

Nomogram to Predict the Benefit of Radiation for Older Patients With Breast Cancer Treated With Conservative Surgery

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This study used the linked Surveillance, Epidemiology, and End Results–Medicare database. The interpretation and reporting of these data are the sole responsibility of the authors.

Authors' disclosures of potential conflicts of interest and author contributions are found at the end of this article.

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ABSTRACT

Purpose

The role of radiation therapy (RT) after conservative surgery (CS) remains controversial for older patients with breast cancer. Guidelines based on recent clinical trials have suggested that RT may be omitted in selected patients with favorable disease. However, it is not known whether this recommendation should extend to other older women. Accordingly, we developed a nomogram to predict the likelihood of long-term breast preservation with and without RT.

Methods

We used Surveillance, Epidemiology, and End Results–Medicare data to identify 16,092 women age 66 to 79 years treated with CS between 1992 and 2002, using claims to identify receipt of RT and subsequent mastectomy. Time to mastectomy was estimated using the Kaplan-Meier method. Cox proportional hazards models determined the effect of covariates on mastectomy-free survival (MFS). A nomogram was developed to predict 5- and 10-year MFS, given associated risk factors, and bootstrap validation was performed.

Results

With a median follow-up of 7.2 years, the overall 5- and 10-year MFS rates were 98.1% (95% CI, 97.8% to 98.3%) and 95.4% (95% CI, 94.9% to 95.8%), respectively. In multivariate analysis, age, race, tumor size, estrogen receptor status, and receipt of RT were predictive of time to mastectomy and were incorporated into the nomogram. Nodal status was also included given a significant interaction with RT. The resulting nomogram demonstrated good accuracy in predicting MFS, with a bootstrap-corrected concordance index of 0.66.

Conclusion

This clinically useful tool predicts 5- and 10-year MFS among older women with early breast cancer using readily available clinicopathologic factors and can aid individualized clinical decision making by estimating predicted benefit from RT.

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INTRODUCTION

Although almost half of breast cancers are diagnosed in women age 65 and older,¹ the importance of radiation therapy (RT) after conservative surgery (CS) remains controversial for this population. In general, RT is recommended for older women to achieve the following two goals: prevention of local recurrence and preservation of the breast. However, multiple clinical trials have shown that risk of locoregional recurrence decreases with age,²⁻⁴ and recent trials have suggested that RT may have minimal benefit for older patients who have a lower baseline recurrence risk.⁵⁻⁸ Specifically, the Cancer

and Leukemia Group B 9343 trial showed that within a highly selected group of patients age 70 and older, despite RT reducing the 10-year risk of locoregional recurrence from 9% to 2% ($P = .015$), RT did not improve mastectomy-free survival (MFS) or overall survival.^{6,7} These data suggest that the small local control benefit from RT may not translate into an improved likelihood of breast preservation or survival. In response, the National Comprehensive Cancer Network modified their guidelines to state that RT may be omitted in women age 70 and older with estrogen receptor (ER)–positive, stage I breast cancer receiving endocrine therapy.⁹

However, important differences may exist between patients treated in routine practice and patients treated on clinical trials, particularly regarding treatment quality, follow-up frequency, and patient compliance with long-term endocrine therapy.¹⁰⁻¹⁷ Accordingly, the impact of omission of RT on the outcomes of patients treated in the general population is not known. Furthermore, it is uncertain whether RT may be omitted in older patients who do not meet the strict criteria outlined in the National Comprehensive Cancer Network guidelines.

To address these questions, we used population-based data to identify clinicopathologic factors associated with failure to pre-

serve the breast, as assessed through a claim for mastectomy occurring after initial breast cancer treatment. We then developed a nomogram based on these factors to predict the likelihood of long-term breast preservation with and without RT. The aim of the present study was to develop a practical clinical tool that could be used for individualized risk assessment and to provide estimates of potential benefit from RT with respect to the end point of MFS.

