The Trade-Off of Post-Mastectomy Radiotherapy Usage for the Breast Cancer Patients Aged 70 Years or Older: A Study Based on SEER Database

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Research

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Abstract

Introduction: This study aimed to investigate the role of post-mastectomy radiotherapy (PMRT) in the female aged 70 years or older diagnosed with breast cancer, which is still controversial.

Methods: This retrospective study enrolled women aged 70+ years diagnosed with breast cancer between 2004 and 2016 following mastectomy from the Surveillance, Epidemiology, and End Results (SEER) database. Propensity score matching (PSM) was performed to reduce covariable imbalance. A nomogram was created to predict the 1,3,5-years overall survival (OS) of elderly patients based on the the univariable and multivariable COX regression model results. The X-tile software determined the optimal cutoff value of risk scores from the nomogram and divided patients into three risk groups.

Results: Of the 27,636 females were eligible, 17.2% (n=4,747) received PMRT while 82,8% (n=22889) not. After 1:1 matching, PMRT were associated with significant improvement in breast cause-specific survival (BCSS) and OS (p <0.001). By contrast, the BCSS and OS benefit from PMRT were not significant in patients with T1N1 tumor (BCSS：HR = 0.716，p = 0.249；OS：HR = 0.908，p = 0.572), and T2N1 tumor (BCSS：HR = 0.866，p = 0.289；OS：HR = 0.879，p = 0.166). Stratified by subtype, the HR+/HER-2- subtype and the HR-/HER-2- subtype (all p<0.001) have a significant prolonged survival, yet not significant difference are shown in the HER-2+ tumor. The nomogram has high predictive accuracy and discrimination, and well distinguish three risk groups. In the low-risk group, PMRT didn't significantly better OS (p=0.203).

Conclusions: This study demonstrated that post-mastectomy radiotherapy improves the survival of females with elderly breast cancer. After a comprehensive assessment of the side effects and the quality of life, the omission of PMRT could be considered in patients with T1-2N1 breast cancer. Furthermore, the nomogram we constructed could be used as a decision tool for the omission of PMRT in low-risk elderly patients.

Introduction

As the most common female malignancy globally, breast cancer accounts for nearly 30% of all tumors diagnosed in female patients.[1] With the worldwide population aging gradually, the burden of tumors continues to increase, and the elderly malignancy grows to be a non-negligible health issue worldwide. It is reported that almost half of breast cancer-specific deaths occur in female patients aged 70 or over.[2] A 2019 study about global cancer incidence estimated that the number of newly diagnosed cancer in the elderly population would be double by 2035, from 2.8 to 5.7 million among elderly females. By 2035, 58% of the total cancer incidence globally will happen in older people.[3]

As a primary treatment of local therapy, the appropriate usage of radiotherapy can reduce the local recurrence rate and prolong survival. In a pity, limited category I evidence to date has demonstrated the role of postmastectomy radiotherapy in the cohort of elderly female patients.[4] The majority of recommendations are composed of extrapolation from analyses in all-age patients.[5] NCCN guidelines

supported postmastectomy radiotherapy for patients with 4 or more positive lymph nodes, and "strongly recommended" for those with 1–3 positive lymph nodes. Although multiple cancer care guidelines recommending its usage had been published, no improved usage rate in PMRT was observed between 1999 and 2005. Indeed, only 54.8% of high-risk (T3/T4 and/or N2/N3) patients received PMRT.[6]

It was considered in the past that PMRT was associated with some long-time side effects, such as cardiovascular system diseases, secondary cancer, and arm lymphedema, which shouldn't be ignored. However, with the advancement of radiotherapy techniques, the death risk from side effects caused by PMRT has significantly decreased over time.[7, 8] On the other hand, in the era of increasingly effective comprehensive systematic therapy, the status of PMRT use is being challenged.[9, 10] Based on the above considerations, the impact of PMRT on elderly breast cancer patients should be reassessed, especially for low-risk patients.

This study used data from Surveillance, Epidemiology, and End Results Program (SEER) database, aiming to investigate the role of post-mastectomy radiotherapy in females aged 70 years or older diagnosed with breast cancer. On this basis, we further constructed a nomogram to predict the prognosis of elderly breast cancer patients for the sake of identifying the population who could omit PMRT safely.

Methods

Population

Women aged 70 years or more diagnosed with breast cancer between 2004 and 2016 following mastectomy extracted from the Surveillance, Epidemiology, and End Results Program (SEER) database met the inclusion criteria. The exclusion criteria are as follows: M1, bilateral, special histological types, multiple primary carcinomas, unknown histology grade, autopsy or death certificate only, pre-and intraoperative radiation, unknown ER/PR status, unknown marital status and race, and unknown examined lymph nodes number. Data included in the calculations contains age at diagnosis, race, marital status, laterality, histology grade, AJCC T stage, AJCC N stage, chemotherapy status, ER and PR status, HER-2/neu status, and subtype.

Statistical analysis

Based on with or without PMRT, patients were divided into PMRT cohort and non-PMRT cohort. In the survival analysis, breast cancer-specific survival (BCSS) was defined as the time from first diagnosed to die of breast cancer, overall survival (OS) was defined as the time from first diagnosed to all-cause death or the date of the last follow-up. Propensity score matching (PSM) was applied to control confounding factors such as selection bias to make two cohorts comparable. The difference in baseline clinicopathological characteristics before and after PSM were compared by Chi-square and Fisher’s exact probability tests. After PSM, standardized mean difference (SMD) <10% was considered a sufficient balance criterion.[11] Patients in the non-PMRT cohort were randomized into a training cohort and a validation cohort in a 7:3 ratio. Independent prognostic variables that could influence outcomes were

assessed by the univariable and multivariable COX regression model. Accordingly, a nomogram was created to predict the 1,3,5-years OS of patients. The discrimination of the nomogram was evaluated using the concordance index (C-index), and calibration curves were formulated to assess the consistency between predicted and actual outcomes. The X-tile software determined the optimal cutoff value of risk scores from the nomogram and divided patients into three groups (low risk, moderate risk, and high risk). [12] Statistical analyses were performed by R statistical software (version 4.0.3, http://www.R-project.org/.) and SPSS (version 22.0).

