and liver transplant recipients. Of the 556 subjects with

confirmed pathology, there were 474 abdominal transplant recipients, 18 of whom (4%) had a pancreas transplant (primarily kidney/pancreas). The sensitivity analysis of the model with pancreas transplant recipients reclassified in the thoracic transplant category suggests that the higher level of immunosuppression required after pancreatic transplantation increases the risk for SCC and that increased immunosuppression increases the risk for SCC, similar to previous reports. Notably, the sample size required to detect a hazard ratio of 1.43 is 431, well within our cohort size of 556. Therefore we are confident that our model is robust to adjustment for transplanted organ as a marker for level of immunosuppression.

Notably, because this study examined the risk factors associated with skin cancer development in a large cohort of American transplant recipients of diverse Fitzpatrick skin phototypes and both abdominal and thoracic organ transplants, its findings can be generalized to a broader US post-transplant population. Our population breakdown was similar in gender, age, and transplanted organ to the US transplant population during the period studied based on Organ Procurement and Transplantation Network (OPTN) data. Although diverse with regards to Fitzpatrick skin type, our population predominantly self-identified as white.

In addition, the confirmation of reported skin cancer history with pathology review decreased the possibility of recall bias in this observational study. We have previously described a correct classification rate of 0.83 for self-report of SCC in this cohort.(23) Although our questionnaire did not ask specifically about immunosuppressive medications, organ transplant category was used as a proxy for level of immunosuppression.(6, 24–28) Further studies may examine why no significant difference in risk was seen between the organ transplant categories. We collected data regarding race, hair color, eye color and Fitzpatrick skin type, but did not obtain skin color. Future studies are needed to determine the relative predictive value of constitutive skin color versus tanning ability in determining skin cancer risk.

This study demonstrates that Fitzpatrick skin type, age at time of transplantation, and male sex are independent risk factors for the development of squamous cell carcinoma in the post-transplant population. In our experience, clinicians often assign a FST to patients during the physical examination based on race and pigmentary phenotype; it is important to remember that FST is a patient-reported variable not determined by clinical exam. Notably, within the group self-identifying as white there were subjects who reported burning and tanning histories consistent with each FST. Ultimately, the significantly increased risk of SCC based on FST should compel dermatologists to use this measure rather than race to risk stratify patients who have undergone, or will undergo, solid organ transplantation. Until a clinical predictive model is validated in a prospective study, male transplant recipients, patients who receive a transplant at or after age 50, and those with a burning and tanning history consistent with Fitzpatrick skin types I, II or III should receive significant education and aggressive surveillance for the development of skin cancers.

Acknowledgments

Abbreviations

BCC	Basal cell carcinoma
FST	Fitzpatrick Skin Type

NMSC	Non-melanoma skin cancer
OTR	Organ transplant recipient
SCC	Squamous cell carcinoma

References

1. O'Reilly Zwald F, Brown M. Skin cancer in solid organ transplant recipients: Advances in therapy and management Part I. Epidemiology of skin cancer in solid organ transplant recipients. J Am Acad Dermatol. 2011; 65(2):253–61. [PubMed: 21763561]

2. Berg D, Otley CC. Skin cancer in organ transplant recipients: Epidemiology, pathogenesis, and management. J Am Acad Dermatol. 2002; 47(1):1–17. quiz 8–20. [PubMed: 12077575]

3. Traywick C, O'Reilly FM. Management of skin cancer in solid organ transplant recipients. Dermatol Ther. 2005; 18(1):12–8. [PubMed: 15842608]

4. Carroll RP, Ramsay HM, Fryer AA, Hawley CM, Nicol DL, Harden PN. Incidence and prediction of nonmelanoma skin cancer post-renal transplantation: a prospective study in Queensland, Australia. Am J Kidney Dis. 2003; 41(3):676–83. [PubMed: 12612993]

5. Ong CS, Keogh AM, Kossard S, Macdonald PS, Spratt PM. Skin cancer in Australian heart transplant recipients. J Am Acad Dermatol. 1999; 40(1):27–34. [PubMed: 9922009]

6. Otley CC, Pittelkow MR. Skin cancer in liver transplant recipients. Liver Transpl. 2000; 6(3):253–62. [PubMed: 10827224]

7. Fitzpatrick TB. The validity and practicality of sun-reactive skin types I through VI. Arch Dermatol. 1988; 124(6):869–71. [PubMed: 3377516]

8. Weinstock MA. Assessment of sun sensitivity by questionnaire: validity of items and formulation of a prediction rule. J Clin Epidemiol. 1992; 45(5):547–52. [PubMed: 1588360]