Patient Demographic or Disease Characteristic	All Patients		Patients Treated With RT		P†
	No.	%*	No.	%*	
Entire cohort	16,092	100.0	14,392	89.4	
Age, years					< .001
66-69	4,563	28.4	4,222	92.5	
70-74	6,123	38.0	5,591	91.3	
75-79	5,406	33.6	4,579	84.7	
Race					< .001
White	14,557	90.5	13,071	89.8	
Hispanic	186	< 2	163	87.6	
Black	813	5.1	661	81.3	
Asian	286	< 2	263	92.0	
Other/unknown	250	< 2	234	93.6	
Comorbidities, No.					< .001
0	9,796	60.9	9,036	92.2	
1	3,682	22.9	3,266	88.7	
≥ 2	1,935	12.0	1,636	84.6	
Unknown	679	4.2	454	66.9	
Year of diagnosis					< .001
1992-1995	3,635	22.6	3,155	86.8	
1996-1999	5,017	31.2	4,502	89.7	
2000-2002	7,440	46.2	6,735	90.5	
Tumor size, cm					< .001
≤ 2.0	13,297	82.6	11,972	90.0	
2.1-5.0	2,668	16.6	2,310	86.6	
> 5.0	127	< 2	110	86.6	
Tumor histology					< .001
Invasive ductal/other/unknown	14,742	91.6	13,175	89.4	
Invasive lobular	1,350	8.4	1,217	90.1	
Tumor grade					< .001
Non-high grade	12,436	77.3	11,083	89.1	
High grade	3,656	22.7	3,309	90.5	
Estrogen receptor status					.010
Positive	13,893	86.3	12,391	89.2	
Negative/borderline	2,199	13.7	2,001	91.0	
Axillary lymph node status					< .001
Clinical node negative	3,038	18.9	2,122	69.9	
Pathologic node negative	10,472	65.1	9,860	94.2	
1-3 positive nodes	2,073	12.9	1,944	93.8	
4-9 positive nodes	364	2.3	339	93.1	
≥ 10 positive nodes	145	< 2	127	87.6	

Abbreviation: RT, radiation therapy.
 *Note that the percentages shown for all patients indicate the percentage of patients in each subgroup of the given clinicopathologic factor, whereas the percentages shown for patients treated with RT indicate the percentage of patients in each subgroup who received RT.
 †P value from Pearson's χ^2 .

Clinical Variable	5 Years		10 Years		P*
	MFS	95% CI	MFS	95% CI	
Entire cohort	98.1	97.8 to 98.3	95.4	94.9 to 95.8	
Demographic characteristics					
Age, years					.005
66-69	97.9	97.4 to 98.3	95.0	94.1 to 95.8	
70-74	97.9	97.5 to 98.2	94.9	94.1 to 95.5	
75-79	98.4	98.0 to 98.7	96.4	95.6 to 97.0	
Race					< .001
White	98.1	97.9 to 98.3	95.5	95.0 to 96.0	
Black	96.5	94.9 to 97.6	91.8	88.7 to 94.1	
Other/unknown	98.8	97.6 to 99.4	96.6	94.4 to 97.9	
Comorbidities, No.					.137
0	98.1	97.8 to 98.3	95.4	94.8 to 95.9	
1	98.3	97.8 to 98.7	95.9	94.8 to 96.7	
2 or more	97.7	96.9 to 98.3	94.2	92.3 to 95.7	
Unknown	97.4	95.8 to 98.5	94.9	92.5 to 96.6	
Year of diagnosis					.038
1992-1995	97.6	97.0 to 98.0	94.6	93.8 to 95.4	
1996-1999	98.2	97.8 to 98.6	95.9	95.2 to 96.5	
2000-2002	98.2	97.8 to 98.5	—†		
Disease characteristics					
Tumor size, cm					< .001
≤ 2.0	98.2	98.0 to 98.5	95.6	95.1 to 96.1	
> 2.0	97.1	96.4 to 97.7	94.1	92.7 to 95.2	
Tumor histology					.879
Invasive ductal/other/unknown	98.1	97.8 to 98.3	95.4	94.9 to 95.8	
Invasive lobular	97.9	96.9 to 98.5	95.4	93.5 to 96.7	
Tumor grade					< .001
Non-high grade	98.3	98.1 to 98.6	95.7	92.5 to 96.2	
High grade	97.1	96.4 to 97.6	94.2	93.2 to 95.1	
Estrogen receptor status					< .001
Positive	98.4	98.2 to 98.6	95.9	95.5 to 96.4	
Negative/borderline	95.6	94.6 to 96.4	91.7	90.0 to 93.1	
Axillary lymph node status					.251
Clinical node negative	97.7	97.1 to 98.2	95.7	94.8 to 96.5	
Pathologic node negative	98.3	98.0 to 98.5	95.3	94.7 to 95.8	
Node positive	97.4	96.7 to 98.0	95.3	94.0 to 96.3	
Treatment characteristics					
Receipt of radiation therapy					< .001
No	95.0	93.8 to 96.0	91.1	89.0 to 92.8	
Yes	98.4	98.2 to 98.6	95.8	95.4 to 96.3	

Abbreviation: MFS, mastectomy-free survival.
 *P value from log-rank test.
 †Ten-year estimates could not be provided for this group with maximum follow-up of 9 years.