Results

Clinicopathological characteristics

Of the 27,636 women met all criteria for inclusion and exclusion, 17.2% (n=4,747) received PMRT while 82,8% (n=22889) not. The median follow-up time was 73 months. Clinicopathological characteristics among two arms before PSM are presented in Tab. 1. Overall, patients who received radiotherapy were more likely to be invasive tumors with younger age, higher grades, larger tumor size, more positive lymph nodes, and negative hormone receptor status. There was a significant variation of adjuvant radiotherapy utilization among age groups, which decreased from 19.7% in patients aged 70-74 years to 12.6% in patients aged 85 years or older. A reduction of PMRT usage was also observed in different hormone receptors status, from 18.3% in the ER- group to 16.9% in the ER+ group and from 18.5% in the PR- group to 16.5% in the PR+ group. Additionally, the proportions of patients who received versus not received chemotherapy in the non-PMRT arm were 17.4% versus 82.6%, while that in the PMRT arm were similar (51.3% versus 48.7%). Conversely, there was no statistical difference in race and laterality between patients treated with and without adjuvant radiotherapy.

Table 1
Baseline characteristics of elderly patients with breast cancer before and after PSM.

Characteristics	Before PSM			After PSM			
	Non-PMRT (N=22889)	PMRT (N=4747)	P value	Non-PMRT (N=3777)	PMRT (N=3777)	P value	SMD
Age group at diagnosis, y			<0.001			0.586	0.032
70-74	8028 (35.1)	1970 (41.5)		1476 (39.1)	1527 (40.4)		
75-79	6634 (29.0)	1406 (29.6)		1123 (29.7)	1079 (28.6)		
80-84	4869 (21.3)	883 (18.6)		745 (19.7)	731 (19.4)		
85+	3358 (14.7)	488 (10.3)		433 (11.5)	440 (11.6)		
Race			0.156			0.637	0.022
White	18868 (82.4)	3906 (82.3)		3183 (84.3)	3154 (83.5)		
Black	2054 (9.0)	460 (9.7)		346 (9.2)	358 (9.5)		
Others	1967 (8.6)	381 (8.0)		248 (6.6)	265 (7.0)		
Marital Status			<0.001			0.981	0.001
Married	9252 (40.4)	2057 (43.3)		1547 (41.0)	1549 (41.0)		
Unmarried	13637 (59.6)	2690 (56.7)		2230 (59.0)	2228 (59.0)		
Laterality			0.874			0.982	0.001
Left	11821 (51.6)	2445 (51.5)		1959 (51.9)	1957 (51.8)		
Right	11068 (48.4)	2302 (48.5)		1818 (48.1)	1820 (48.2)		
Grade			<0.001			0.988	0.004
Grade I	4340 (19.0)	543 (11.4)		399 (10.6)	402 (10.6)		

PMRT=post-mastectomy radiotherapy; ER=estrogen receptor; PR=progesterone receptor; PSM=propensity score matching; SMD=standardized mean difference

Characteristics	Before PSM			After PSM			
	Non-PMRT (N=22889)	PMRT (N=4747)	P value	Non-PMRT (N=3777)	PMRT (N=3777)	P value	SMD
Grade II	10491 (45.8)	2108 (44.4)		1694 (44.9)	1697 (44.9)		
Grade III+IV	8058 (35.2)	2096 (44.2)		1684 (44.6)	1678 (44.4)		
T			<0.001			0.591	0.032
T0/T1	11500 (50.2)	866 (18.2)		735 (19.5)	746 (19.8)		
T2	9134 (39.9)	2197 (46.3)		1902 (50.4)	1859 (49.2)		
T3	1395 (6.1)	1036 (21.8)		749 (19.8)	748 (19.8)		
T4	860 (3.8)	648 (13.7)		391 (10.4)	424 (11.2)		
N			<0.001			0.506	0.035
N0	14966 (65.4)	975 (20.5)		899 (23.8)	943 (25.0)		
N1	5659 (24.7)	1685 (35.5)		1514 (40.1)	1465 (38.8)		
N2	1460 (6.4)	1347 (28.4)		882 (23.4)	868 (23.0)		
N3	804 (3.5)	740 (15.6)		482 (12.8)	501 (13.3)		
ER			0.017			0.909	0.003
Negative	4462 (19.5)	998 (21.0)		776 (20.5)	771 (20.4)		
Positive/Borderline	18427 (80.5)	3749 (79.0)		3001 (79.5)	3006 (79.6)		
PR			<0.001			0.262	0.026
Negative	7549 (33.0)	1719 (36.2)		1365 (36.1)	1413 (37.4)		

PMRT=post-mastectomy radiotherapy; ER=estrogen receptor; PR=progesterone receptor; PSM=propensity score matching; SMD=standardized mean difference

Characteristics	Before PSM			After PSM			
	Non-PMRT (N=22889)	PMRT (N=4747)	P value	Non-PMRT (N=3777)	PMRT (N=3777)	P value	SMD
Positive/Borderline	15340 (67.0)	3028 (63.8)		2412 (63.9)	2364 (62.6)		
Chemotherapy			<0.001			0.531	0.015
No/Unknown	18902 (82.6)	2311 (48.7)		2157 (57.1)	2129 (56.4)		
Yes	3987 (17.4)	2436 (51.3)		1620 (42.9)	1648 (43.6)		

PMRT=post-mastectomy radiotherapy; ER=estrogen receptor; PR=progesterone receptor; PSM=propensity score matching; SMD=standardized mean difference

Propensity score matching and subgroup analysis

After propensity score matching in a 1:1 ratio, there were 3,777 patients in each arm, and the clinicopathological characteristics across two arms were well-balanced in terms of these matched characteristics (all SMD<10%, Tab. 1). In whole cohort, as shown in Fig. 2, PMRT was associated with significant improvement in terms of BCSS (HR = 0.790, 95%CI 0.715-0.874, p<0.001) and OS (HR = 0.755, 95%CI 0.701-0.813, p<0.001).

To further identify patients who may benefit from PMRT, subgroup analyses were performed on the basis of clinicopathological factors, especially tumor size, number of positive lymph nodes, and subtype. Fig. 3 demonstrates that the overall survival benefit from PMRT observed in the most of different subgroups were consistent, except for patients with grade I tumor (HR=0.702, 95%CI 0.453-1.089, p=0.114), and patients with negative lymph nodes (N0, HR=0.985, 95%CI 0.729-1.331, p=0.921), the overall survival of those patients didn't show the difference.

