

# A Study of the Relation Between Mastectomy Specimen Weight and Volume With Implant Size in Oncoplastic Reconstruction

UMAR WAZIR, HIBA EL HAGE CHEHADE, CHRISTINA CHOY, ABDUL KASEM and KEFAH MOKBEL

*The London Breast Institute, Princess Grace Hospital, London, U.K.*

**Abstract.** *Background:* There is no general consensus regarding the best and most accurate method for assessing the size of implant required for achieving the best symmetry in oncoplastic reconstruction. *Materials and Methods:* Breast weight, volume and size of implant were recorded prospectively on patients undergoing immediate reconstruction over a 3-year period. Cases with specimen size greater than 2,000 g were excluded. The primary endpoint was size of implant used in relation to specimen weight and volume. Secondary endpoints were the influence of age and histology on specimen weight, volume and breast density. *Results:* A total of 278 mastectomies were performed. Correlation of implant size with volume was marginally stronger than that with weight ( $r=81\%$ ,  $p<0.001$  vs.  $r=78.9\%$ ,  $p<0.001$  respectively). Women aged 50 years and above had lower breast weight for the same breast volume than women under 50 years. The difference was merely 4%, but was statistically significant ( $p=0.001$ ). Histology had no statistically significant influence on breast density. *Conclusion:* Specimen weight and volume were found to be closely correlated. Weight can be measured more accurately and easily with reproducible readings compared to volume.

Reconstruction surgery is increasingly offered to women undergoing mastectomy. Implant reconstruction with acellular dermal matrix has gained popularity in recent years compared to pedicle and free flap reconstructions (1). There is no general consensus as to what the best and most accurate method of assessing the size of implant to be used in order to achieve desirable result in terms of symmetry. Some surgeons use the volume of mastectomy specimen to determine the implant size, whilst others use specimen weight (2). There are very few published reviews on this topic.

This article is freely accessible online.

*Correspondence to:* Professor Kefah Mokbel, London Breast Institute, the Princess Grace Hospital, 45 Nottingham Place, London W1U 5NY, U.K. E-mail: kefahmokbel@hotmail.com

*Key Words:* Mastectomy, breast, breast density, body weight.

This study examined the relation of mastectomy specimen weight and volume with implant size in order to better inform intra-operative decision-making regarding implant selection.

## Materials and Methods

Data were collected prospectively on patients who underwent mastectomy at the London Breast Institute. Breast weight, volume measurement and size of implant were recorded if immediate reconstruction was chosen. Patients were under the care of two senior oncoplastic breast surgeons from January 2014 to December 2016. The exclusion criteria included patients with mastectomy specimen weighing more than 2,000 g. The volume of breast tissue was measured by volume displacement method. The weight of breast tissue was measured on a scale in grams.

The primary endpoint studied was size of implant used in relation to mastectomy specimen weight and volume. Secondary endpoints were the influence of age on specimen weight and volume relation; the influence of the presence of invasive cancer, ductal carcinoma *in situ* (DCIS) on weight and volume relation, and breast weight to volume ratio (BWV, *i.e.* breast tissue density).

These variables were analysed using regression, two-sample *t*-test, Pearson's correlation test, and Wald test as appropriate.

## Results

A total of 278 operations were performed on 221 women, of whom 53 had bilateral mastectomies (N=278). The mean age of women was 48 years (range=24-90 years). There were 150 right and 128 left breast specimens. The complete dataset is presented in Table I.

*Relation between breast weight and volume.* There was strong positive linear relation between breast weight and volume ( $r=99.07$ ,  $p<0.001$ ) (Figure 1). The R-squared parameter of the regression suggested that 98.1% of the variation in weight was explained by the variation in volume.

*Influence of histology on BWV.* The population was stratified into groups based on histology: Invasive carcinoma, DCIS and benign histology (Figure 2). These were compared for differences in BWV. Different tests led to the conclusion that histology had no statistically significant influence on breast density.

*Influence of age on breast weight, volume and BWV.* Breast weight, volume and BWV were studied in patients above and below the age of 50 using regression analysis and the Student's *t*-test.