METHODS

Data and Cohort Selection

The cohort was derived from the Surveillance, Epidemiology, and End Results (SEER)–Medicare database, inclusive of patients diagnosed from 1992 to 2002 (with follow-up through 2007). Consistent with our prior methods,¹⁸ the treatment interval was defined as the 9 months after diagnosis, and the follow-up interval was defined as beginning 10 months after diagnosis and continuing until any of the following events occurred: mastectomy, death, loss to follow-up, or completion of 10 years of follow-up.

Because our prior population-based study suggested that RT is unlikely to benefit women age 80 and older because of the competing risk of nonbreast cancer–related death,¹⁸ the present analysis was limited to women age 66 to 79 years. We identified 93,335 women in this age range diagnosed with breast cancer between 1992 and 2002 with no prior history of cancer. We then excluded patients with lobular carcinoma in situ, nonepithelial histology or no pathologic diagnosis, unknown stage, distant metastasis, bilateral breast cancer or unknown tumor laterality, second breast or any other cancer diagnosed within the treatment interval, death within the treatment interval, and those without Parts A and B Medicare coverage from 12 months before to 9 months after diagnosis. Of the resulting 53,391 women, 27,926 were treated with CS. Type of initial breast surgery was determined from both SEER and Medicare claims data, and the most extensive surgery reported by either source was considered the definitive procedure (Appendix Table A1, online only).

We then excluded 931 women who developed a contralateral breast cancer during the follow-up interval (based on SEER data), because a mastectomy claim does not distinguish between salvage treatment for the initial breast cancer and treatment of a new contralateral cancer. To ensure that all

patients had complete claims data available to identify subsequent mastectomy events, we excluded 2,595 women who lost fee-for-service Part A or B coverage during the follow-up interval, leaving 24,400 women in the CS cohort with adequate follow-up for the outcome of MFS. Finally, we excluded 4,493 women with ductal carcinoma in situ and 3,815 women with missing data (unknown nodal status, tumor size, and/or ER status), yielding a final analytic cohort of 16,092 patients.

Outcome

The primary outcome was MFS after initial therapy. Subsequent mastectomy during the follow-up interval was identified by the billing claim codes listed in Appendix Table A1.

Covariates

Patients were considered to have undergone pathologic axillary assessment if one or more pathologically evaluated nodes were reported by SEER. Patients were considered to have had only a clinical axillary assessment if they had a SEER historic stage of local but no pathologically sampled nodes. Receipt of RT was identified if either SEER or Medicare claims data indicated that the patient received RT (Appendix Table A1). Endocrine therapy data were not available from SEER-Medicare at the time of this study. Clinicopathologic factors examined in this study included patient characteristics (age at diagnosis, year of diagnosis, race, SEER registry, and Charlson comorbidity index calculated using claims as per our prior methods¹⁸), tumor characteristics (size, grade, histology, and ER status), and lymph node involvement. Consistent with our prior methods,¹⁸ age at diagnosis was treated as a categorical variable to reflect current differences in treatment recommendations for patients younger versus older than age 70.^{6,7,9}

