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Research Article

Do Breast Implants Adversely Affect Prognosis among Those Subsequently Diagnosed with Breast Cancer? Findings from an Extended Follow-Up of a Canadian Cohort

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Abstract

Background: Cosmetic breast implants may impair the ability to detect breast cancers. The aims of this study were to examine whether implants and implant characteristics are associated with more advanced breast tumors at diagnosis and poorer survival.

Methods: Study population includes all invasive breast cancer cases diagnosed during follow-up of the large Canadian Breast Implant Cohort. A total of 409 women with cosmetic breast implants and 444 women with other cosmetic surgery were diagnosed with breast cancer. These women were compared for stage at diagnosis using multinomial logistic regression models. Cox proportional hazards regression models were used for breast cancer-specific mortality analyses. Comparisons were also conducted according to implant characteristics.

Results: Compared with women with other cosmetic surgery, those with cosmetic breast implants had at later stage breast cancer diagnosis (OR of having stage III/IV vs. stage I at diagnosis: 3.04, 95% confidence interval (CI): 1.81–5.10; $P < 0.001$). A nonstatistically significant increase in breast cancer-specific mortality rate for women with breast implants relative to surgical controls was observed (HR = 1.32, 95% CI: 0.94–1.83, $P =$ 0.11). No statistically significant differences in stage and breast cancer mortality were observed according to implant characteristics.

Conclusions: At diagnosis, breast cancers tended to be at more advanced stages among women with cosmetic breast implants. Breast cancer-specific survival was lower in these women although the reduction did not reach statistical significance.

Impact: Further investigations of the effect of breast implants on breast cancer prognosis are warranted. *Cancer Epidemiol Biomarkers Prev; 21(10); 1868–76. ©2012 AACR.*

Introduction

An estimated 5 to 10 million women across the world have breast implants (1). Such implants have become one of the most frequently conducted cosmetic surgeries among women (2). Public health concern arose in the past decades about possible long-term health effects of breast augmentation (1, 3–5). Numerous epidemiologic investigations focused on long-term cancer risk, especially for breast carcinoma because of the proximity of the tissue to the implant (6–12). However, studies showed either no association or a negative association between breast implants and breast cancer development (6–12).

Nonetheless, cosmetic breast implants still raise some concerns because they may impair the ability to detect breast cancers at an early stage. Implants are radiopaque at mammography. Consequently, they can hinder visualization of breast tissue and affect the identification of breast tumors even when using specialized radiographic techniques (13–16). Thus, breast implants could result in a later stage at diagnosis and reduced survival (17). As the female population with breast implants increases and ages, the number of breast cancers diagnosed in this population will increase and public health concerns associated with the detection and survival of these breast cancers need to be addressed.

Several epidemiologic studies that focused on the detection of breast cancer have compared the stage distribution at diagnosis among women with cosmetic breast implants to stage at diagnosis of breast cancer in nonaugmented women. The results of these studies were conflicting which can be attributed, at least in part, to methodologic

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issues (18). Only 3 publications, including our previous report, showed a statistically significant shift toward more advanced breast tumors at diagnosis among augmented women (19–21). However, several other publications reported no statistically significant differences in breast cancer stage at diagnosis comparing augmented to nonaugmented women (6, 9, 12, 22–35). Furthermore, specific implant characteristics such as implant volume and placement might affect the detection of breast cancer (36). Specifically, implants placed directly under breast tissue (subglandular placement) are suspected to obstruct mammographic visualization of breast tissue more so than submuscular placement (33, 37, 38). However, only our previous report was able to investigate this issue. It did not provide clear evidence of more advanced stage of breast cancer at diagnosis among women with subglandular implants compared with women whose implants are placed submuscularly (21).