In this population, no statistically significant correlation was seen for breast weight by age group. However, women at an age of 50 years and above had lower breast weight for the same breast volume than women under 50 years of age. The difference was merely 4%, but was statistically significant ( $p=0.001$ ).

Analysis of the correlation of age with BWV confirmed this finding. We found that women at an age of 50 years and over had a lower breast weight for the same breast volume than women under 50 years of age ( $p=0.0001$ ). This was confirmed by regression analysis. R-Squared of the regression suggested that age would account for 5.3% of variation in BWV.

*Implant size used in relation to breast weight and volume.* Correlation of implant size with volume was marginally stronger than that with weight ( $r=81\%$ ,  $p<0.001$  vs.  $r=78.9\%$ ,  $p<0.001$ , respectively).

**Discussion**

Mastectomy specimen weight and volume are fairly closely correlated. The presence of cancer whether in the form of invasive disease or DCIS did not seem to affect the correlation between weight and volume of the breast tissue. The weight can be measured more accurately easily with repeated readings on a scale, whereas volume measurement

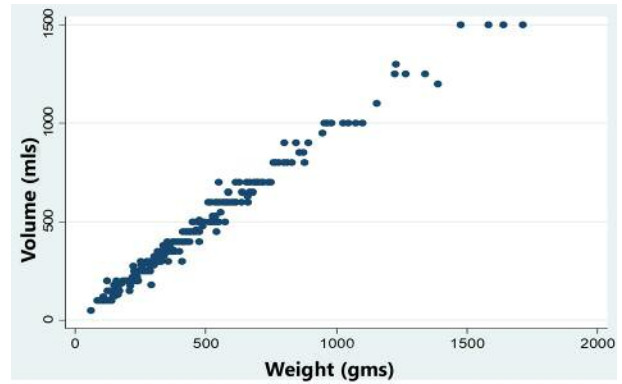


Figure 1. Scatter plot of mastectomy specimen weight vs. volume.

is best estimated to the nearest 25-50 cc. However, there are many other factors in deciding the type and size of implant, including whether to use a fixed volume or expandable prosthesis. Patient preference regarding size, and the limits of commercial availability of implants of certain sizes are also crucial considerations.

However, age is an important factor in the relation between weight and volume. A higher age results in lower breast weight for the same volume. On average, specimens from women after 50 years of age, taken arbitrarily as the age of menopause, were found to have about 4% lower weight than those from woman under 50 with the same breast volume. This fits with the general belief that younger breasts have denser glandular breast tissue.

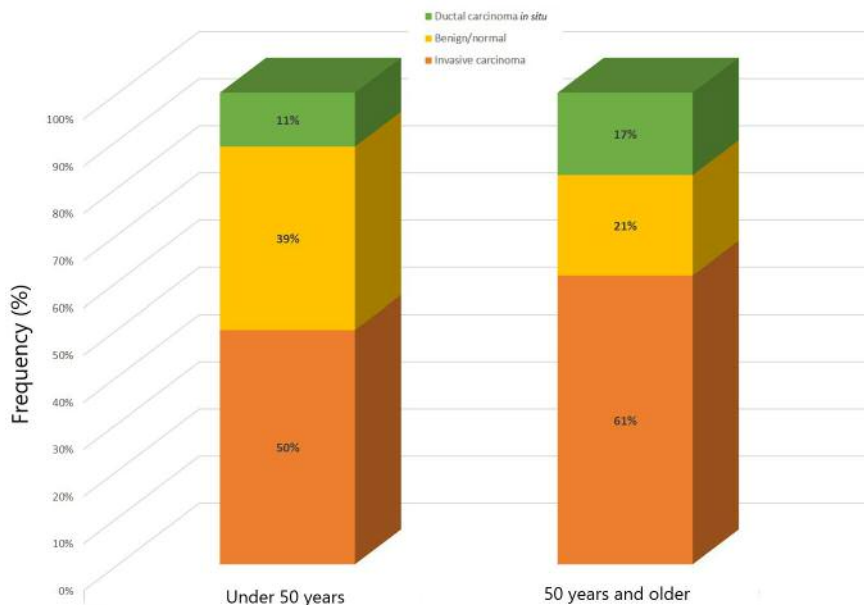


Figure 2. Stratification of histology by age group.