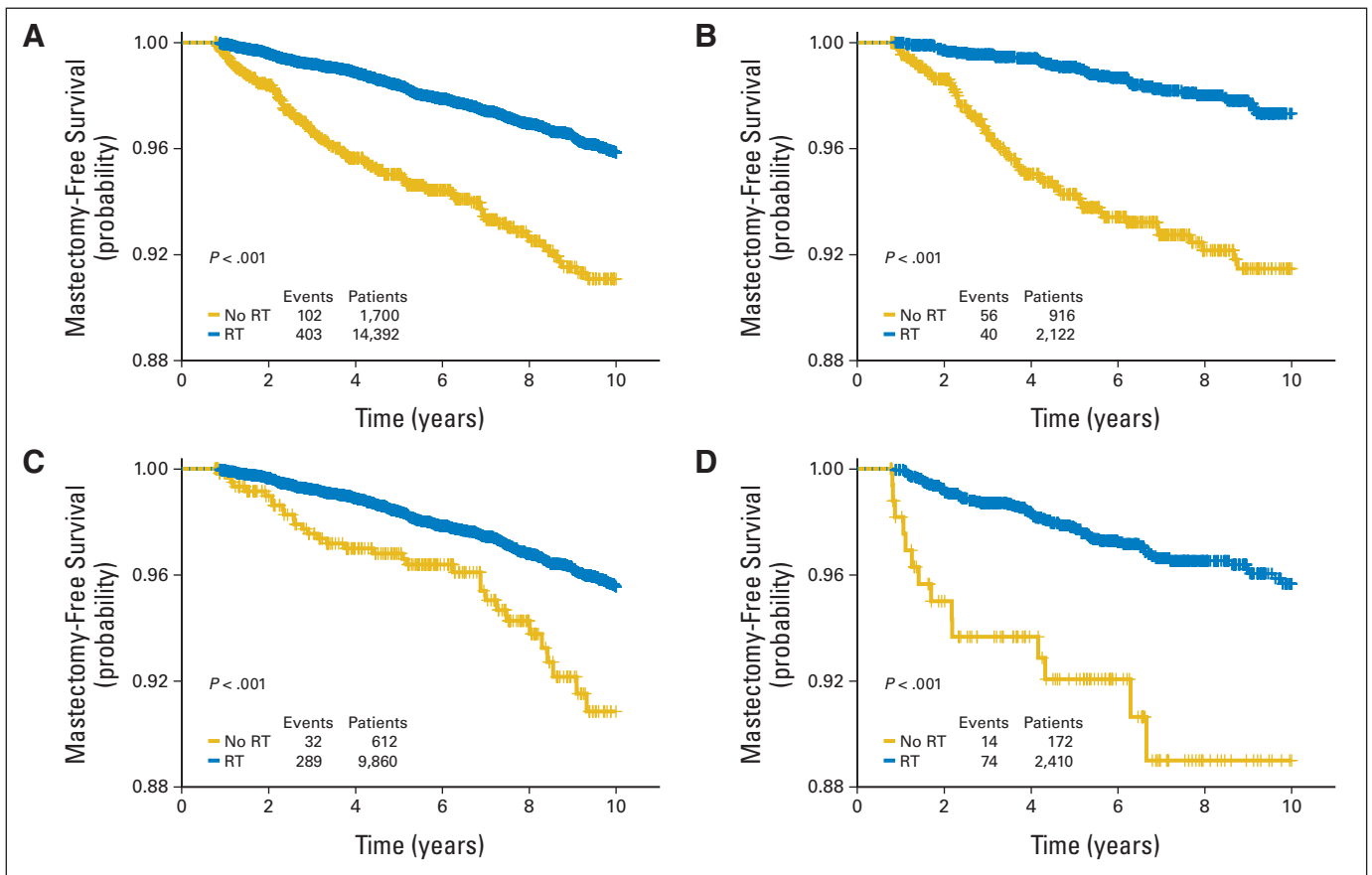


Fig 1. Cumulative risk of mastectomy by receipt of radiation therapy in (A) the entire patient cohort (N = 16,092); (B) patients with clinical node-negative disease; (C) patients with pathologic node-negative disease; and (D) patients with node-positive disease. P value is from the log-rank test. RT, radiation therapy.

Statistical Analysis

The clinical end point for analysis was time from initial therapy to subsequent mastectomy. Data were first summarized using standard descriptive statistics and frequency tabulation. Associations between categorical variables and receipt of RT were assessed with Pearson's χ^2 test. Time to mastectomy was estimated using the Kaplan-Meier method, and the comparisons between or among patient characteristics were assessed using the log-rank test. A multivariate Cox proportional hazards model was applied to estimate the effect of covariates of interest on MFS. A nomogram was developed to predict the risk of patients having a mastectomy 5 or 10 years after initial treatment, given the associated risk factors. We used the bootstrap validation method to estimate the bias-corrected or overfitting-corrected predictive accuracy of the model, which is presented by concordance index (C-index). Calibration curves, which plot the average Kaplan-Meier estimate against the corresponding nomogram for 5- or 10- year predicted MFS (by equally dividing patients into seven groups according to the predicted probability of MFS), are provided to evaluate the performance of the nomogram based on the Cox model. Bootstrap-corrected MFS rates were calculated by averaging the Kaplan-Meier estimates based on 200 bootstrap samples. All computations were carried out in SAS Version 9.2 (SAS Institute, Cary, NC) and S-Plus Version 8.0 (Statistical Sciences, Seattle, WA) or R 2.12.2. This project was granted exempt status by our institutional review board.