9. Naldi L, Fortina AB, Lovati S, Barba A, Gotti E, Tessari G, et al. Risk of nonmelanoma skin cancer in Italian organ transplant recipients. A registry-based study. Transplantation. 2000; 70(10):1479–84. [PubMed: 11118094]

10. Ramsay HM, Fryer AA, Reece S, Smith AG, Harden PN. Clinical risk factors associated with nonmelanoma skin cancer in renal transplant recipients. Am J Kidney Dis. 2000; 36(1):167–76. [PubMed: 10873887]

11. Moloney FJ, Almarzouqi E, O'Kelly P, Conlon P, Murphy GM. Sunscreen use before and after transplantation and assessment of risk factors associated with skin cancer development in renal transplant recipients. Arch Dermatol. 2005; 141(8):978–82. [PubMed: 16103326]

12. Caforio AL, Fortina AB, Piaserico S, Alaibac M, Tona F, Feltrin G, et al. Skin cancer in heart transplant recipients: risk factor analysis and relevance of immunosuppressive therapy. Circulation. 2000; 102(19 Suppl 3):III222–7. [PubMed: 11082391]

13. Espana A, Martinez-Gonzalez MA, Garcia-Granero M, Sanchez-Carpintero I, Rabago G, Herreros J. A prospective study of incident nonmelanoma skin cancer in heart transplant recipients. J Invest Dermatol. 2000; 115(6):1158–60. [PubMed: 11121158]

14. Fortina AB, Caforio AL, Piaserico S, Alaibac M, Tona F, Feltrin G, et al. Skin cancer in heart transplant recipients: frequency and risk factor analysis. J Heart Lung Transplant. 2000; 19(3):249–55. [PubMed: 10713249]

15. Bouwes Bavinck JN, Euvrard S, Naldi L, Nindl I, Proby CM, Neale R, et al. Keratotic skin lesions and other risk factors are associated with skin cancer in organ-transplant recipients: a case-control study in The Netherlands, United Kingdom, Germany, France, and Italy. J Invest Dermatol. 2007; 127(7):1647–56. [PubMed: 17380113]

16. Binder DA. Fitting Cox Proportional Hazards Models from Survey Data. Biometrika. 1992; 79(1):139–47.

17. Lin DY. On fitting Cox's proportional hazards models to survey data. Biometrika. 2000; 87(1):37–47.

18. Zwald FO, Brown M. Skin cancer in solid organ transplant recipients: Advances in therapy and management: Part 1. Epidemiology of skin cancer in solid organ transplant recipients. J Am Acad Dermatol. 2011; 65:253–61. [PubMed: 21763561]

19. Stern RS, Momtaz K. Skin typing for assessment of skin cancer risk and acute response to UV-B and oral methoxsalen photochemotherapy. Arch Dermatol. 1984; 120(7):869–73. [PubMed: 6732259]

20. Fuente MJ, Sabat M, Roca J, Lauzurica R, Fernandez-Figueras MT, Ferrandiz C. A prospective study of the incidence of skin cancer and its risk factors in a Spanish Mediterranean population of kidney transplant recipients. Br J Dermatol. 2003; 149(6):1221–6. [PubMed: 14674900]

21. Andreassi L, Simoni S, Fiorini P, Fimiani M. Phenotypic characters related to skin type and minimal erythemal dose. Photodermatol. 1987; 4(1):43–6. [PubMed: 3615247]

22. Lindelof B, Sigurgeirsson B, Gabel H, Stern RS. Incidence of skin cancer in 5356 patients following organ transplantation. Br J Dermatol. 2000; 143(3):513–9. [PubMed: 10971322]

23. Dybbro E, Mihalis E, Hirose R, Arron ST. Validity of patient skin cancer report among organ transplant recipients. Clin Transplant. 2012; 26(2):E132–6. [PubMed: 22428900]

24. Bouwes Bavinck JN, Vermeer BJ, van der Woude FJ, Vandenbroucke JP, Schreuder GM, Thorogood J, et al. Relation between skin cancer and HLA antigens in renal-transplant recipients. N Engl J Med. 1991; 325(12):843–8. [PubMed: 1875968]

25. Espana A, Redondo P, Fernandez AL, Zabala M, Herreros J, Llorens R, et al. Skin cancer in heart transplant recipients. J Am Acad Dermatol. 1995; 32(3):458–65. [PubMed: 7868716]

26. Euvrard S, Kanitakis J, Claudy A. Skin cancers after organ transplantation. N Engl J Med. 2003; 348(17):1681–91. [PubMed: 12711744]

27. Jensen P, Hansen S, Moller B, Leivestad T, Pfeffer P, Geiran O, et al. Skin cancer in kidney and heart transplant recipients and different long-term immunosuppressive therapy regimens. J Am Acad Dermatol. 1999; 40(2 Pt 1):177–86. [PubMed: 10025742]

28. Parrish JA. Immunosuppression, skin cancer, and ultraviolet A radiation. N Engl J Med. 2005; 353(25):2712–3. [PubMed: 16371639]

Capsule

- Solid organ transplant recipients have a significantly higher risk of developing non-melanoma skin cancers, especially squamous cell carcinomas.