Table I. Complete dataset regarding the 278 included mastectomies.

Case number	Age, years	Laterality	Mastectomy specimen		Implant used	Indication
			Weight, g	Volume, ml		
1	58	Right	615	700	No reconstruction	Prophylactic: Strong family history.
2	58	Left	589	600	No reconstruction	Prophylactic: Strong family history.
3	26	Right	236	200	TSF 295	Prophylactic: <i>PTEN</i> ; multiple fibroadenoma and hamartoma; Cowden syndrome.
4	26	Left	218	200	TSF 295	Prophylactic: <i>PTEN</i> ; multiple fibroadenoma and hamartoma; Cowden syndrome.
5	41	Right	641	650	Becker 500	DCIS
6	41	Left	520	600	Becker 500	Contralateral DCIS
7	44	Left	183	200	Becker 25-250	2002: Grade 2 IDC (WLE, SNB & radiotherapy). 2014: Recurrent DCIS
8	46	Left	368	350	Becker 350	Grade 2 IDC, 1/8 lymph node (micro-metastases)
9	37	Left	365	350	TSF 335	Prophylactic: <i>BRCA</i> 2 carrier
10	37	Right	302	280	TSF 335	Prophylactic: <i>BRCA</i> 2 carrier
11	49	Right	143	150	Becker 25-250	2007: Grade 2 IDC (WLE, SNB & radiotherapy). 2013: Recurrent grade 1 IDC
12	40	Right	186	200	Becker 200	Prophylactic: Contralateral carcinoma.
13	67	Right	584	600	No reconstruction	7 cm Grade 3 IDC
14	50	Right	575	600	Becker 500	Prophylactic: Previous left sided ILC and LCIS.
15	50	Left	523	500	Becker 500	Prophylactic: Previous left sided ILC and LCIS.
16	53	Left	375	350	Becker 350	Large ILC
17	39	Right	520	500	Becker 500	Prophylactic: <i>BRCA</i> carrier
18	39	Left	537	530	Becker 500	<i>BRCA</i> -positive. Left sided IDC.
19	39	Right	517	500	TSF 385	Extensive DCIS
20	39	Left	245	250	TSF 385	Prophylactic: Contralateral DCIS
21	40	Right	312	300	Becker 300	Prophylactic: left sided IDC
22	40	Left	245	250	Becker 300	Left grade 3 IDC
23	45	Right	282	300	Becker 300	Grade 2 IDC, 3/10 lymph nodes
24	77	Left	264	250	Becker 250	Multifocal grade 1 IDC
25	39	Right	434	450	No reconstruction	Grade 3 IDC
26	41	Right	250	250	TSF 365	Prophylactic: Contralateral carcinoma
27	55	Right	233	245	Becker 25-300	Extensive high-grade DCIS
28	40	Left	295	300	Becker 400	Multifocal grade 3 IDC
29	39	Right	495	500	Becker 500	Large area IDC and DCIS
30	55	Right	124	150	Becker 250	Prophylactic: Contralateral DCIS
31	55	Left	131	150	Becker 250	DCIS
32	50	Left	413	400	Becker 400	3 cm Grade 3 IDC
33	47	Right	207	200	Becker 250	4 cm Grade 2 IDC
34	44	Left	456	450	TSM 445	Prophylactic: Contralateral carcinoma
35	44	Right	412	450	Becker 400	Extensive grade 2 ILC
36	65	Left	325	350	Becker 300	3 cm Grade 3 IDC
37	61	Left	311	300	Becker 25-250	Extensive grade 2 IDC
38	44	Left	255	280	TSM 175	Grade 2 IDC
39	73	Right	659	700	No reconstruction	Large ILC
40	55		582	600	No reconstruction	IDC
41	64	Right	538	600	Becker 400	High grade DCIS
42	65	Right	690	700	Becker 500, LD	Invasive carcinoma
43	59	Right	583	600	Becker 500	4 cm Grade 2 IDC
44	35	Left	391	400	TSF 415	IDC
45	35	Right	333	350	TSF 415	Prophylactic: Contralateral carcinoma
46	57	Left	527	530	TSF 385	Grade 2 IDC. Patient wanted smaller reconstructed breast
47	54	Right	130	150	Becker25-200	Recurrent invasive carcinoma.
48	55	Left	1154	1100	No reconstruction	IDC and residual DCIS with 2/14 lymph nodes. Completion mastectomy.
49	50	Left	400	350	Becker 50-500	Grade 2 ILC with-positive margin and subareolar tissue
50	54	Right	301	300	Becker 300	Recurrent invasive disease after radiotherapy.
51	49	Left	271	250	TSF 415	Carcinoma on right breast, LCIS on left. <i>BRCA</i> negative. Risk reduction. Patient wanted larger reconstructed breasts.

