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Original Article

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Comparison of Long-Term Oncological Outcomes in Oncoplastic Breast Surgery and Conventional Breast-Conserving Surgery for Breast Cancer: A Propensity Score-Matched Analysis

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ABSTRACT

Purpose: The oncoplastic breast-conserving surgery (OPS) technique, combined with the principles of oncological safety and plastic surgery, results in complete tumor resection while preserving the natural appearance of the breast. The purpose of this study was to evaluate the long-term oncological results after OPS compared with conventional breast-conserving surgery (BCS) for early breast cancer.
Methods: The medical records of patients who underwent breast cancer surgery and adjuvant radiation therapy at Seoul National University Hospital between 2011 and 2014 were reviewed. Ipsilateral breast tumor recurrence (IBTR)-free survival rate and recurrence-free survival (RFS) rates were compared between the OPS and BCS groups.
Results: One-to-one propensity score matching was conducted, yielding 371 patients in each group. The mean tumor distance from the nipple was shorter, and the mean retrieved specimen size and pathologic tumor size, including ductal carcinoma in situ, were larger in the OPS group than in the conventional BCS group ($p < 0.001$). Surgical margin positivity was not significantly different between the two groups ($p = 0.777$). The surgical technique was not significantly associated with IBTR (OPS versus conventional BCS, 5-year survival rate, 96.9% vs. 98.6%; $p = 0.355$) and RFS (5-year survival rate, 92.9% vs. 94.5%; $p = 0.357$) on the log-rank test. Multivariate analysis revealed that OPS versus conventional BCS was not significantly associated with survival outcomes.
Conclusion: We observed no significant differences in long-term IBTR and RFS between the OPS and conventional BCS groups in this retrospective analysis. OPS can be an oncologically and surgically safe alternative option for conventional BCS for early breast cancer.

Keywords: Breast Neoplasms; Disease-Free Survival; Mastectomy, Segmental; Reconstructive Surgical Procedures; Treatment Outcome

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Conflict of Interest

Han-Byoel Lee and Wonshik Han report being a member on the board of directors of and holding stock and ownership interests at DCGen, Co., Ltd., not relevant to this study. Other authors declare that they have no competing interests.

Author Contributions

Conceptualization: Oh MY, Kim Y, Kim HK, Han W; Data curation: Oh MY, Kim J, Cheun JH; Formal analysis: Oh MY, Kim J, Cheun JH Funding acquisition: Lee HB; Investigation: Kim J, Cheun JH; Methodology: Oh MY; Project administration: Han W; Supervision: Kim Y, Han W; Visualization: Oh MY; Writing - original draft: Oh MY; Writing - review & editing: Kim Y, Jung JG, Kim HK, Lee HB, Han W.

INTRODUCTION

Breast-conserving surgery (BCS) followed by radiotherapy is accepted as the standard treatment for early breast cancer, since the long-term oncological outcomes were shown to be comparable to total mastectomy in randomized controlled trials and several subsequent studies [1,2]. Since the concept of breast conservation has been acknowledged, oncological safety and aesthetic outcomes have become common goals in breast cancer surgical treatment [3].

Conventional BCS aims to surgically resect only enough breast tissue to achieve tumor-free resection margins. Despite the reliable oncological outcome of conventional BCS, previous studies have reported that approximately 20%–30% of patients treated with conventional BCS experience unsatisfactory cosmetic results [4]. Furthermore, free margins are difficult to obtain in specific oncologic and anatomic conditions, such as large tumor size, high tumor-to-breast ratio, central and low-pole tumor location, or multifocal disease [5]. Therefore, further developments have been made to overcome these challenges and to extend the indications for BCS [6].

Oncoplastic breast-conserving surgery (OPS) combines the principles of oncology and plastic surgery, merging the complete excision of the tumor with safe margins and preserving the natural shape of the breast [7,8]. A satisfactory cosmetic and oncologic result can be obtained as OPS allows extensive resections with immediate breast reshaping by mammoplasty [9,10].

OPS has recently gained a great deal of interest, and an increasing number of studies have shown promising cosmetic results with OPS as an alternative procedure for patients who would otherwise have undergone mastectomy [11-14]. However, OPS lacks long-term results, especially with regard to oncologic outcomes, which must be a prerequisite for its adoption as a new standard treatment for early breast cancer.