Based on these above findings, patients were further divided into various subgroups according to tumor size and the number of positive lymph nodes (shown in Fig. 3) to investigate the possible omission of PMRT in certain populations. Results show that the benefit from PMRT on breast cancer-specific survival and overall survival were not statistically significant in patients with T1N1 tumor (BCSS: HR=0.716, 95%CI 0.406-1.263, p=0.249; OS: HR=0.908, 95%CI 0.648-1.270, p=0.572, Fig. 2), consistent with results in patients with T2N1 tumor (BCSS: HR=0.866, 95%CI 0.664-1.130, p=0.289; OS: HR=0.879, 95%CI 0.732-1.055, p=0.166, Fig. 2). In further analyses for T1-2N1 breast cancer, shown in Fig. 4, results were consistent in different positive numbers of lymph nodes groups, different HR status groups, different grade groups, and different subtype groups.

To illustrate the effects of PMRT on prognostic outcomes among different subtype groups, we conducted a rematch in a 1:1 ratio by adjustment for age at diagnosis, race, marital status, grade, T and N

classification, chemotherapy, and subtype. As shown in Fig. 4, there are significant improvement on BCSS and OS of PMRT for the HR+/HER-2- subtype (BCSS: p=0.001; OS: p<0.001), and the HR-/HER-2- subtype (BCSS: p=0.004; OS: p<0.001). A tendency for BCSS benefit associated with radiotherapy was observed for the HR+/HER-2+ subtype (p=0.061) without statistical significance. But no BCSS and OS difference were observed in the HR-/HER-2+ subtype (BCSS: p=0.405; OS: p=0.121).

Establishment of a Prognostic Nomogram

The results of univariable and multivariable analysis were shown in Tab. 2. Age, race, marital status, histology grade, T stage, N stage, ER status, PR status, and given chemotherapy were independent prognostic factors for the overall survival of elderly breast cancer patients in the non-PMRT cohort (all p<0.001). A total of 22,889 patients in the non-PMRT cohort were randomized into the training cohort and the validation cohort in a 7:3 ratio. A nomogram was created to predict the 1-year, 3-year, and 5-year OS of patients by all the above independent prognostic factors (Fig. 5). The prediction nomogram had an acceptable discrimination capacity of distinguishing between alive and dead patients (C-index was 0.72). The 1-year, 3-year, and 5-year calibration curves demonstrated excellent agreement across prediction and actual observation in the training and validation cohorts (Fig. 5).

Table 2
Prognostic factors for OS in elderly patients without PMRT by univariable and multivariable analysis.

Characteristics	Univariable			Multivariable		
	Hazard ratio	95%CI	*P* value	Hazard ratio	95%CI	*P* value
Age group at diagnosis, y			0.000			0.000
70-74	Reference			Reference		
75-79	1.535	1.440-1.637	0.000	1.449	1.359-1.546	0.000
80-84	2.440	2.291-2.600	0.000	2.133	1.998-2.277	0.000
≥85	4.241	3.975-4.525	0.000	3.162	2.949-3.390	0.000
Race			0.000			0.000
White	Reference			Reference		
Black	1.199	1.113-1.290	0.000	1.360	1.236-1.497	0.000
Others	0.656	0.596-0.721	0.000	1.510	1.344-1.697	0.000
Marital Status			0.000			0.000
Married	Reference			Reference		
Unmarried	1.708	1.629-1.791	0.000	1.270	1.209-1.334	0.000
Laterality			0.512			
Left	Reference					
Right	0.986	0.944-1.029	0.512			
Grade			0.000			0.000
Grade I	Reference			Reference		
Grade II	1.325	1.240-1.417	0.000	1.101	1.029-1.178	0.005
Grade III+IV	1.899	1.776-2.030	0.000	1.337	1.243-1.439	0.000

PMRT=post-mastectomy radiotherapy; ER=estrogen receptor; PR=progesterone receptor; OS=overall survival

Characteristics	Univariable			Multivariable		
	Hazard ratio	95%CI	*P* value	Hazard ratio	95%CI	*P* value
T			0.000			0.000
T0/T1	Reference			Reference		
T2	1.827	1.742-1.917	0.000	1.431	1.360-1.505	0.000
T3	3.151	2.906-3.416	0.000	1.904	1.745-2.077	0.000
T4	4.664	4.260-5.108	0.000	2.343	2.123-2.585	0.000
N			0.000			0.000
N0	Reference			Reference		
N1	1.556	1.479-1.636	0.000	1.381	1.311-1.456	0.000
N2	2.893	2.690-3.110	0.000	2.103	1.945-2.273	0.000
N3	4.649	4.260-5.074	0.000	3.312	3.011-3.642	0.000
ER			0.000			0.000
Negative	Reference			Reference		
Positive/Borderline	0.686	0.652-0.722	0.000	0.817	0.762-0.877	0.000
PR			0.000			0.000
Negative	Reference			Reference		
Positive/Borderline	0.704	0.673-0.736	0.000	0.854	0.805-0.906	0.000
Chemotherapy			0.000			0.000
No/Unknown	Reference			Reference		
Yes	0.803	0.754-0.855	0.000	1.454	1.358-1.558	0.000

PMRT=post-mastectomy radiotherapy; ER=estrogen receptor; PR=progesterone receptor; OS=overall survival

Furthermore, we calculated the risk scores of all patients according to the nomogram, then identified the optimal cut-off value of scores by X-tile software. Accordingly, 27,636 patients were divided into three groups: 12,703 in the low-risk group (risk score < 140), 12067 in the moderate-risk group (risk score: 140-241), and 2,866 in the high-risk group (risk score > 241). The Kaplan-Meier curve demonstrates that patients in the low-risk groups have a better prognosis than the other two groups ($p<0.001$ Fig. 6). Corrected by Cox regression, PMRT was associated with the improved OS of patients in the moderate-risk and high-risk groups, while no OS difference was observed in the low-risk groups ($p=0.203$, Fig. 6), suggesting that this nomogram could sufficiently identify patients who were unable to benefit from PMRT.

Discussion

To critically assess the impact of PMRT in elderly patients, we conducted a large retrospective population-based study in older women from the SEER database and further analyzed various subgroups seeking to offer accurate treatment recommendations depending on various subgroups.