Table I. Continued

Table I. Continued

Case number	Age, years	Laterality	Mastectomy specimen		Implant used	Indication
			Weight, g	Volume, ml		
52	40	Left	329	300	SF 335	Prophylactic: Contralateral carcinoma
53	43	Right	297	300	Becker 300	Grade 2 IDC
54	43	Left	325	300	Becker 300	Grade 1 IDC
55	47	Right	381	350	Becker 50-400	Prophylactic: Contralateral carcinoma
56	47	Left	415	400	Becker 50-400	3 cm Grade 1 IDC
57	53	Left	230	250	Becker 25-250	3.5 cm Grade 2 IDC
58	69	Right	800	800	No reconstruction	Invasive carcinoma
59	40	Right	424	400	Becker 400	Prophylactic: Contralateral carcinoma. <i>BRCA</i> 1-positive
60	43	Left	150	150	Becker 300	Multifocal IDC
61	69	Left	279	300	Becker 50-300	Extensive ILC >7 cm on MRI
62	46	Right	257	250	324-5275- 275	Grade 2 IDC 20 mm
63	44	Right	408	400	No reconstruction	2013: Grade 3 IDC with 4/16 lymph nodes (WLE and ANC with radiotherapy). 2014: Recurrent grade 3 IDC
64	48	Right	543	600	Becker 400	January 2015: Grade 3 IDC, 12/12 lymph nodes. July 2015: recurrent grade 3 IDC
65	79	Right	964	1000	No reconstruction	Grade 1 ILC with 0/3 lymph nodes
66	51	Left	439	400	Becker 400	High grade DCIS
67	57	Left	389	400	Becker50-400	Multifocal grade 3 IDC
68	42	Left	410	400	Becker50-400	Multifocal grade 2 ILC with LCIS
69	39	Right	190	200	Becker 25-250	Grade 2 IDC with DCIS
70	50	Left	261	250	Becker50-300	DCIS
71	43	Right	541	450	Becker 50-500	Right high-grade DCIS
72	43	Left	722	700	Becker 50-500	Prophylactic: Contralateral DCIS
73	41	Left	292	290	Becker 300	Multifocal grade 2 IDC
74	68	Right	1228	1300	No reconstruction	Multifocal disease with-positive nodes.
75	43	Left	244	250	Becker 300	Grade 2 IDC (1.8 cm) with multifocal DCIS
76	43	Right	115	100	TSF265	Prophylactic: <i>BRCA</i> carrier
77	43	Left	95	100	TSF265	Prophylactic: <i>BRCA</i> carrier
78	50	Right	615	600	Becker 50 - 500	Multifocal ILC
79	45	Right	230	200	Becker 450	Prophylactic: Contralateral carcinoma
80	52	Right	768	800	Becker 50-600	Multifocal grade 2 invasive carcinoma
81	65	Right	661	630	No reconstruction	Inflammatory carcinoma. Post neoadjuvant chemotherapy.
82	55	Left	289	275	Becker 25-300	4.0 cm Grade 3 IDC
83	45	Left	274	250	TSF485	Prophylactic: Contralateral carcinoma
84	56	Right	399	400	TSF450	Prophylactic: Contralateral carcinoma
85	56	Left	354	350	TSF450	Invasive carcinoma
86	57	Left	145	150	Mod Plus 150	Change from TSF200 to Mod Plus 150
87	49	Right	1024	1000	No reconstruction	3.8 cm high-grade DCIS
88	47	Left	670	700	Becker 25-600	2.3 cm Retro-areolar intermediate-grade DCIS and LIQ high-grade DCIS
89	45	Right	553	600	Becker 50-500	Post chemotherapy
90	49	Left	237	220	Becker 25-250	Multifocal DCIS
91	51	Left	472	500	TSF485	Post chemotherapy
92	37	Right	287	250	TSF335	Prophylactic: family history
93	37	Left	230	250	TSF335	Prophylactic: Contralateral carcinoma
94	45	Left	167	150	Becker25-200	Multifocal grade 1 IDC
95	51	Right	1045	1000	Becker50-600	Prophylactic: family history
96	51	Left	953	1000	Becker 50-600	High-grade DCIS
97	49	Left	437	400	Becker 50-400	Multifocal grade 3 IDC
98	45	Right	156	150	TSF275	Multifocal IDC
99	45	Left	137	150	TSF275	Multifocal bilateral IDC
100	58	Right	514	500	Becker 50-400	Previous WLE
101	37	Left	450	500	Becker 25-400	Multifocal grade 1 IDC (2.1 cm and 2 cm)
102	44	Right	428	450	Becker 25-400	Post chemotherapy and trastuzumab
103	60	Right	137	150	Becker 25-150	Grade 1 IDC and DCIS
104	68	Right	338	380	Becker50-400	2012: Grade 3 IDC (WLE, SNB and radiotherapy). 2015: Grade 2 IDC
105	29	Right	366	350	Becker25-350	2.4 cm grade 2 IDC with satellites
106	49	Left	802	900	No reconstruction	Post tamoxifen still 5cm carcinoma
107	38	Left	352	350	Becker 50-300	Multifocal grade 1 IDC