In addition to the concern of possible delayed diagnosis of breast cancer among augmented women, breast cancer-related survival has been subject to several investigations (21, 26–29, 33). If diagnosis of breast cancer is delayed in augmented women, such delay could translate into poorer survival. To date, all published studies reported no statistically significant differences in breast cancer-specific survival when comparing augmented women with breast cancer to nonaugmented women with breast cancer (21, 26–29, 33, 39). However, the small numbers of incident breast cancer cases and insufficient follow-up time after diagnosis in these studies may have limited the statistical power necessary to detect a difference in survival. In addition, no study has evaluated breast cancer survival according to implant characteristics.

To investigate these concerns, we provide analyses of an extended follow-up of the Canadian Breast Implant Cohort, the largest cohort assembled to date to examine long-term health effects of cosmetic breast implants (21). Specifically, we evaluate whether implants are associated with more advanced breast tumors at diagnosis, and whether specific implant characteristics such as placement, implant type, implant envelope, and fill volume affect the stage at diagnosis of breast cancer. We also examine whether cosmetic breast implants and specific implant characteristics are associated with poorer survival following diagnosis of breast carcinoma. With the addition of 10 more years of follow-up to our cohort, the identification of additional incident breast cancer cases and attendant mortality events can help clarify the effect, if any, of breast implants on the detection and prognosis of breast cancer.

Materials and Methods

Study population

Incident breast cancer cases were identified among a Canadian cohort of women ($N = 40{,}451$) who previously underwent bilateral cosmetic breast augmentation ($N = 24{,}453$) or other cosmetic surgery ($N = 15{,}893$) in Ontario or Quebec between January 1, 1974 and December 31, 1989, and who were 18 years of age or older at the time of first cosmetic surgery. A detailed description of the study population with selection criteria is provided in our previous publications (7, 21, 40). Other cosmetic surgeries included the following procedures: chemical peel or dermabrasion, coronal brow lift (eyebrow and forehead lift), otoplasty (ear surgery), rhinoplasty (nose surgery), rhytidectomy (face-lift), and blepharoplasty (eyelid surgery).

Ascertainment of breast cancer cases and vital status

Incident cases of breast cancer and deaths were identified by linking personal identifying information of the cohort members to national and provincial databases. In our previous follow-up (21), cohort members were linked to the Canadian Cancer Registry (41) and the Canadian Mortality Database (42) to identify incident breast cancer cases and vital status from the date of index cosmetic surgery until December 31, 1997. The cohort was also linked to cancer registry data before the index date of surgery, back to the year 1969, to exclude women diagnosed with cancer before their index surgeries. For the extended follow-up, incident cases of breast cancer who were diagnosed between January 1, 1998 and December 31, 2006 (Quebec) or December 31, 2007 (Ontario) were identified by linking to provincial registry databases, namely the Ontario Cancer Registry (43) for the Ontario cohort and the Quebec Tumor Registry for the Quebec cohort (44). The date of diagnosis was extracted from the registries for all identified incident breast cancer cases. The cohort was also linked to provincial registers to identify vital status and, if applicable, cause of death. Provincial linkage for vital status and cause of death was done for the period from January 1, 1998 to December 31, 2007 for the Quebec cohort using the mortality files of Quebec held by the Quebec Institute of Statistics and the *Régie d'Assurance Maladie du Québec*. The linkage for vital status and cause of death for the Ontario cohort was done for the period from January 1, 1998 to December 31, 2006 with the use of the Ontario Mortality Database, held by the Registrar General of Ontario. Where no death was found, each subject was assumed to be alive and was censored at the end of follow-up.

Ascertainment of breast cancer prognostic factors

Medical records of breast cancer cases detected through the linkages described above were reviewed. This review served both to confirm the diagnosis of breast cancer, as well as to provide clinical and pathologic information about stage of breast cancer at diagnosis, tumor size, axillary lymph node involvement, and tumor histology. Stage of breast cancer at diagnosis was classified according to the tumor–node–metastasis (TNM) 6th edition (45). Pathologic TNM stage group was assigned to the large majority of these cases, augmented by the clinical stage group where the pathologic stage was not available. In addition, information on body mass index (BMI) was collected among a subsample ($N = 265$) of women diagnosed with breast cancer after 1998 in Quebec.