RESULTS

Patient Characteristics and Follow-Up

Baseline patient, disease, and treatment characteristics are listed in Table 1. The cohort included 16,092 patients with a median follow-up time of 7.2 years. In this cohort, 28.4% of patients were age 66 to 69 years, 38.0% were age 70 to 74 years, and 33.6% were age 75 to 79 years. The majority of patients were white (90.5%) and had tumors less than or equal to 2.0 cm (82.6%). Additionally, 84% of patients had clinical or pathologic node-negative disease, and 16% had node-positive disease. Grade was low or intermediate in 77.3% and high in 22.7% of tumors, and ER status was positive in 86.3% and negative or borderline in 13.7% of tumors. The majority of patients (89.4%) received RT as part of their initial breast-conserving treatment (Table 1).

Factors Associated With MFS

In total, 505 patients (3.1%) underwent a subsequent mastectomy, yielding 5- and 10-year Kaplan-Meier MFS estimates of 98.1% (95% CI, 97.8% to 98.3%) and 95.4% (95% CI, 94.9% to 95.8%), respectively. On univariate analysis, the clinicopathologic factors most strongly associated with longer MFS were older age, nonblack race, smaller tumor size, non-high-grade histology, ER positivity, and receipt of RT. The 10-year MFS rate was 95.8% (95% CI, 95.4% to 96.3%) for patients who received RT and 91.1% (95% CI, 89.0% to 92.8%) for patients who did not (Table 2, Fig 1A).

On multivariate analysis, younger age, black race, and larger tumor size remained associated with higher mastectomy risk (Table 3). When developing the multivariate model, a significant association was noted between tumor grade and ER status; 92% of non-high-grade tumors were also ER positive, whereas only 67% of high-grade tumors were ER positive ($P < .001$). Given this association, only ER status was included in the final model, and this remained a strong predictor of subsequent mastectomy. Additionally, although axillary nodal status was not associated with mastectomy risk, a significant interaction was noted between nodal status and RT ($P = .03$); that is, the effect size of RT varied by nodal status. RT was associated with a

Table 3. Multivariate Model for Risk of Mastectomy

Variable	Hazard Ratio	95% CI	P
Age, years			
75-79	1		
70-74	1.53	1.22 to 1.90	< .001
66-69	1.40	1.11 to 1.78	.006
Race			
White	1		
Black	1.52	1.11 to 2.09	.009
Other/unknown	0.77	0.47 to 1.24	.282
Tumor size, cm			
≤ 2.0	1		
> 2.0	1.29	1.04 to 1.61	.023
Estrogen receptor status			
Positive	1		
Negative/borderline	2.27	1.85 to 2.78	< .001
Nodal status*			
			.168
Receipt of RT*			
			< .001
Interaction terms			
Nodal status and RT			.030
Receipt of RT by nodal status			
Clinical node negative			
No	1		
Yes	0.24	0.16 to 0.35	< .001
Pathologic node negative			
No	1		
Yes	0.49	0.34 to 0.70	< .001
Node positive			
No	1		
Yes	0.30	0.17 to 0.53	< .001

Abbreviation: RT, radiation therapy.

*Hazard ratios are not shown for the primary effects of nodal status and RT because the significant interaction between these two covariates indicates that hazard ratios for receipt of RT are different by nodal status. Accordingly, hazard ratios for RT by nodal status are presented.

greater reduction in subsequent mastectomy risk for patients with node-positive disease (hazard ratio [HR], 0.30; 95% CI, 0.17 to 0.53; $P < .001$) and those with only clinically assessed node-negative disease (HR, 0.24; 95% CI, 0.16 to 0.35; $P < .001$) as compared with patients with pathologically confirmed node-negative disease (HR, 0.49; 95% CI, 0.34 to 0.70; $P < .001$). Figure 1 shows Kaplan-Meier curves for MFS for the overall cohort by receipt of RT (Fig 1A), as well as the differential benefit from RT by nodal status (Figs 1B to 1D).

Nomogram Development

A nomogram to predict 5- and 10-year MFS was developed using the results from the multivariate analysis (Figs 2 and 3). Because age, race, tumor size, ER status, and receipt of RT were predictive of time to mastectomy on multivariate analysis (Table 3), these variables were included in the nomogram. Moreover, because the effect size of RT was dependent on axillary nodal status, the magnitude of this difference was incorporated into the model. A weighted total score is calculated from these factors, which is used to provide estimates of 5- and 10-year MFS.