The rather limited category I evidence has demonstrated the impact of PMRT usage in older women, and there is no randomized controlled trial evaluating PMRT in this population. A comparative study about the SEER database from 1992 to 1999 explored the impact of PMRT on elderly breast cancer. Results have shown that PMRT was not associated with improved survival in the whole cohort (adjusted HR 1.03; P=0.49), only favor the patients in the high-risk group (T3/T4 and/or N2/N3).[13] In our study, after adjusting confounding factors by the propensity score matching, PMRT substantially prolongs the breast cancer-specific and overall survival of elderly patients, especially with unfavorable disease features as T3-T4 and/ or N2-N3 stage. It demonstrated that PMRT still improves the outcomes of most elderly patients.

To date, adjuvant radiotherapy for patients with less than four positive lymph nodes has not yet become a consensus. Previous studies, such as the British Columbia randomized trials, the Danish Breast Cancer Cooperative Group (DBCG) protocols 82b and 82c trials, showed the significant improvement of adjuvant radiotherapy on survival. [14–16] A large meta-analysis conducted by the Early Breast Cancer Trialists Collaborative Group (EBCTCG) demonstrated that PMRT could reduce locoregional recurrence, overall recurrence, and breast cancer mortality for women with axillary dissection and 1-3 positive lymph nodes, even when stratified by age. [17] In contrast, at the retrospective analysis of the SEER database (1992-1999), for low-risk (T1/T2 N0) and intermediate-risk (T1/T2 N1) breast cancer, PMRT did not improve survival, while for high-risk (T3/T4 and/or N2/N3) patients, PMRT was associated with a significant improvement in survival ($p =0.02$).[13] However, the EBCTCG analysis evaluated trials that recruited patients from 1964 to 1986, and the retrospective analysis of the SEER database involved patients from 1992 to 1999. This period's systemic therapy and RT treatment differed significantly from the new therapies used in the modern treatment era. Also, the analysis in EBCTCG did not focus on patients with less than 5cm size tumors. Therefore, reevaluating survival outcomes in elderly patients impacted by PMRT is warranted, particularly for those with T1-2N1.

Our study found that there was no significant correlation between PMRT and survival for patients with T1-2N1 tumors, both on BCSS and OS. This finding was consistent with the further analysis of patients with T1-2N1 tumors stratified by different grades, different numbers of positive LNs, different HR statuses, and different subtypes. Contrasting our study, a previous study published by Zhou et al. found that PMRT could improve OS for patients aged 75+ years old with a tumor size of ≤5cm and 1-3 positive lymph nodes.[18] Whereas it is a pity that the population in that study consisted of earlier diagnosed patients (between 1998 and 2005), and the missing data of chemotherapy therapy also could affect the reliability of this study's results. In addition, another recent clinical trial reported by Cao et al. showed that PMRT could not improve the survival outcome for all elderly patients with 1-3 positive lymph nodes. Only an improvement in survival by PMRT was detected in patients with tumors >5 cm,[19] which is supportive of our results. Combined with these results, our findings further confirm the feasibility of separating patients with 5 cm less or above tumor in the discussion of PMRT usage range.

Although molecular subtype has not been recommended to guide the usage of PMRT, this issue has still been discussed in several studies. Few studies analyzed the different roles of PMRT for older patients on the basis of HER2/neu status and molecular subtypes. The DBCCG 82b and 82c trials analyzed the response to PMRT on different subtypes for patients with PMRT. It showed significant overall survival improvement after receiving PMRT was found in the HR+/HER-2- subtype patients, while not found in the HR-/HER-2+ and triple-negative subtype.[20] Another study for patients with T1-2N1 tumors found that HER2 positive patients (including Luminal B and HER2 enriched subtype) did not improve survival, with only a marginal advantage of overall survival observed for the HR+/ HER-2+ group.[21] Our study displayed the benefit from PRMT for HR+/HER-2- and HR-/HER-2- subtype on both BCSS and OS. Interestingly, elderly patients with HER-2+ tumors did not significantly benefit from PMRT, with only a marginal survival advantage was shown for the HR+/ HER-2+ subtype in patients with T1-2N1 tumor. Indeed, some literature reported that overexpressed HER-2 with receipt of RT have an increased recurrence risk than HER-2 negative subtype.[22] These results may be due to individual radioresistance associated with multiple molecular mechanisms in the HER-2 positive subtype.[23]

A key clinical challenge is to determine specific elderly patients who are more likely to benefit from PMRT. Based on the results of the univariable and multivariable analysis in the non-PMRT cohort, we determined its independent prognostic factors (age, race, marital status, histology grade, T stage, N stage, ER status, PR status, and given chemotherapy), and developed a prognostic nomogram to predict OS at 1-, 3-, and 5-years in the non-PMRT cohort. C-index and calibration curves demonstrated its accuracy and discrimination. X-tile helped us to stratify the entire cohort into different risk groups by the optimal cut-off values. Results found that PMRT substantially improves overall survival in the low-risk group, while no survival difference is shown in the moderate- and high-risk groups. To the best of our knowledge, this is the first study to build up a nomogram predicting the effect of PMRT in elderly breast cancer patients based on large sample size.

This study has several limitations: 1) The data of endocrine therapy and targeted therapy was over permission in the SEER database. Also, it does not contain data about the locoregional recurrence rate,

which was a predictor widely used to reflect the local tumor control by radiotherapy; 2) The retrospective nature of this study may lead to selection bias, although PSM has been introduced to minimize baseline differences between the two groups; thus, we need further prospective trials to validate our findings. One prospective randomized trial, the SUPREMO trial, will be reported in 2023, which randomized patients with T1-2N1, T3N0, or T2N0 to be treated with or without postmastectomy radiotherapy.[24]

In conclusion, our study demonstrates that post-mastectomy radiotherapy has a definite role in improving survival for females with elderly breast cancer. After a comprehensive assessment of the side effects and the quality of life, the omission of PMRT could be considered in patients with T1-2N1 breast cancer.

Abbreviations

PMRT: post-mastectomy radiotherapy

PSM: Propensity score matching

BCSS: breast cause-specific survival

OS: overall survival

NCCN: National Comprehensive Cancer Network

ER: estrogen receptor

PR: progesterone receptor

HER-2: human epidermal growth factor receptor 2

SMD: standardized mean difference

Declarations

Ethics approval and consent to participate

Ethical approval

This article does not contain any studies with human participants or animals conducted by any of the authors.

Informed consent

As this study contains data released from published literature, informed consent was not needed.