Among the 40,451 women, 409 women with breast implants and 444 nonaugmented women were diagnosed with breast cancer. Women diagnosed with Ductal Carcinoma *in situ* were excluded from the analysis, so as to be consistent with our earlier article (21) and previous investigations (9, 12).

Statistical analysis

The evaluation of stage distribution of breast cancer at diagnosis was assessed using the ORs and their 95% confidence intervals (CI), which were calculated from logistic regression models and multinomial logit models adjusting for relevant confounding variables (46). First, we compared augmented women with breast cancer to other plastic surgery women with breast cancer using multinomial logistic regression to examine the effect of breast implant on the following outcomes: stage at diagnosis (TNM stage I, II, III/IV, or unknown), tumor size (<21, 21–≤50, >50 mm, or unknown), lymph node involvement (yes, no, or unknown), and tumor histology (infiltrating duct carcinoma, lobular carcinoma, or other). Restricted analyses which included only those women who received breast implants and developed breast cancer were conducted to identify possible differences in stage of breast cancer at diagnosis in terms of implant characteristics at time of implantation: type of implant (silicone gel-filled implants, saline, or unknown), envelope (polyurethane-coated, not polyurethane-coated, or unknown), placement (subglandular, submuscular, or unknown), and fill volume (<200, ≥ 200 cc, or unknown). The influence of the following potential confounding variables was evaluated in multivariate models: age at index surgery (18–<25, 25–<30, 30–<35, 35–<40, 40–<45, or ≥45 years), province of residence (Ontario or Quebec), calendar period of index surgery (1974–1977, 1978–1981, 1982–1985, or 1986–1989), age at diagnosis (<45, 45–<50, 50–<60, or ≥60 years), and period of breast cancer diagnosis. Because Ontario started their organized breast cancer screening program in 1990 and Quebec started in 1998, period of breast cancer diagnosis was grouped into 3 calendar periods (<1990, 1990–1997, or ≥1998). Evaluation of confounding in the multivariable models was done by a backward deletion approach (47). This was done by adjusting for all potential confounders and then by removing one by one in a stepwise manner the least significant confounding variables as long as the total proportional change in OR compared with the fully adjusted model was less than 10%. Covariates that were not confounders, but increased the precision of the estimates were kept in the final model.

Multivariate Cox proportional hazards model (48) was used to compare breast cancer-specific mortality (hazard) rates between the breast implant and other plastic surgery cases and within subgroups of the former, by implant characteristics, while adjusting for relevant confounders. Mortality was assessed until December 31, 2007 for Quebec breast cancer cases and until December 31, 2006 for Ontario. Individuals whose underlying cause of death is not breast cancer were censored at the date of their death. In these analyses, no adjustment for stage of breast cancer was made to capture the overall effect of implants on breast cancer-specific survival. We evaluated the assumption of proportionality by inspecting plots of the log-negative log-mortality curves and examining the statistical significance of time-dependent covariates in proportional hazards models (48). Survival curves to investigate differential survival between groups were produced using Cox proportional hazards model after adjusting for covariates. These analyses were carried out with SAS, version 9.2 (49).

A sensitivity analysis was also conducted to examine the potential confounding influence of BMI in the associations described above. Increased BMI is associated with lower breast cancer survival (50) and BMI is expected to be lower in women who have breast implants (51). Thus, BMI is a potential confounder in our analyses. Specifically, we used information collected for BMI at time of diagnosis among a subsample of women ($N = 265$; 30% of cases) to impute (52, 53) values of BMI to all other breast cancer cases (54). We generated 70 simulated data sets using linear regression to impute values of BMI (55). The following variables were used to impute values of BMI: implant status, age at diagnosis, stage at diagnosis, period of diagnosis, survival time, censoring, and the interaction between survival time and censoring. The Stata software was used to generate this subanalysis (56).