Internal Validation of the Model

The resulting model was internally validated using the bootstrap validation method. The model demonstrated good accuracy for predicting MFS, with an unadjusted C-index of 0.662 and a bootstrap-corrected C-index of 0.655. Calibration curves for 5- and 10-year MFS

Prediction of RT Benefit in Older Patients With Breast Cancer

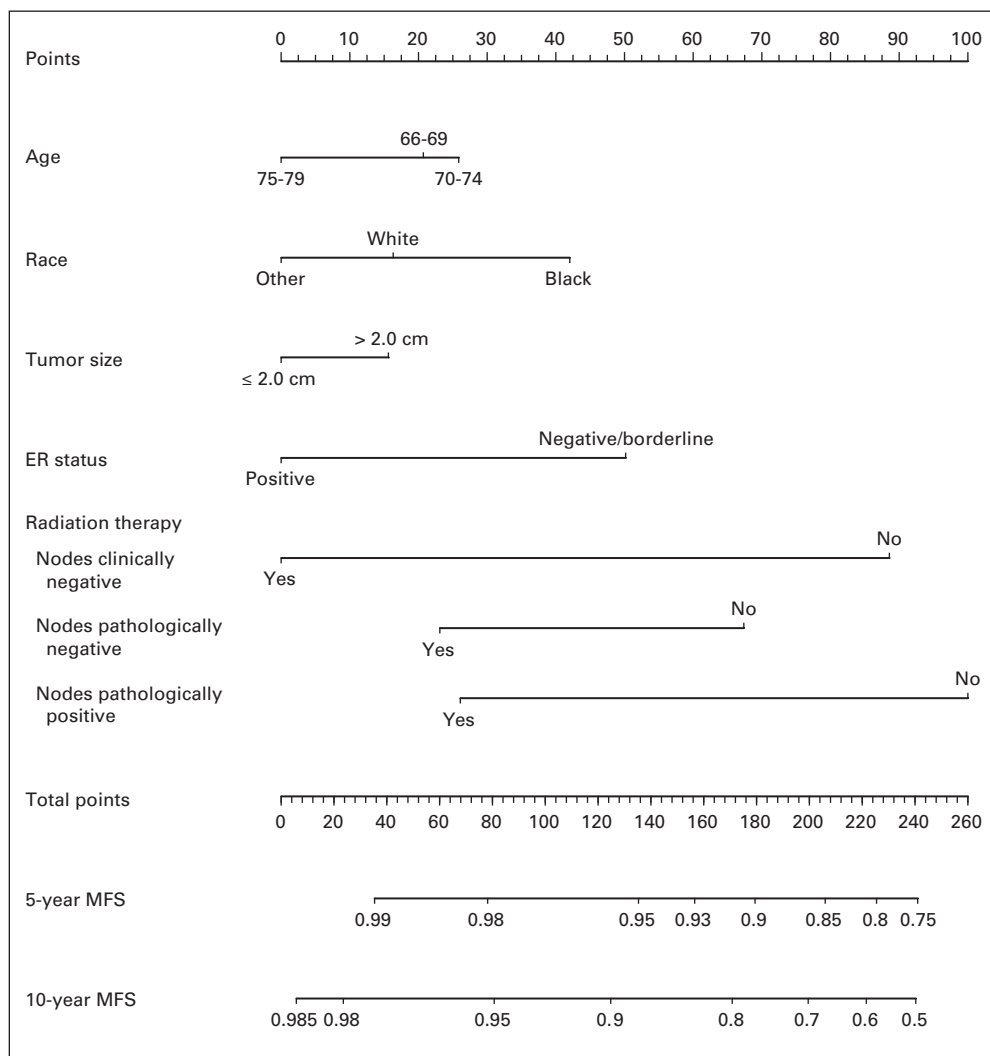


Fig 2. Nomogram for predicting 5- and 10-year mastectomy-free survival (MFS) after conservative surgery. To calculate probability of MFS, first determine the value for each factor by drawing a vertical line from that factor to the points scale. Then sum all of the individual values and draw a vertical line from the total points scale to the 5- and 10-year MFS probability lines to obtain MFS estimates. For radiation therapy (yes/no), the points assigned should be chosen based on whether the patient’s nodes were clinically negative (and pathologically not sampled), pathologically negative, or pathologically positive. One and only one of these three options should be selected. The “yes/no” adjacent to each of these three options refers to whether the patient received radiation therapy not to their nodal status. For example, if a patient received radiation therapy and was clinically node negative, then 0 points are given for radiation therapy (yes/no). In contrast, if a patient did not receive radiation and was pathologically node positive, then 100 points are given for radiation therapy (yes/no). ER, estrogen receptor.

estimates revealed acceptable model calibration, with good correlation between the MFS estimates from the nomogram and those derived from Kaplan-Meier estimates (Fig 3).