The aim of this study was to evaluate the long-term oncological outcomes after OPS compared with conventional BCS for breast cancer. We conducted propensity score matching to reduce selection bias due to confounding variables.

METHODS

Case selection

A retrospective review of primary breast cancer patients who underwent conventional BCS followed by radiotherapy at Seoul National University Hospital between January 2011 and December 2014 was performed. A total of 1,697 patients underwent BCS, of whom 1,134 had conventional BCS, and 563 had OPS. Patients who underwent surgery for recurrent tumors or palliative purposes and who did not receive radiotherapy were excluded. Patients who underwent level I OPS techniques, including glandular mobilization and reposition, simple nipple reposition, simple round block techniques, and bat-wing incision technique were excluded. Electronic medical records were reviewed to analyze patient demographics, radiologic and histopathological tumor characteristics, operative procedures, surgical outcomes, postoperative complications, and recurrences. The specimen volume was calculated using the ellipsoid formula (height × length × width) × π/6. Postoperative wound complications were defined as those requiring interventions or medications, such as aspiration for seroma and hematoma, antibiotic treatment for wound infection, and surgical treatments for wound dehiscence.

Statistical analysis

Student's *t-test* was used to analyze the categorical variables, and one-way analysis of variance was used for continuous variables. The log-rank test was used to estimate the difference between the survival curves drawn using the Kaplan-Meier method. Variables with a *p*-value of 0.100 or less were adjusted using the Cox proportional hazard regression model to analyze the prognostic factors for ipsilateral breast tumor recurrence (IBTR)-free survival and recurrence-free survival (RFS). All statistical analyses were performed using SPSS software (version 26.0; IBM, Armonk, USA). The Institutional Review Board (IRB) at Seoul National University Hospital granted approval for all data collection, storage, and analysis (IRB No. 2106-187-1230), and individual consent for this retrospective analysis was waived. To reduce abovementioned confounding factors and to minimize selection bias, propensity score matching procedure was performed using the "MatchIt" R package (version 3.6.3) [15]. Detailed information on the propensity score matching analysis is provided in the **Supplementary Data 1** (**Supplementary Table 1**).

RESULTS

Demographics

One-to-one propensity score matching yielded 371 patients in each group. The patients and tumor characteristics of each group (OPS vs. conventional BCS) after propensity score matching are shown in **Table 1**. The mean patient age was 48.9 (range, 26–77) and 49.4 (range, 19–81) for the OPS and conventional BCS groups, respectively. The mean follow-up duration was 84.4 and 87.9 months for OPS and conventional BCS groups, respectively.

The tumor size, including in situ lesions, was significantly larger in the OPS group (mean size, 3.0 cm; range, 0–8.5 cm) than in the conventional BCS group (mean size, 2.3 cm; range, 0–7.0 cm) ($p < 0.001$), while the T stage was not different between the two groups ($p = 0.979$). The mean distance between the tumor and nipple measured on ultrasonography was shorter in the conventional BCS group (mean distance, 3.2 cm; range, 0–10.0 cm) than in the conventional BCS group (mean distance, 4.4 cm; range, 0–10.0 cm) ($p < 0.001$). Additionally, the OPS group was significantly associated with more calcifications on mammography (42.6% vs. 32.9%; $p < 0.001$). There were no differences in other clinicopathologic factors, including variables for propensity score matching between the two groups (**Table 1**). Eight patients had cT4 stage disease, and all had skin involvement and underwent neoadjuvant chemotherapy. Upon surgery, we were able to perform breast-conserving surgeries since the extent of skin involvement had markedly decreased after neoadjuvant chemotherapy. Of the eight cT4 patients, two underwent OPS, and six underwent conventional BCS; however, we did not have a specific criteria for deciding between the two methods.

Oncoplastic surgery techniques

Various level II OPS techniques, including both volume displacement and replacement approaches, were used in the OPS group (**Table 2**). For volume replacement techniques, mini-latissimus dorsi (LD) flap and laparoscopic omental flap by breast surgeons were included. Conventional LD flap or implant insertion performed by a plastic surgeon was not included in this study. The most common OPS technique was the tennis-racket incision (229 cases,

Table 1. Demographic and clinical characteristics of cohort after propensity score matching