Ethics approval for the study was granted by the University of Toronto's Office on Research Studies, the ethics committee of the Centre Hospitalier *A*ffilié universitaire de Québec's (CH*A*) Saint-Sacrement Hospital, and the Ethics Committee for Clinical Research of Laval University.

Results

Characteristics of the 409 breast implant women with incident breast cancers and the 444 breast cancer cases among the other cosmetic surgery women is presented in Table 1. These numbers include an additional 227 breast implant women and 242 other plastic surgery women with invasive breast cancers compared with our previous article (21). Mean age at surgery was higher among the other cosmetic surgery women (38.1 vs. 36.2 years). Women with other cosmetic surgery were slightly older, on average, at breast cancer diagnosis compared with implant women (53.6 vs. 52.3 years). More than 70% of the breast cancer cases came from the province of Quebec among both the implant women and other cosmetic surgery women. More than half (55%) of breast cancer cases in both groups were diagnosed in the period after 1998.

Women who received breast implants were more likely than those with other cosmetic surgery to have stage III/IV tumor (OR = 3.04, 95% CI: 1.81–5.10, $P < 0.001$; Table 2). In addition, breast implant women had increased odds of

Table 1. Frequency distribution for selected characteristics of women diagnosed with breast cancer who received breast implants and other cosmetic surgeries, Canadian Breast Implant Cohort Study

Characteristics	Breast implant women with breast cancer ($n = 409$)	Other cosmetic surgery women with breast cancer ($n = 444$)
Time since surgery, years, *N* (%)[a]		
<5	29 (7.1)	38 (8.6)
5–<10	53 (13.0)	72 (16.2)
10–<15	96 (23.5)	94 (21.2)
15–<20	101 (24.7)	113 (25.5)
20–<25	80 (19.6)	88 (19.8)
≥25	50 (12.2)	39 (8.8)
Mean duration of follow-up (*SD*), years[b]	16.1 (7.2)	15.5 (7.1)
Period of surgery, *N* (%)		
1974–1977	86 (21.0)	67 (15.1)
1978–1981	123 (30.1)	121 (27.3)
1982–1985	110 (26.9)	145 (32.7)
1986–1989	90 (22.0)	111 (25.0)
Age at surgery, years, *N* (%)		
18–<35	187 (45.7)	167 (37.6)
35–<45	150 (36.7)	162 (36.5)
≥45	72 (17.6)	115 (25.9)
Mean age at surgery (*SD*), years	36.2 (8.4)	38.1 (10.0)
Province of residence, *N* (%)		
Ontario	101 (24.7)	125 (28.2)
Quebec	308 (75.3)	319 (71.9)
Age at breast cancer diagnosis, years, *N* (%)		
<45	85 (20.8)	81 (18.2)
45–<50	85 (20.8)	78 (17.6)
50–<60	148 (36.2)	167 (37.6)
≥60	91 (22.2)	118 (26.6)
Mean age at breast cancer diagnosis (*SD*), years	52.3 (9.6)	53.6 (9.9)
Length of cancer follow-up, years, *N* (%)		
<5	141 (34.5)	136 (30.6)
5–<10	123 (30.1)	126 (28.4)
10–<15	89 (21.8)	116 (26.1)
15–<20	28 (6.8)	48 (10.8)
≥20	28 (6.8)	18 (4.1)
Period of diagnosis, *N* (%)		
<1990	52 (12.7)	56 (12.6)
1990–<1998	132 (32.3)	141 (31.8)
≥1998	225 (55.0)	247 (55.6)

[a]Length of interval between the date of index cosmetic surgery and breast cancer diagnosis.
[b]Mean duration of follow-up between the date of index cosmetic surgery and breast cancer diagnosis.

having nodal involvement at breast cancer diagnosis compared with controls (OR = 1.60, 95% CI: 1.17–2.19, $P = 0.004$). We found no statistically significant differences between the implant and other plastic surgery women for tumor size and histologic type.