Table I. Continued

Table I. Continued

Case number	Age, years	Laterality	Mastectomy specimen		Implant used	Indication
			Weight, g	Volume, ml		
108	63	Left	191	200	Becker 25-200	Multifocal DCIS
109	39	Right	180	190	Becker 25-250	IDC. Post chemotherapy
110	40	Right	572	600	Becker 50-500	Prophylactic: Contralateral carcinoma
111	49	Right	325	300	Delayed recon later	2.1 cm Grade 1 IDC
112	34	Right	308	300	Becker50-300	Prophylactic: Contralateral carcinoma
113	34	Left	311	300	Becker50-300 previous ca	Prophylactic: Family history
114	37	Right	474	500	Becker50-500	Prophylactic: Family history; previous WLE for carcinoma.
115	37	Left	566	600	Becker50-500	Prophylactic: family history
116	38	Right	385	400	Becker25-400	Multifocal (2.5 cm, 0.9 cm) grade 2 IDC
117	70	Right	341	350	No reconstruction	5 cm Grade 2 IDC
118	58	Right	533	500	No reconstruction	Prophylactic: family history
119	58	Left	375	359	No reconstruction	Recurrent invasive disease
120	43	Right	209	150	Becker 25-250	Prophylactic: Contralateral disease
121	43	Left	139	100	Becker 25-250	Prophylactic: Previous invasive disease
122	35	Right	860	850	Becker 35-565	Multifocal 5.6 cm grade 3 IDC
123	40	Right	211	175	Becker 50-300	Prophylactic: Contralateral carcinoma
124	40	Left	272	250	Becker 50-300	Invasive cancer
125	74	Right	450	500	Becker 25-500	Multifocal grade 2 ILC (more than 7.5 cm)
126	27	Left	430	450	Becker 25-400	5.4 cm DCIS. Post mantle radiotherapy
127	48	Left	146	150	Becker 25-250	Recurrent grade 2 IDC
128	49	Right	287	300	Becker 25-50-300	Invasive carcinoma. <i>CHEK2</i>
129	49	Left	324	300	Becker 25-300	Prophylactic: <i>CHEK2</i>
130	58	Right	222	275	Becker 25-250	Prophylactic: <i>BRCA</i> -positive. Previous contralateral disease
131	63	Left	681	650	No reconstruction	ILC
132	82	Left	1264	1250	No reconstruction	Multifocal grade 2 ILC
133	70	Right	320	325	No reconstruction	3 cm high-grade DCIS
134	47	Right	447	450	Becker 50-400	2.4 cm grade 1 IDC
135	67	Right	105	100	No reconstruction	Prophylactic: family history
136	67	Left	60	50	No reconstruction	Previous carcinoma
137	69	Left	258	280	Becker 25-250	Extensive DCIS and LCIS
138	40	Right	312	300	Becker 25-350	Previous WLE for extensive DCIS
139	45	Right	558	550	Becker 50-500	DCIS
140	39	Right	414	400	Becker 50-400	Prophylactic: Previous carcinoma
141	39	Left	379	400	Becker 50-400	Prophylactic: Contralateral carcinoma
142	47	Left	303	325	Becker 50-300	Carcinoma
143	49	Left	740	700	Becker 50-500	Extensive DCIS
144	55	Right	700	700	No reconstruction	High-grade DCIS
145	52	Right	337	350	Becker 50-300	3.3 cm grade 3 IDC with 1/4 lymph node
146	44	Right	341	330	Becker 50-300	Prophylactic: <i>MUTYH</i> and <i>MHS2</i>
147	44	Left	375	350	Becker 50-300	Prophylactic: <i>MUTYH</i> and <i>MHS2</i>
148	63	Right	945	950	No reconstruction	Pleomorphic LCIS and ILC
149	39	Right	1074	1000	Becker 50-600	Multifocal IDC
150	50	Right	214	200	Becker 50-300	Multifocal DCIS
151	36	Left	812	800	Becker 25-500	4.1 cm Grade 3 IDC
152	43	Right	362	375	Becker 25-500	Multifocal high-grade DCIS
153	47	Left	235	200	Becker 35-290	Positive margins in previous WLE
154	53	Left	703	700	Becker 50-600	Prophylactic: Contralateral carcinoma
155	31	Right	328	300	Becker 25-250	Grade 3 IDC, high-grade DCIS
156	31	Left	126	100	Becker 25-250	Prophylactic: Contralateral carcinoma
157	37	Right	323	300	Becker 50-300	Prophylactic: <i>BRCA</i> -positive
158	37	Left	242	200	Becker 50-300	Prophylactic: <i>BRCA</i> -positive
159	35	Right	373	400	Becker 25-300	Prophylactic: family history
160	35	Left	375	350	Becker 25-300	Prophylactic: family history
161	55	Right	420	400	Becker 50-300	Prophylactic: <i>BRCA</i> -positive
162	55	Left	440	450	Becker 50-300	Prophylactic: <i>BRCA</i> -positive
163	75	Right	657	700	No reconstruction	IDC, DCIS
164	51	Right	146	140	Becker 25-200	DCIS. Post chemotherapy.
165	51	Left	149	150	Becker 25-200	IDC. Post chemotherapy