- In this study, Fitzpatrick skin type was a significant risk factor for the development of SCCs in a diverse post-transplant US population.

- The findings of advancing age, male sex and FST as risk factors can be generalized to a broader US post-transplant population and should guide skin cancer surveillance and education.
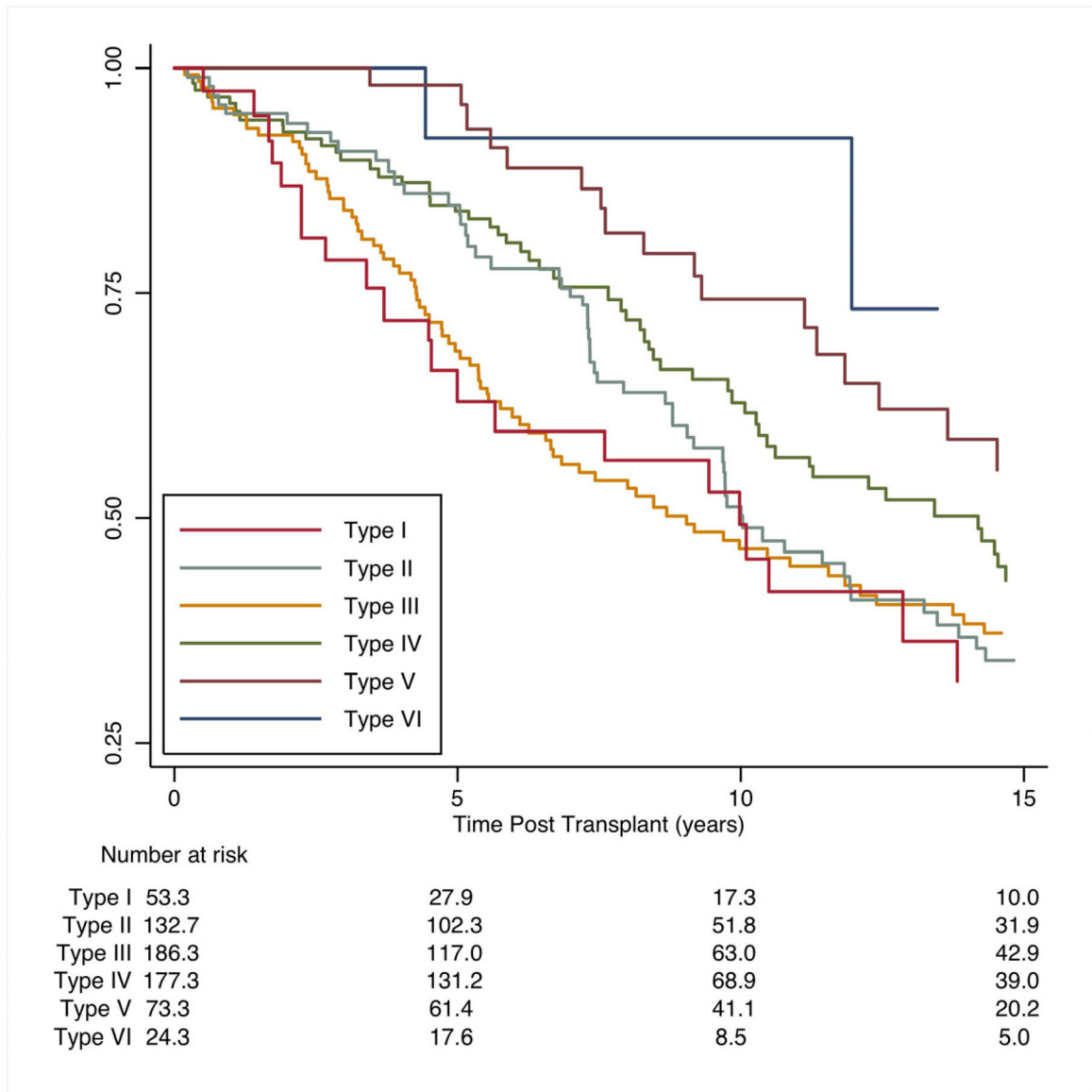
Figure 1.
Squamous cell carcinoma-free survival after organ transplantation by Fitzpatrick Skin Type.