The investigation of the effects of implant characteristics on breast cancer stage was done by grouping the stage categories (excluding unknown) into 2 groups (Table 3). For the purpose of this analysis, stages I/II were defined as early stage cancers, whereas stages III/IV were defined as advanced. This analysis showed no statistically significant differences in stage of breast cancer at diagnosis according to any of the implant characteristics.

There were 76 breast cancer deaths among 400 implant women with breast cancer and 66 breast cancer deaths among 434 surgical controls with such disease. We evaluated mortality differences between implant women and other surgery women using Cox proportional hazards model adjusting for age at diagnosis, province, and period

Table 2. ORs[a] and 95% CIs for selected characteristics of incident cases of breast cancer comparing breast implant women to other cosmetic surgery women

Characteristics	Implant cases (n = 409)	Control cases (n = 444)	OR	95% CI
TNM stage at diagnosis				
I	127	181	1.0	–
II	158	170	1.33	0.97–1.82
III/IV	55	27	3.04	1.81–5.10
Unknown	69	66	1.53	1.01–2.33
Tumour size, mm				
<21	209	251	1.0	–
21–≤50	101	115	1.08	0.78–1.50
>50	18	17	1.29	0.64–2.61
Unknown	81	61	1.63	1.11–2.39
Nodal involvement				
No	175	243	1.0	–
Yes	154	128	1.60	1.17–2.19
Unknown	80	73	1.51	1.02–2.24
Histology				
Ductal	260	288	1.0	–
Lobular	59	70	0.89	0.59–1.35
Nonmissing others	76	74	1.15	0.80–1.67
Unknown	14	12	1.22	0.54–2.76

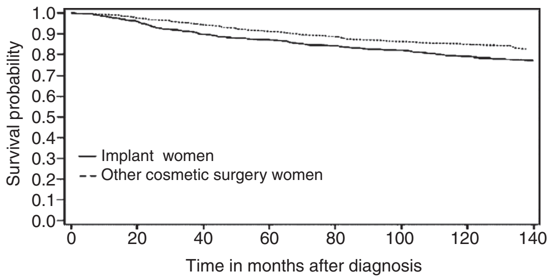
[a]OR adjusted for age at diagnosis, period of diagnosis, and province.

of diagnosis (data not shown). We found a nonsignificant increase in breast cancer-specific mortality rate as shown by the elevated HR for women with breast implants relative to surgical controls (HR = 1.32, 95% CI: 0.94–1.83, $P = 0.11$). When we further adjusted for stage at diagnosis the HR decreased substantially (HR = 1.05, 95% CI: 0.75–1.47, $P = 0.78$). Analyses according to implant characteristics showed no differences in breast

Table 3. ORs[a] and 95% CIs for stage distribution of breast cancer for selected breast implant characteristics

	Stage			
Characteristics	Stage I/II cases	Stage III/IV cases	OR	95% CI
Type of fill				
Saline	44	7	1.0	–
Silicone	194	35	1.47	0.57–3.80
Unknown	47	13	2.22	0.71–6.90
Polyurethane coating				
No	180	31	1.0	–
Yes	22	4	1.73	0.52–5.79
Unknown	83	20	1.81	0.90–3.66
Fill volume (cc)				
<200	143	28	1.0	–
≥200	141	27	0.88	0.48–1.61
Unknown	1	0	0.00	N.E.
Site of implantation				
Submuscular	142	31	1.0	–
Subglandular	108	19	0.78	0.41–1.47
Unknown	35	5	0.56	0.20–1.59

[a]OR adjusted for age at diagnosis, period of diagnosis, and province.



[a]Survival curves were adjusted for age at diagnosis, period of diagnosis, and province using Cox proportional hazards model (*P* value for differences in survival curves = 0.11)

Figure 1. Breast cancer-specific survival curves[a] comparing breast implant with other cosmetic surgery women.

cancer-specific mortality rates within each (all P values $\geq$ 0.14). Figure 1 shows the breast cancer-specific survival curves adjusted for age at diagnosis, period of diagnosis, and province comparing breast implant and other surgery women. Five- and 10-year breast cancer-specific survival rates among implant women were 87.0% and 79.0%, respectively. The corresponding numbers for the other surgery group were 91.0% and 84.8%.