Consent for publication

No applicable.

Availability of data and materials

All data generated or analysed during this study are included in this published article [and its supplementary information files].

Competing interests

The authors have declared that no competing interests exist.

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Authors' contributions

JYL: Formal analysis, investigation, visualization, writing–original draft and writing - review and editing; SPL: Formal analysis, data curation, methodology, software, writing - review and editing; JZ: Formal analysis, data curation, methodology, supervision, validation, writing - review and editing; CGS: Conceptualization, project administration, resources, supervision, writing - review and editing. All authors read and approved the final manuscript.

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Figures

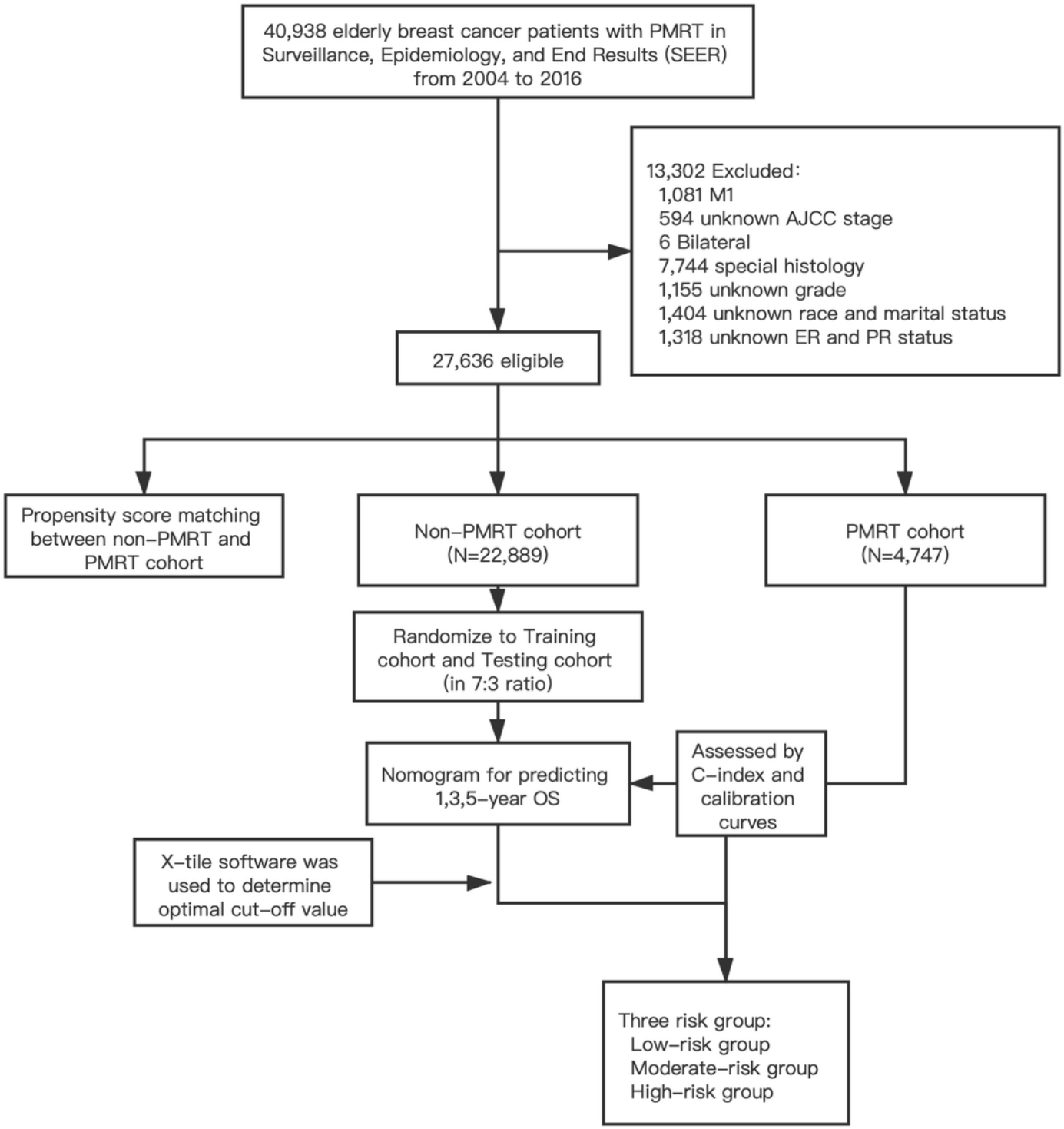

Figure 1

Flowchart of this study design. PMRT: post-mastectomy radiotherapy; ER: estrogen receptor; PR: progesterone receptor.