Table I

Characteristics

Sex	
Male	449 (64.7)
Female	245 (35.3)
Organ Category	
Kidney, Liver, Pancreas	587 (84.6)
Heart, Lung (including Kidney)	107 (15.4)
Fitzpatrick Skin Type	
I: Always burns easily	53 (7.6)
II: Always burns easily, tans little	134 (19.3)
III: Burns moderately, tans gradually	195 (28.1)
IV: Burns a little, tans well	188 (27.1)
V: Rarely burns, tans profusely	80 (11.5)
VI: Never burns	24 (3.5)
Race	
White	639 (92.1)
Black/African American	11 (1.6)
Hispanic/Latino	26 (3.8)
Asian	1 (0.1)
American Indian/Alaskan Native	3 (0.4)
More than one race reported	6 (0.9)
Eye Color	
Brown	213 (30.7)
Hazel	136 (19.6)
Green	25 (3.6)
Blue/Gray	301 (43.4)
Hair Color	
Black	72 (10.4)
Brown	445 (64.1)
Blonde	124 (17.9)
Red	34 (4.9)
Age at Time of Transplant (years)	46.9 ± 14.1
Age <50	384 (55.3)
Age 50	299(43.1)

Data presented as n (%) or mean ± SD. n=694.

Note: Categories may not total to 694 due to missing data points.

Table II

Subjects with complete skin cancer data (n=556).

	Developed SCC n=317	No SCC n=239	p value
Sex			
Male	226 (62.4)	136 (37.6)	p<0.001
Female	91 (46.9)	103 (53.1)	
Organ Category			
Kidney, Liver, Pancreas	251 (52.9)	223 (47.1)	p<0.001
Heart, Lung (including kidney)	66 (80.5)	16 (19.5)	
Fitzpatrick Skin Type			
I: Always burns easily	29 (67.4)	14 (32.6)	p<0.001
II: Always burns easily, tans little	70 (64.2)	39 (35.8)	
III: Burns moderately, tans gradually	105 (68.2)	49 (31.8)	
IV: Burns a little, tans well	77 (51.7)	72 (48.3)	
V: Rarely burns, tans profusely	25 (40.3)	37 (59.7)	
VI: Never burns	5 (21.7)	18 (78.3)	
Race			
White	309 (60.1)	197 (38.9)	p<0.001 (white vs. nonwhite)
Nonwhite	7 (16.7)	35 (83.3)	
Black/African American	0 (0)	11 (100)	
Hispanic/Latino	4 (16)	21 (84)	
Asian	0 (0)	1 (100)	
American Indian/Alaskan Native	0 (0)	2 (100)	
More than one race reported	3 (100)	0 (0)	
Eye Color			
Brown/Hazel	150 (54.2)	127 (45.8)	p=0.08
Blue/Gray/Green	161 (61.7)	100 (38.3)	
Hair Color			
Brown/Black	245 (58.6)	173 (41.4)	p=0.8
Red/Blonde	71 (57.3)	53 (42.7)	
Age at Time of Transplant (years)	47.7 ± 14.5	44.5 ± 13.6	p=0.002
Age <50	166 (51.7)	155 (48.3)	
Age 50	149 (65.4)	79 (34.6)	
Time to Event (years)	9.9 ± 8.3	10 ± 7.5	

Data presented as n (%) or mean ± SD. p-value by Fisher's exact test or Wilcoxon rank-sum.

Note: Categories may not total to 556 due to missing data points.

Table III

Relative risk of developing squamous cell carcinoma (hazard ratios) based on Fitzpatrick skin type.

	Hazard Ratio[*]	95% CI	P-value
Fitzpatrick Skin Type			
I	3.47	1.46 – 8.28	0.01
II	2.63	1.16 – 5.92	0.02
III	2.79	1.24 – 6.30	0.01
IV	2.07	0.91 – 4.70	0.08
V	1.58	0.66 – 3.81	0.3
Male Sex	1.33	1.04 – 1.71	0.02
Age 50 at Transplant	4.34	3.24 – 5.83	<0.001
Thoracic Organ Transplant	1.32	0.96 – 1.83	0.09

[*] A hazard ratio of >1.0 represents a greater risk for developing squamous cell carcinoma for subjects with a given Fitzpatrick skin type relative to those with Fitzpatrick skin type VI. Linear test for trend p = 0.0006. Models were stratified by race (white versus non-white).

Table IV

Cumulative incidence of SCC by Fitzpatrick skin type.

	5-year	10-year	15-year
Overall	**0.20**	**0.43**	**0.59**
I. Always burns easily, never tans	0.37	0.51	0.68
II. Always burns easily, tans a little	0.15	0.49	0.66
III. Burns moderately, tans gradually	0.31	0.53	0.63
IV. Burns a little, always tans well	0.16	0.37	0.57
V. Rarely burns, tans profusely	0.02	0.26	0.45
VI. Never Burns	0.08	0.08	0.27