Additional analyses were carried out to explore the confounding effect of BMI at time of diagnosis. When further adjusting for imputed values of BMI, the strength of the relation of implant status to stage III/IV decreased slightly (OR = 2.89, 95% CI: 1.70–4.90, $P < 0.001$). In addition, results showed that the HR for breast cancer-specific mortality increased slightly to 1.39 (95% CI: 0.95–2.03, $P = 0.09$) when further adjusting for BMI.

Discussion

Principal findings and comparison with previous studies

The extension of our previous analysis showed that with the additional follow-up time we have more than doubled the number of incident breast cancer cases and breast cancer deaths among members of our cohort. Specifically, we have confirmed the finding of our previous work that women with breast implants were more likely to have advanced breast cancers stage at diagnosis when compared with the other cosmetic surgery women (21). In addition to our previous report, 2 publications by Silverstein and colleagues reported that breast implant women presented with more advanced stage at breast cancer diagnosis when compared with nonaugmented women (19, 20). Although not statistically significant, several studies showed a tendency toward advanced breast tumors at diagnosis for women who received augmentation mammaplasty (6, 29–35). However, several other publications found little or no evidence that implant women were diagnosed at a later stage (9, 12, 22–28, 57). One possible explanation is the small number of breast cancer cases among augmented women (7–137 cases), which may have affected study power in these studies. Our finding of later stage at diagnosis among cases occurring in women with implants are coherent with the well established evidence that breast implants are radiopaque and obscure some portions of breast tissue from mammographic visualization (58), even in the presence of implant displacement technique mammography (33).

Questions have been raised about breast cancer detection according to implant characteristics, especially about the placement of the implant. Specifically, implants placed under the breast glands (subglandular placement), because of their proximity with breast tissue, have been shown to obscure mammograms more so than submuscular placement (37, 38). Previous reports showed that subglandular placement may obscure 39% to 49% of breast tissue compared with 9% to 28% for submuscular implant placement (38). In this study, we have found no statistically significant differences in stage of breast cancer at diagnosis according to any of the implant characteristics, including implant placement as in our previous report (21). One possible explanation is that subglandular implants, because of their proximity with breast tissue, could serve as a base against which the mass may be easier to feel at breast examination and be more palpable compared with women with submuscular implant placement (33, 58). This may compensate for the potential impairment in visualization (59, 60). However, this explanation needs to be further confirmed (29, 30, 34).

To date, although not statistically significant, 4 out of 5 studies (including our own) indicated poorer breast cancer-specific survival among augmented women [Deapen and colleagues, HR = 2.05 (28); Handel and colleagues, HR = 1.81 (33)] or poorer overall survival [Holmich and colleagues, HR = 1.54 (26)]. One study indicated a small improvement in breast cancer-specific survival among augmented women [Birdsell and colleagues, HR = 0.90 (27)]. For the latter studies, HRs and their 95% CIs were estimated from data or Kaplan–Meier survival curves in the published manuscripts (61, 62). The inverse variance weighted average of the 5 study-specific HRs available to date (63) yielded a pooled HR of 1.38 (95% CI: 1.08–1.76). Thus, taken together, findings to date suggest an increased risk of breast cancer-specific mortality among augmented women with breast cancer.

Studies have consistently reported that women with cosmetic breast implants are not at an increased risk of breast cancer mortality compared with women in the general population or to women with other cosmetic surgery (40, 64–69). This reduction in mortality is primarily attributable to a reduction in breast cancer incidence seen consistently in implant women. The increased breast cancer mortality following the diagnosis of such disease may not be sufficient to counterbalance the significantly reduced breast cancer incidence among these women (70).