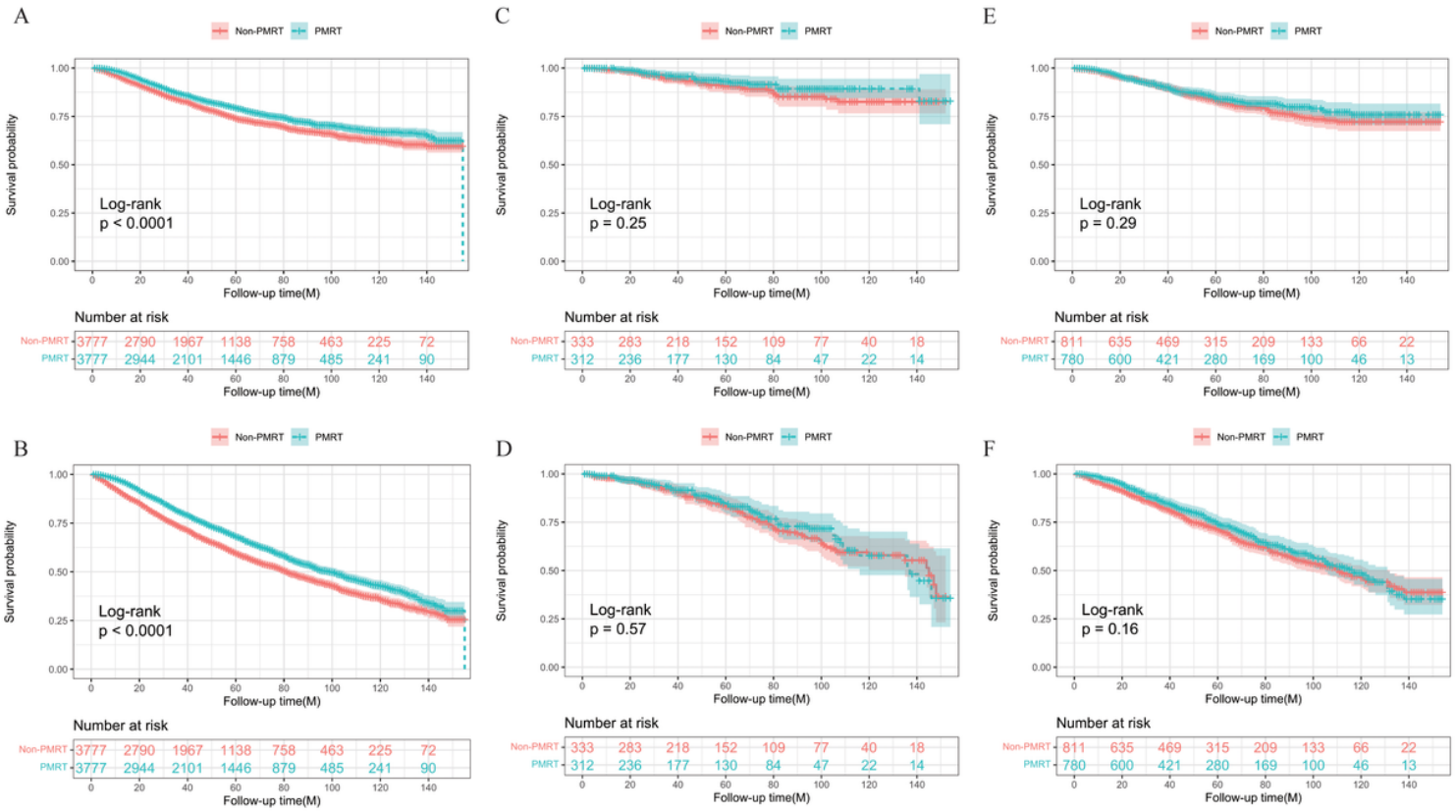

Figure 2

Kaplan-Meier curves for comparing the BCSS and OS of elderly breast cancer patients with or without PMRT. (A) BCSS and (B) OS in the whole cohort; (C) BCSS and (D) OS in the T1N1 tumor group; (E) BCSS and (F) OS in the T2N1 tumor group. BCSS: Breast cause-specific survival; OS: Overall survival; PMRT: Postmastectomy radiotherapy.

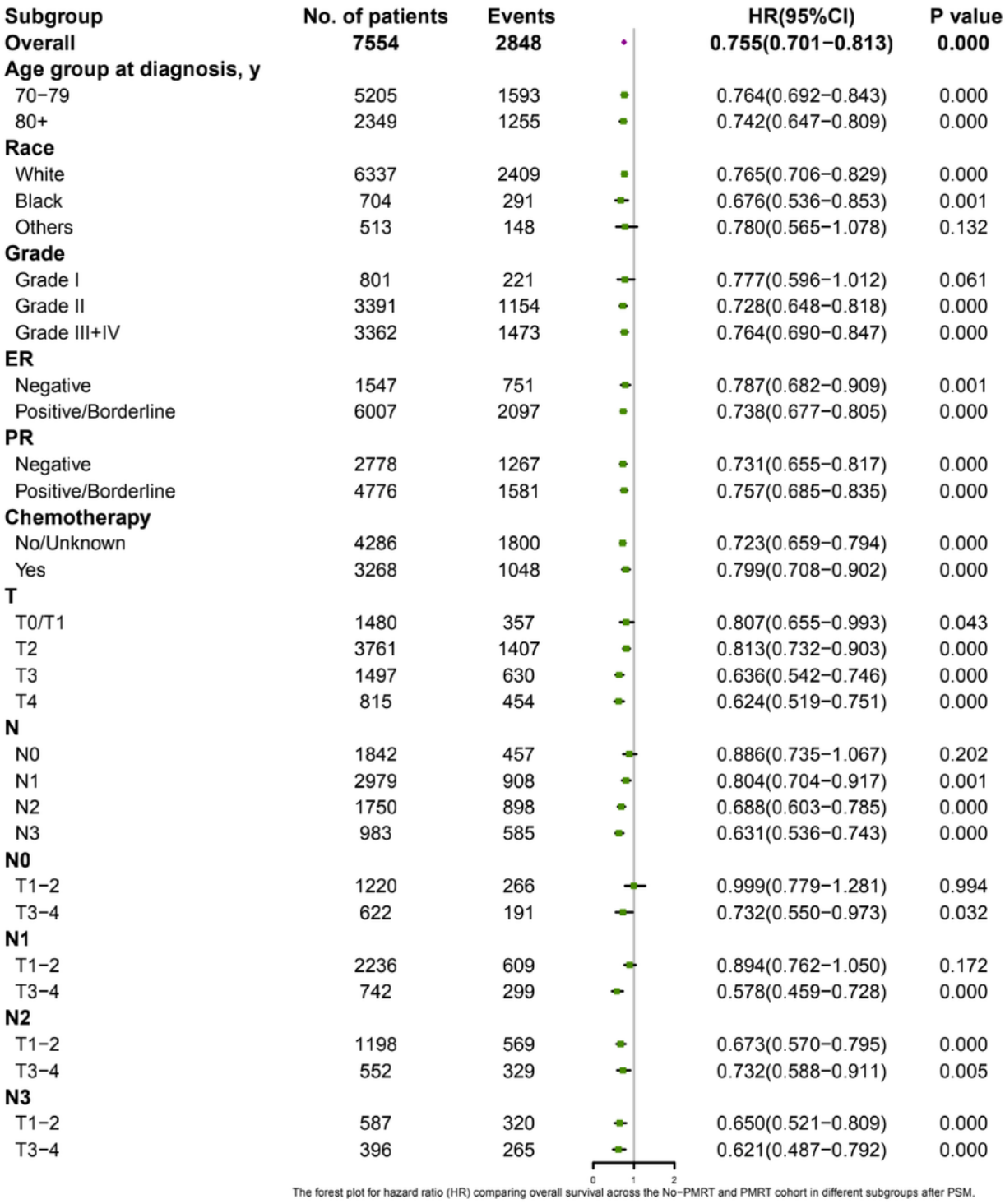

Figure 3

Forest plots of multivariable COX regression analysis for OS in matched patients. PMRT: post-mastectomy radiotherapy; ER: estrogen receptor; PR: progesterone receptor.