Table I. Continued

Table I. Continued

Case number	Age, years	Laterality	Mastectomy specimen		Implant used	Indication
			Weight, g	Volume, ml		
166	52	Right	199	200	Becker 25-200	Multifocal high-grade DCIS
167	35	Right	475	450	Becker 25-350	Prophylactic: <i>BRCA</i> -positive
168	36	Left	164	130	Becker 25-200	Post chemotherapy. Grade 3 IDC
169	47	Right	385	400	Becker 50-300	Multifocal grade 3 IDC and high-grade DCIS
170	41	Right	233	200	Becker 25-250	Multifocal grade 2 ILC
171	43	Right	575	500	Becker 50-500	Multifocal grade 2 ILC
172	46	Right	241	250	Becker 25-250	Prophylactic: Contralateral carcinoma
173	46	Left	281	250	Becker 25-250	0.7 cm Grade 2 IDC with extensive DCIS
174	61	Left	550	500	No reconstruction	Bone metastases. Palliative mastectomy
175	44	Right	1715	1500	Becker 50-600	Prophylactic: Contralateral carcinoma. <i>BRCA</i> 1-positive
176	44	Left	1582	1500	Becker 50-600	<i>BRCA</i> 1-positive. Multifocal grade 2 IDC
177	40	Right	525	500	Becker 50-300	4 cm Grade 2 IDC
178	56	Right	1476	1500	Becker 25-600	Grade 3 IDC
179	58	Left	241	250	Becker 25-250	Previous cancer recurrence IDC
180	30	Left	880	800	Becker 25-600	Multifocal grade 3 IDC
181	47	Right	324	300	Becker 50-300	Prophylactic: Previous carcinoma (DCIS and LCIS)
182	47	Left	330	300	Becker 50-300	Prophylactic: Previous contralateral carcinoma (DCIS and LCIS)
183	42	Left	875	850	Becker 25-600	Multifocal grade 3 0.8-2 cm IDC. Non-responsive to chemotherapy.
184	42	Right	150	180	HP300	Prophylactic: <i>BRCA</i> 1/2 -positive.
185	42	Left	170	180	HP300	Prophylactic: <i>BRCA</i> 1/2 -positive.
186	43	Right	846	900	Becker50-600	Prophylactic: Contralateral carcinoma.
187	43	Left	630	700	Becker50-600	IDC. Post chemotherapy
188	50	Right	422	450	Mod Plus 400	Multifocal grade 1 IDC
189	42	Right	239	200	Becker 25-250	Extensive multifocal IDC
190	45	Right	292	180	Becker50-300	Recurrent IDC
191	45	Left	410	300	Becker50-300	Prophylactic: Contralateral carcinoma.
192	45	Left	611	600	Becker50-500	Prophylactic: Contralateral carcinoma. <i>BRCA</i> 1/2-positive.