In our breast cancer survival analysis, adjustment for stage at diagnosis could explain almost entirely the observed excess in rate of breast cancer death. This observation reinforces the view that the increased breast cancer mortality observed in our study may be a true effect and that the lack of statistical significance may be associated primarily to insufficient power to detect a 30% increase in HR even in our relatively large group of cases. No other study examined differences in survival according to implant characteristics, which may be explained by the relatively small series of breast cancer cases in previous studies.

Strengths and limitations of the study

Several limitations of our study need to be considered. First, comparisons were made between implant women and a control group consisting of women who received other cosmetic surgery. It is well recognized that these women are a more appropriate comparison group when studying the health effects associated with cosmetic breast implants because these women tend to be similar in terms of sociodemographic and lifestyle factors to women with breast implants (51, 71). Even after using this control group and adjusting for covariables in our models, residual confounding is still possible. Our sensitivity analysis of the confounding effect of BMI at time of diagnosis suggests that this factor has minimal confounding effect in both analyses of stage distribution and breast cancer-specific mortality. In addition, information on implant characteristics was available only at time of implantation and we did not ascertain if augmented women went through a reoperation to modify or replace their implants. In fact, recent studies have reported reoperation rates ranging from approximately 20% to 30% after 6 years of follow-up following breast augmentation surgery (72–75). Thus, reoperation may have prevented the identification of associations of some implant characteristics with stage or mortality if characteristics of the subsequent implants are different from those of the initial implants. Furthermore, no information was available in our study about the method used to diagnosed breast cancers which makes it difficult to conclude whether implants themselves or breast cancer screening behaviors are responsible for differences in stage of breast cancer at diagnosis. However, women undergoing cosmetic procedures are recognized to be of higher socioeconomic status and to be health conscious (76), which are both factors correlated with having regular mammographic examinations (77). Therefore, using women with other cosmetic surgery as comparison group should have limited such potential residual confounding by screening behaviors.

Another limitation of this analysis but also of all other studies of the effects of breast implants on breast cancer stage at diagnosis and survival is the relative lack of statistical power, in particular, when comparing augmented women to nonaugmented women. The combination, in a meta-analysis, of all studies published to date on breast cancer stage and survival may be the best approach to take full advantage of all currently available information on these 2 associations.

Strengths of our study include the largest sample size to date to study the effect of breast implants on stage of breast cancer at diagnosis and subsequent survival. In addition, the long follow-up period for survival analyses, the detailed information on implant characteristics and several breast cancer prognostic factors, and the use of a proper control group for comparisons with breast implant women are also strengths of our study.

This study provided further evidence that women with breast implants have a higher likelihood of being diagnosed with advanced breast cancers compared with non-augmented women. No differences were observed for stage at diagnosis according to implant characteristics. The more advanced stage at diagnosis among augmented women led to an association of breast implants with poorer breast cancer-specific survival although this result did not reach statistical significance. No differences were found for breast cancer-specific survival according to implant characteristics. The number of women with breast implants is increasing and these women are ageing. Thus, an increasing number of women with breast implants will be diagnosed with breast cancer in coming years. Therefore, further investigations are required to clarify whether breast implants result in more advanced stage at breast cancer diagnosis and reduced survival among augmented women.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Authors' Contributions

Conception and design: E. Lavigne, E.J. Holowaty, S.Y. Pan, L. Xie, J. Brisson.
Development of methodology: E. Lavigne, E.J. Holowaty, S.Y. Pan, L. Xie, P.J. Villeneuve, J. Brisson.
Acquisition of data (provided animals, acquired and managed patients, provided facilities, etc.): E. Lavigne, E.J. Holowaty, L. Xie, J. Brisson.
Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): E. Lavigne, E.J. Holowaty, S.Y. Pan, L. Xie, P.J. Villeneuve, J. Brisson.
Writing, review, and/or revision of the manuscript: E. Lavigne, E.J. Holowaty, S.Y. Pan, L. Xie, P.J. Villeneuve, H. Morrison, J. Brisson.
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