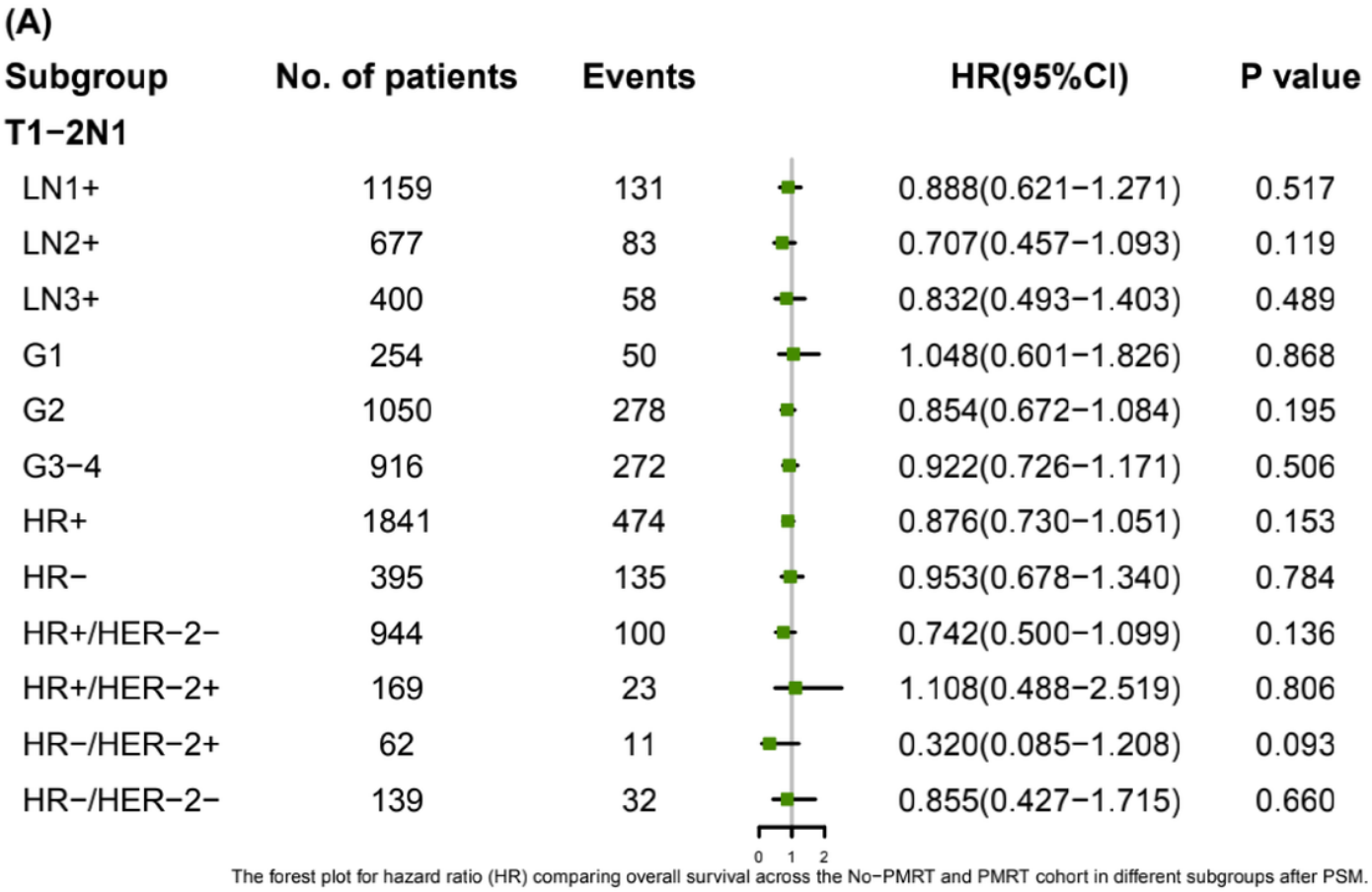

Figure 4

(A) Forest plots of multivariable COX regression analysis for OS in matched patients with T1-2N1 breast cancer; (B) Forest plots of multivariable COX regression analysis for OS in patients rematched by known subtype. LN: lymph node; G: Grade; HR: hormone receptor; HER-2: human epidermal growth factor receptor 2.