DISCUSSION

Substantial controversy exists regarding the appropriate indications for RT in older women with early breast cancer. Although several recent clinical trials have attempted to define subgroups of older patients for whom RT may be safely omitted,⁵⁻⁸ the extent to which these findings should impact current clinical practice continues to be debated.^{19,20} Furthermore, these trials have included highly selected patients with the most favorable disease characteristics, limiting the applicability of these data to the majority of older patients with early breast cancer who do not meet such strict criteria. To help guide management decisions in this population, we used a population-based cohort to develop a nomogram to estimate 5- and 10-year MFS among older women with early breast cancer treated with CS using readily available clinicopathologic factors.

In addition to providing estimates of baseline probability of MFS, our nomogram also provides individualized estimates of

potential benefit from RT. For example, a 75-year-old (0 points) white woman (17 points) with a 1.5-cm ER-positive tumor (0 points) and pathologically confirmed node-negative disease who underwent RT (23 points) has a total of 40 points, yielding an estimated 10-year MFS of 97%. If this same patient did not receive RT, the estimated 10-year MFS rate would be 95%, suggesting a small benefit from RT for this patient. Considering the potential morbidity,⁶ cost,²¹ and inconvenience of RT, this particular patient may choose to avoid RT given the minimal expected benefit. However, a 70-year-old woman (26 points) of black race (42 points) with a 1.5-cm ER-positive tumor (0 points) and node-positive disease who underwent RT (26 points) would have a total score of 94 and a corresponding 10-year MFS of 93%. However, if this patient did not receive RT, the total score would increase to 168 points, and the estimated 10-year MFS is only 81%, suggesting that RT is associated with a much greater benefit for this patient.

Determining the specific indications for RT in older patients is a considerable task that will continue to increase in significance as the population ages. Notably, a 57% increase in breast cancer diagnoses in older women has been projected in the United States over the next two decades,²² underscoring the clinical and public health significance of

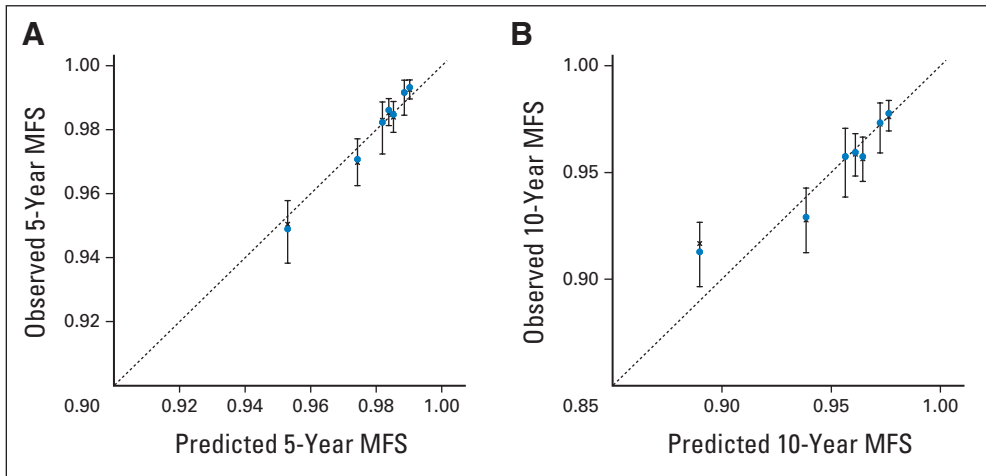


Fig 3. Nomogram model calibration curves: (A) 5-year and (B) 10-year nomogram calibration curves. The cohort was divided into seven equal groups according to predicted probability of mastectomy-free survival (MFS). The dashed line represents the ideal fit, where nomogram-predicted probability (x-axis) matches the observed probability from Kaplan-Meier estimates (y-axis). Blue circles represent nomogram-predicted probabilities for each group, and X's represent the bootstrap-corrected estimates. Error bars represent the 95% CIs of these estimates.

determining appropriate adjuvant therapies for this large and heterogeneous group of patients.