Characteristics	OPS (n = 371)	Conventional BCS (n = 371)	*p*-value
Mean age (yr)	48.9 ± 9.2	49.4 ± 9.7	0.502
< 50	205 (55.3)	204 (55.0)	0.941
≥ 50	166 (44.7)	167 (45.0)	
Tumor size including in situ lesions (cm)	3.0 ± 1.7	2.3 ± 1.3	< 0.001
Distance from nipple (cm)	3.2 ± 1.6	4.4 ± 2.0	< 0.001
Calcification			
Present	158 (42.6)	122 (32.9)	0.006
Absent	213 (57.4)	249 (67.1)	
Multifocality			
Unifocal	297 (80.1)	321 (86.5)	0.018
Multifocal	74 (19.9)	50 (13.5)	
T stage*			
T1	172 (46.4)	172 (46.4)	0.979
T2	187 (50.4)	186 (50.1)	
T3–4	12 (3.2)	13 (3.5)	
N stage*			
N0	209 (56.3)	214 (57.7)	0.471
N1	127 (34.2)	124 (33.4)	
N2	29 (7.8)	22 (5.9)	
N3	6 (1.6)	11 (3.0)	
Ki-67 index			
< 10%	242 (65.2)	248 (66.8)	0.642
≥ 10%	129 (34.8)	123 (33.2)	
Hormone receptor status			
Present	274 (73.9)	273 (73.6)	0.934
Absent	97 (26.1)	98 (26.4)	
HER2 receptor status			
Present	68 (18.3)	64 (17.3)	0.701
Absent	303 (81.7)	307 (82.7)	
Neoadjuvant CTx.			
Yes	94 (25.3)	86 (23.2)	0.493
No	277 (74.7)	285 (76.8)	
Adjuvant CTx.			
Yes	197 (53.1)	205 (55.3)	0.556
No	174 (46.9)	166 (44.7)	
HER2-targeted treatment			
Yes	51 (13.7)	49 (13.2)	0.830
No	320 (86.3)	322 (86.8)	
Adjuvant HTx.			
Administered	273 (73.6)	273 (73.6)	1.000
Not administered	98 (26.4)	98 (26.4)	
Mean follow-up period (mo)	84.4 ± 22.7	87.9 ± 24.8	0.047

Values are means ± standard deviation (range) or number (%).
OPS = oncoplastic breast surgery; BCS = breast-conserving surgery; HER2 = human epidermal growth factor receptor 2; CTx. = chemotherapy; HTx. = hormone treatment.
*Stratified according to the American Joint Committee on Cancer 8th TNM stage, and patients were evaluated according to the clinical stage after neoadjuvant chemotherapy.

61.7%), followed by reduction mammoplasty (38 cases, 10.2%), J-plasty (21 cases, 5.7%), and mini-LD flap (20 cases, 5.4%).

Surgical outcomes

The mean retrieved specimen size was significantly larger in the OPS than in the conventional BCS group, with a maximum length of 7.8 cm (range, 3.5–17 cm) vs. 6.9 cm (range, 1.5–16 cm) ($p < 0.001$), mean volume of 75.4 cm^3 (range, 29.5–438.5 cm^3) vs. 62.1 cm^3 (range, 14.2–248.6 cm^3) ($p < 0.001$), and mean weight of 76.8 g (range, 18–347 g) vs. 59.5 g (range, 7.5–250 g) ($p < 0.001$). Close or involved resection margins were observed in 26 (7.0%) and 28 (7.5%) cases

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Table 2. Oncoplastic surgery techniques

Technique	OPS (n = 371)
Volume displacement method	
Tennis racket incision	229 (61.7)
Reduction mammoplasty (superior or Inferior Pedicle)	38 (10.2)
J-plasty	21 (5.7)
B-plasty	16 (4.3)
Matrix rotation	13 (3.5)
V-plasty	10 (2.7)
Axillary rotation flap	7 (1.9)
S-shape oblique mammoplasty	5 (1.3)
Grissotti flap	4 (1.1)
Omental flap	2 (0.5)
Others	5 (1.3)
Volume replacement method	
Mini-LD flap	20 (5.4)
Omentopexy	2 (0.5)

Values are presented as number (%).
OPS = oncoplastic breast surgery; LD = latissimus dorsi.