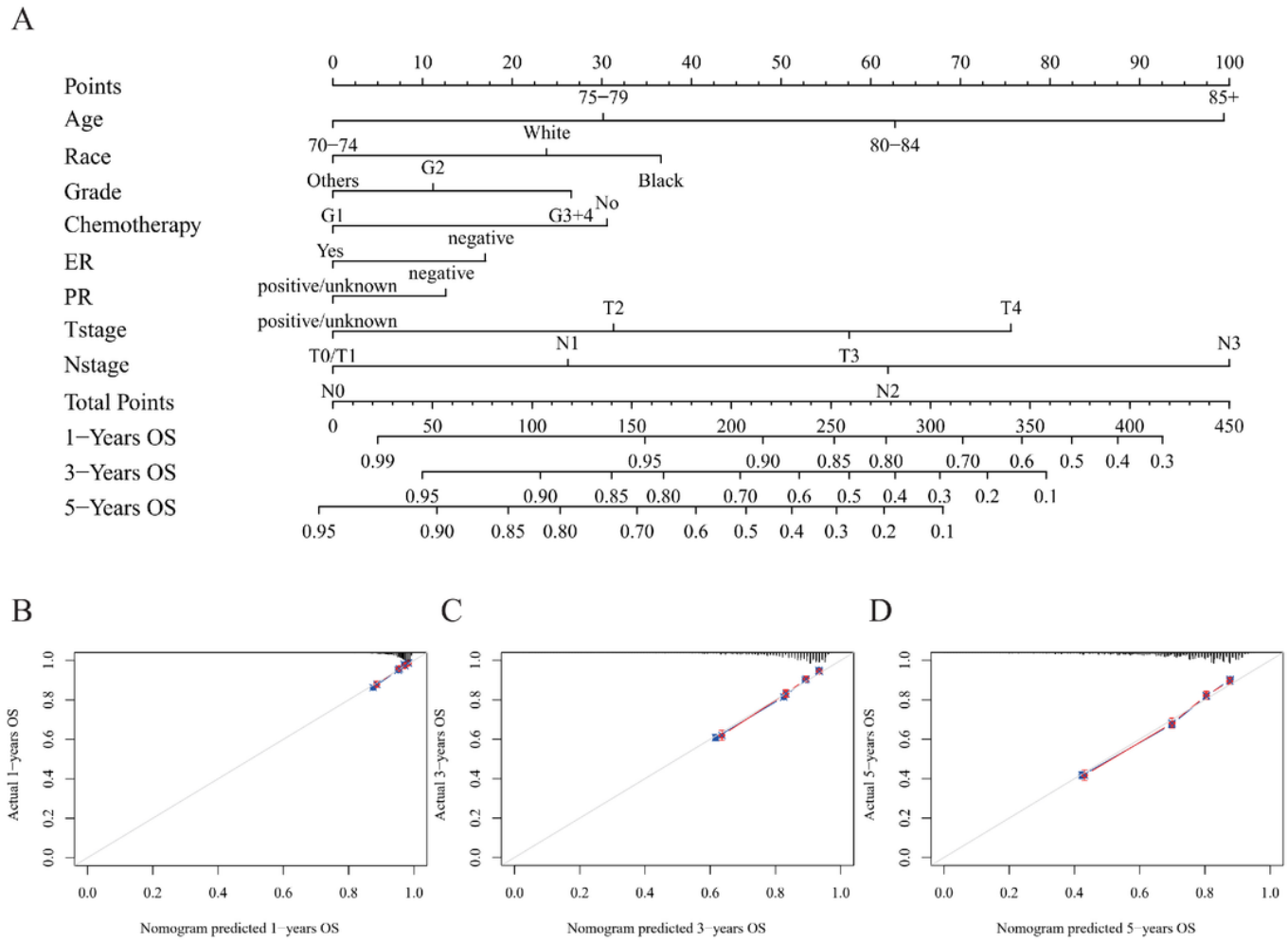

Figure 5

(A) Nomogram and its calibration curves of (B) 1-, (C) 3-, (D) 5-years for patients without PMRT. Blue line: calibration curves in the training cohort; Red line: calibration curves in the validation cohort. ER: estrogen receptor; PR: progesterone receptor; OS: Overall survival.

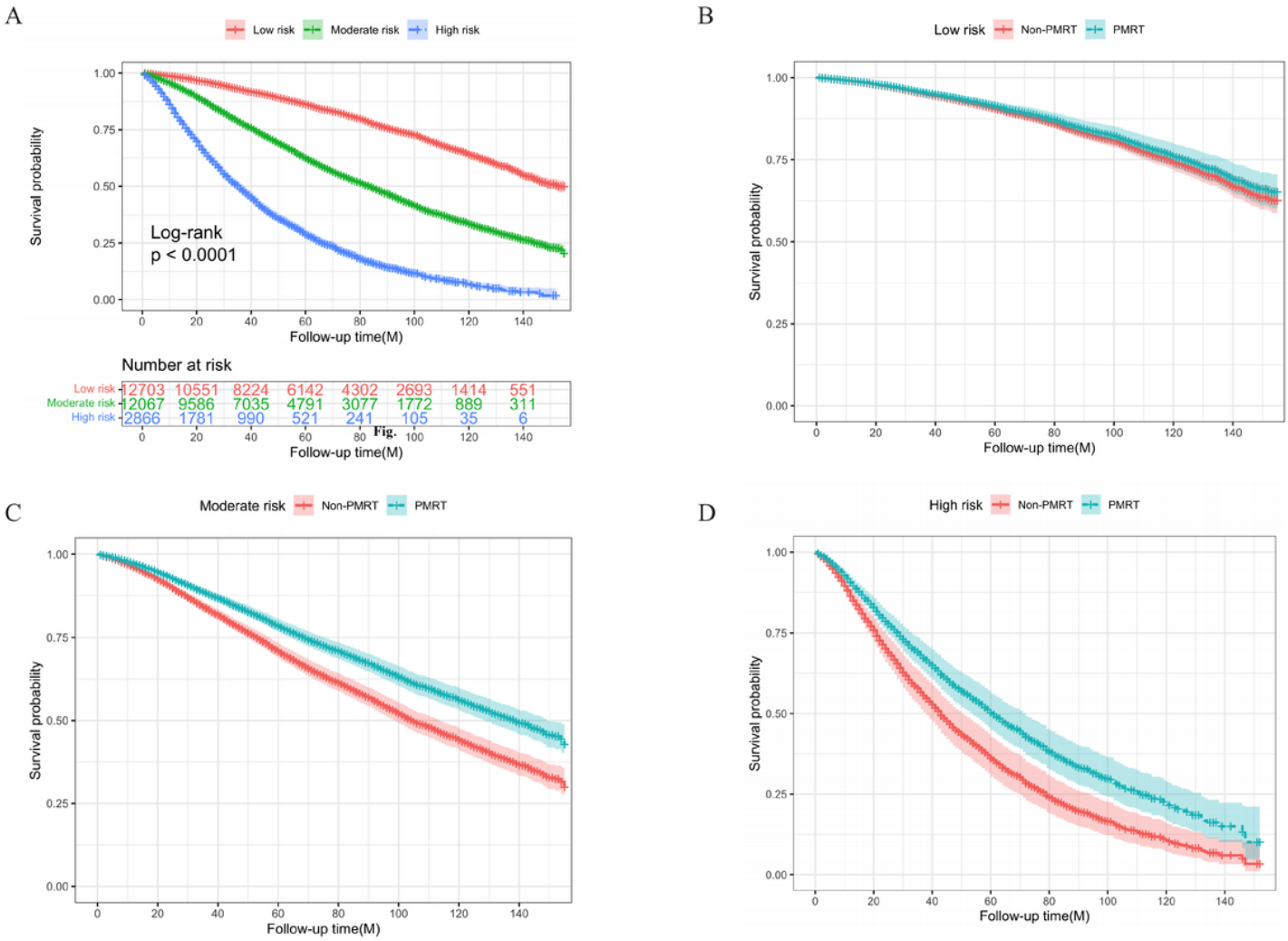

Figure 6

Kaplan-Meier curves for comparing the overall survival of patients in (A) three risk groups, the (B) low-risk group, (C) moderate-risk group, and (D) high-risk group. PMRT: post-mastectomy radiotherapy.