Although the nomogram model demonstrated good accuracy for predicting MFS, there are several limitations to the data that must be considered. Specifically, the use of retrospective data introduces the possibility of treatment selection bias. Moreover, 90% of patients in the study cohort were white, whereas only 5% were black and less than 2% were Hispanic, Asian, or had other/unknown race, so MFS estimates may be less precise for patients of nonwhite race. Additionally, the relatively low percentages of patients who did not receive RT, had node-positive disease, or had tumors greater than 2 cm, combined with a median follow-up of 7.2 years, limit the accuracy of 10-year MFS estimates for patients at higher risk of subsequent mastectomy. As with any predictive model, the point estimates have an inherent range of uncertainty, and the size of this range increases for patients who do not have disease profiles typical of those used to generate the model.²³ However, the bootstrap-corrected C-index of 0.66 suggests a sufficient level of accuracy and is comparable to other accepted cancer nomograms, in which C-indices generally range from 0.6 to 0.8.²⁴⁻²⁹ Furthermore, our C-index of 0.66 compares favorably to other breast cancer-specific risk predictors, including the National Cancer Institute Gail model (C-index, 0.58),³⁰ Adjuvant! Online (C-index, 0.56 to 0.61),³¹ Oncotype DX (C-index, 0.69),³¹ and the recently published nomogram from the Memorial Sloan-Kettering Cancer Center that predicts the risk of local recurrence after breast-conserving surgery for ductal carcinoma in situ (C-index, 0.69).²⁶

Another limitation is that endocrine therapy data were not available and were therefore not included in the nomogram. Treatment with endocrine therapy could be a confounder, because it has been shown to reduce local recurrence risk by approximately half.^{32,33} Accordingly, recent clinical trial data have suggested that endocrine therapy may be an adequate substitute for RT in certain highly selected older women with favorable disease.^{6,7} However, although compliance with endocrine therapy is likely high within the clinical trial population, noncompliance is common in general practice, with recent data indicating that approximately three quarters of patients will not fully comply with 5 years of endocrine therapy.^{13-16,34} Thus, the MFS risk estimates reported by clinical trials evaluating endocrine therapy as a substitute for RT may not completely translate outside the clinical trial setting. Within this context, the MFS risk

estimates reported by this nomogram gain added importance, because they are reflective of outcomes as they actually occur in routine practice given real-world compliance with endocrine therapy.

Although it would seem desirable to include receipt of endocrine therapy as a predictor variable in this nomogram, the available literature indicates that compliance with endocrine therapy can be difficult to predict at the time of locoregional treatment decisions.^{13-16,34-37} Thus, it is not clear that adjusting for intended use of endocrine therapy would improve the clinical utility of this nomogram, because treating physicians cannot accurately predict this variable at the outset of treatment. Nevertheless, it is important to highlight that this nomogram computes the expected MFS risk given average compliance with endocrine therapy and may slightly over- or underestimate the risk of mastectomy in patients whose compliance varies substantially from the population-based norm. Finally, it is important to note that this nomogram was not specifically designed to quantify the trade-offs between endocrine therapy alone versus RT alone because endocrine therapy was likely commonly recommended both for patients who did and did not receive RT.

In summary, we used population-based data to develop a nomogram to estimate 5- and 10-year MFS among older women with early breast cancer treated with CS. This clinically useful tool uses readily available clinicopathologic factors to estimate the probability of MFS and can further aid individualized clinical decision making by estimating the potential benefit from RT for this large and growing patient population. Given that indications for RT remain unclear and continue to be debated for older patients, this nomogram will be useful to patients and physicians when evaluating adjuvant treatment options. Future prospective studies are needed to more accurately determine the risk of recurrence for different subgroups of older patients with early breast cancer and further refine indications for RT in this population.

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

Although all authors completed the disclosure declaration, the following author(s) and/or an author's immediate family member(s) indicated a financial or other interest that is relevant to the subject matter under consideration in this article. Certain relationships marked with a "U" are

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Collection and assembly of data: Jeffrey M. Albert, I-Wen Pan, Benjamin D. Smith

Data analysis and interpretation: All authors

Manuscript writing: All authors

Final approval of manuscript: All authors

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