Table 3. Other surgical outcomes

Characteristics	OPS (n = 371)	Conventional BCS (n = 371)	*p*-value
Specimen size			
Mean maximum length (cm)	7.8 ± 2.1	6.9 ± 1.7	< 0.001
Mean volume (cm³)	75.4 ± 49.0	62.1 ± 38.6	< 0.001
Mean weight (g)	76.8 ± 52.0	59.5 ± 35.5	< 0.001
Surgical margin			
Close or involved margin	26 (7.0)	28 (7.5)	0.777
Re-excision for close or involved margin	19 (5.1)	12 (3.2)	0.199
Wound complication			
All complications	15 (4.0)	14 (3.8)	0.850
Seroma	8 (2.2)	7 (1.9)	0.794
Infection/abscess	3 (0.8)	4 (1.1)	0.704
Hematoma	2 (0.5)	2 (0.5)	1.000
Wound dehiscence	2 (0.5)	1 (0.3)	0.563

Values are means ± standard deviation (range) or number (%).
OPS = oncoplastic breast surgery; BCS = breast conserving surgery.

in the OPS and conventional BCS groups, respectively ($p = 0.777$), and the reoperation rate for margin status was not different between the two groups ($p = 0.199$) (**Table 3**).

There were 15 patients (4.0%) in the OPS group who developed postoperative wound complications and 14 patients (3.8%) in the conventional BCS group, with no statistically significant difference between the groups ($p = 0.850$) (**Table 3**). Details regarding postoperative wound complications are summarized in **Supplementary Table 2**. There were three OPS cases and two conventional BCS cases in which adjuvant therapy was delayed due to wound complications.

Long-term oncological outcomes

There was no significant difference in the IBTR and RFS between the two groups. The 5-year IBTR-free survival rates for the OPS and conventional BCS groups were 96.9% and 98.6%, respectively ($p = 0.355$, **Figure 1A**). The 5-year RFS rates for the OPS and conventional BCS groups were 92.9% and 94.5%, respectively ($p = 0.357$, **Figure 1B**). Additionally, multivariate analyses showed no significant difference between the two groups for both IBTR-free survival ($p = 0.367$) and RFS ($p = 0.449$) (**Table 4**). High T/N stage, negative hormone receptor status, and involvement or close resection margin were significant variables affecting RFS

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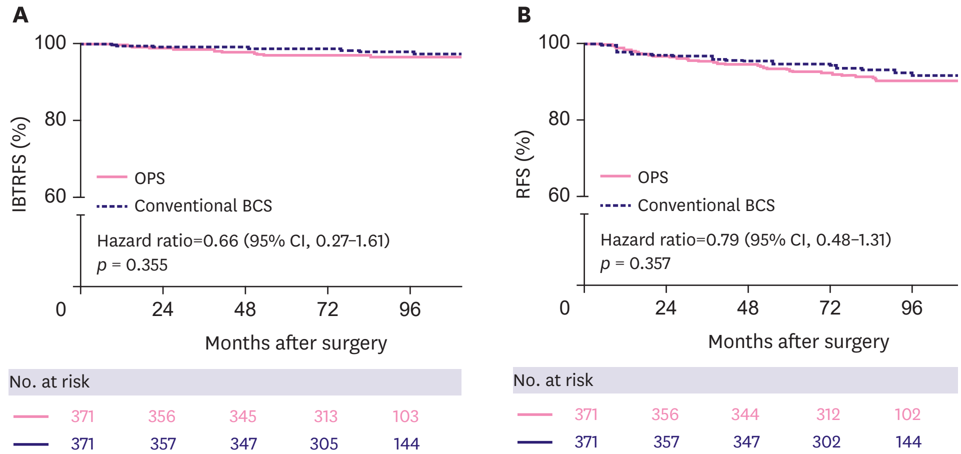

Figure 1. Kaplan-Meier curves for ipsilateral breast tumor recurrence-free survival and recurrence free survival. There was no significant difference between the OPS and conventional BCS groups in terms of (A) IBTFRS and (B) RFS. IBTFRS = ipsilateral breast tumor recurrence-free survival; RFS = recurrence-free survival; OPS = oncoplastic breast surgery; BCS = breast-conserving surgery; CI = confidence interval.

after adjusting for other variables. Subgroup analysis revealed that there was no significant difference in IBTR-free survival and RFS in all tumor subtypes (**Figure 2**).

DISCUSSION

Surgical treatment for breast cancer has been constantly evolving over the years. With the increasing early detection of breast cancer in recent years, BCS has become the standard of practice for appropriate patients with equivalent oncological outcomes and better quality of life compared with total mastectomy [1,2]. However, up to 30% of patients with BCS have residual deformities or poor satisfaction [4,16]. As a result, OPS has gained popularity as surgeons have looked for ways to minimize cosmetic deformities and to achieve better aesthetic outcomes after breast cancer surgery [17]. Furthermore, OPS could extend the indication of BCS for patients previously considered unsuitable for conventional BCS and would have otherwise undergone mastectomy, such as those with a high tumor-to-breast size ratio and tumor location close to the nipple or unfavorable for BCS [18].

Some studies have investigated the oncological outcomes of OPS in breast cancer [11,13,14,19-22]. However, most studies thus far did not have a sufficiently long follow-up duration, included only a small number of cases, and were not well matched with conventional BCS. In line with other studies, our study showed that long-term oncological outcomes of OPS patients were non-inferior to those of BCS patients, indicating that OPS is an oncologically safe procedure. A recent large cohort study by a Swedish team reported comparable long-term survival and recurrence outcomes between OPS and conventional BCS for breast cancer [23]. Although the Swedish study included a large cohort, the actual sample size of OPS patients was 243 for simple OPS and 215 for complex OPS (458 patients with OPS). Additionally, we excluded patients who underwent simple level I OPS to clarify the effect of OPS. Furthermore, contrary to the Swedish study conducted with a registry database, our study analyzed accurate and detailed data from a large institution and observed the patients for a relatively long-term follow-up period of approximately 7 years. Lastly, one of the greatest strengths of our study is that our data is one-to-one propensity score matched to adjust for other confounding variables.

Table 4. Log-rank and Cox regression analyses for IBTRFS and RFS

Characteristics	IBTRFS				RFS			
	Univariate analysis		Multivariate analysis*		Univariate analysis		Multivariate analysis*	
	Hazard ratio (95% CI)†	*p*-value	Hazard ratio (95% CI)†	*p*-value	Hazard ratio (95% CI)†	*p*-value	Hazard ratio (95% CI)†	*p*-value
Initial age (yr)	0.99 (0.94–1.03)	0.539	-	-	0.97 (0.95–1.00)	0.060	0.99 (0.96–1.02)	0.470
T stage‡		0.054		0.105		< 0.001		0.048
T1	Ref.		Ref.		Ref.		Ref.	
T2	2.46 (0.88–6.89)		2.15 (0.76–6.04)		2.77 (1.51–5.08)		2.14 (1.10–4.17)	
T3–4	5.84 (1.13–30.13)		5.53 (1.07–28.61)		6.19 (2.38–16.10)		3.46 (1.09–10.96)	
N stage‡		0.696	-	-		< 0.001		0.012
N0	Ref.				Ref.		Ref.	
N1	0.66 (0.23–1.84)				1.36 (0.76–2.45)		1.00 (0.50–2.00)	
N2	1.39 (0.31–6.16)				3.91 (1.93–7.96)		2.64 (1.14–6.13)	
N3	0.00 (0.00–NC)				5.91 (2.26–15.43)		3.45 (1.20–9.93)	
Resection margin		0.021		0.008		< 0.001		< 0.001
Clear	Ref.		Ref.		Ref.		Ref.	
Involved or close	3.36 (1.12–10.04)		4.70 (1.49–14.85)		3.99 (2.20–7.25)		4.65 (2.39–9.05)	
HR status		0.008		0.045		< 0.001		0.005
Positive	Ref.		Ref.		Ref.		Ref.	
Negative	3.07 (1.28–7.37)		2.86 (1.02–8.00)		2.42 (1.46–4.01)		2.39 (1.31–4.38)	
HER2 receptor status		0.371	-	-		0.413	-	-
Positive	Ref.				Ref.			
Negative	0.63 (0.23–1.74)				0.76 (0.42–1.43)			
Ki-67 index		0.034		0.314		< 0.001		0.057
< 10%	Ref.		Ref.		Ref.		Ref.	
≥ 10%	2.51 (1.04–6.05)		1.68 (0.61–4.59)		2.40 (1.45–3.98)		1.75 (0.98–3.12)	
Neoadjuvant CTx.		0.862	-	-		0.019		0.861
Yes	Ref.				Ref.		Ref.	
No	0.91 (0.33–2.52)				0.54 (0.32–0.91)		1.06 (0.54–2.11)	
Adjuvant CTx.		0.639	-	-		0.239	-	-
Yes	Ref.				Ref.			
No	0.81 (0.33–1.98)				0.73 (0.44–1.23)			
Operation method		0.355		0.367		0.357		0.449
OPS	Ref.		Ref.		Ref.		Ref.	
Conventional BCS	0.66 (0.27–1.61)		0.66 (0.27–1.62)		0.79 (0.48–1.31)		0.82 (0.49–1.37)	

IBTRFS = ipsilateral breast tumor recurrence-free survival; RFS = recurrence-free survival; CI = confidence interval; Ref. = reference; NC = not calculable; HR = hormone receptor; HER2 = human epidermal growth factor receptor 2; CTx. = chemotherapy; OPS = oncoplastic breast surgery; BCS = breast-conserving surgery.
*Variables with a *p*-value of 0.100 or less were adjusted for operation method with Cox proportional hazard regression model, enter method; †Hazard ratio was calculated using univariate Cox regression analysis; ‡Stratified according to the American Joint Committee on Cancer 8th TNM stage and patients were evaluated according to the clinical stage after neoadjuvant chemotherapy.

In this study, OPS enabled the resection of larger tumors and tumors located closer to the nipple, with a larger specimen size. The pathologic tumor size, including in situ lesions, was larger in the OPS group, even after propensity score matching of the T stage. If we did not match the stage between the two groups, the difference in tumor size and specimen size might be more remarkable. This major advantage of OPS, allowing for the resection of larger tumors, has also been highlighted in previous studies [24,25]. Furthermore, it can be inferred that OPS may be associated with poorer survival outcomes than conventional BCS, which is usually indicated for large tumors. Nevertheless, since we have shown that OPS itself does not affect survival outcomes even after adjusting for tumor size, OPS may be deemed as an oncologically safe alternative surgical option to conventional BCS, which also includes larger tumors.

Kaur et al. [26] reported that the specimen size was larger, and surgical margins were wider in OPS patients, resulting in more negative margins than in conventional BCS patients, while Crown et al. [27] reported that OPS significantly reduces mastectomy and postoperative re-excision rates in breast cancer patients. A recent systematic literature review [14] and a meta-analysis study [11] also reported that, in addition to OPS providing similar long-term survival

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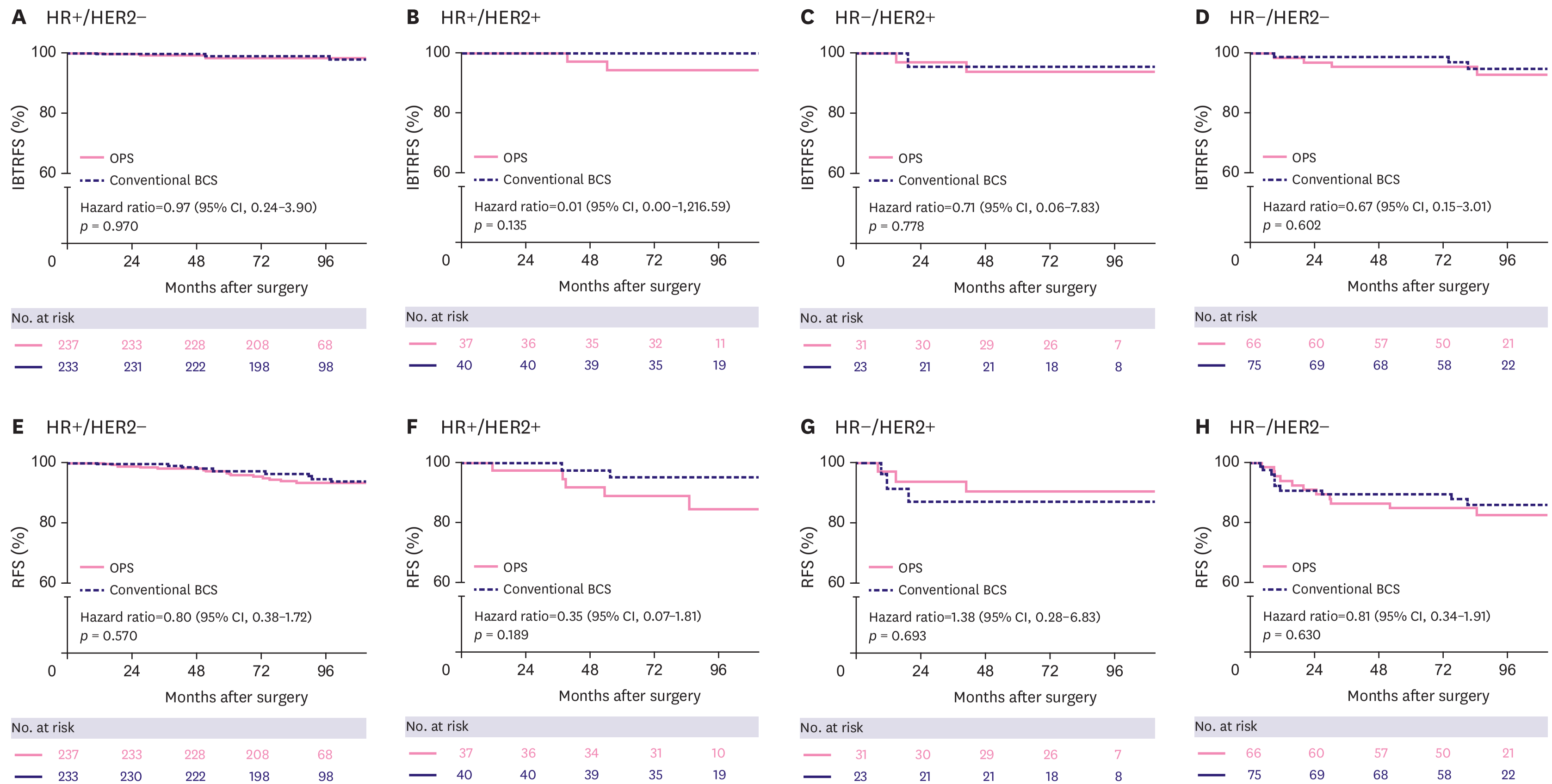

Figure 2. Kaplan-Meier curves for ipsilateral breast tumor recurrence-free survival and recurrence free survival according to tumor subtypes. Kaplan-Meier curves of IBTRFS show no significant difference between the OPS and conventional BCS groups for (A) HR+/HER2−, (B) HR+/HER2+, (C) HR−/HER2+, and (D) HR−/HER2− subtypes. Kaplan-Meier curves of RFS show no significant difference between the OPS and BCS groups for (E) HR+/HER2−, (F) HR+/HER2+, (G) HR−/HER2+, and (H) HR−/HER2− subtypes.
IBTFRS = ipsilateral breast tumor recurrence-free survival; RFS = recurrence-free survival; HR = hormone receptor; HER2 = human epidermal growth factor receptor 2; OPS = oncoplastic breast surgery; BCS = breast-conserving surgery; CI = confidence interval.

as BCS, OPS decreased the re-excision rates. Our study results showed that the OPS and conventional BCS groups had similar percentages of positive margins, but there was a higher percentage of close margins in the conventional BCS group. Nevertheless, the re-excision rates for close or positive margins did not differ between the groups.

OPS is known to be associated with the displacement of a larger volume of glandular tissue and longer scars than BCS, and, therefore, may consequently lead to a higher risk of wound complications, such as seroma, hematoma, and skin necrosis [28]. Postoperative complications may be a problem for patients since they may have to be followed up more frequently and undergo additional procedures or surgeries, but the bigger concern lies with the time to adjuvant therapy. A more extensive surgery could delay the initiation of adjuvant therapy [29], thus negatively affecting the oncological outcome. However, we did not observe any significant difference in terms of surgical complications, which is consistent with the more recent studies showing similar complication rates [14,30] and time to adjuvant therapy [22] between the OPS and conventional BCS patients.

The limitation of our study is its retrospective nature. Additionally, although our data was propensity score matched, we were not able to match certain variables such as tumor size, including in situ lesions and multifocality. A higher level of evidence, including randomized controlled trials, is needed to further prove the oncological safety of OPS. Moreover, since the sample size was small after propensity score matching, variables such as age at operation or Ki-67, both of which are well-known factors affecting RFS, were shown to be non-significant prognostic factors in the multivariate analysis.

The present study found no statistical difference in the long-term oncological outcomes between OPS and conventional BCS, demonstrating the non-inferiority of OPS to conventional BCS. Therefore, OPS is a safe alternative to conventional BCS for patients with breast cancer.

SUPPLEMENTARY MATERIALS

Supplementary Data 1

Method for propensity score matching

Click here to view

Supplementary Table 1

Clinical characteristics of patients before propensity score matching

Click here to view

Supplementary Table 2

Postoperative wound complication

Click here to view

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