193	36	Left	253	290	Becker 25-250	Multifocal ILC
194	42	Right	158	200	Becker25-200	Prophylactic: Contralateral carcinoma.
195	54	Right	108	120	Becker50-300	IDC. Previous augmentation implant.
196	25	Right	486	500	Becker 25-500	High-grade DCIS
197	49	Right	539	500	Becker50-500	DCIS
198	40	Left	346	350	Becker50-400	Paget's disease
199	47	Right	520	500	Becker 25-500	High-grade DCIS
200	53	Left	464	450	Mod Plus 375	Multifocal grade 2 IDC
201	31	Right	464	460	Becker25-500	Multifocal grade 2 IDC
202	42	Right	287	300	Becker50-300	Multifocal grade 2 IDC
203	41	Right	475	400	TSF275	Prophylactic: Contralateral DCIS.
204	41	Left	383	350	TSF275	DCIS
205	46	Left	400	400	Becker 25-400	Grade 3 IDC with DCIS
206	52	Right	401	400	No reconstruction	ILC
207	34	Right	1223	1250	Becker50-600	Bilateral IDC post chemotherapy
208	34	Left	1339	1250	Becker50-600	Bilateral IDC post chemotherapy
209	48	Right	452	500	Becker25-400	DCIS, radial scar, other B3/B1 areas
210	51	Right	230	200	Becker 25-250	Grade 1 IDC with other enhancements on MRI
211	49	Right	715	700	Becker 50-500	Invasive carcinoma
212	31	Right	516	500	Mod Plus 400	<i>BRCA</i> 1 Small focus IDC
213	31	Left	332	350	Mod Plus 401	<i>BRCA</i> 1 left previous WLE cancer now risk reduction
214	61	Right	112	100	Becker 25-150	Bilateral DCIS
215	61	Left	146	150	Becker 25-150	Bilateral DCIS
216	45	Right	300	300	Becker 50-400	<i>BRCA</i> bilateral breast cancer with previous WLE, risk reduction
217	45	Left	316	350	Becker50-400	<i>BRCA</i> bilateral breast cancer with previous WLE, risk reduction
218	67	Right	550	700	Becker50-500	IDC subareolar and margins-positive
219	49	Right	251	300	Becker 25-250	Multifocal ILC
220	49	Right	780	800	Becker 25-600	45 mm and 15 mm grade 3 IDC
221	72	Right	122	200	Becker 25-150	Positive margin DCIS
222	51	Right	337	350	Becker50-300	DCIS
223	73	Left	354	400	Becker 25-500	Multifocal grade 2 IDC

Table I. Continued

Table I. Continued

Case number	Age, years	Laterality	Mastectomy specimen		Implant used	Indication
			Weight, g	Volume, ml		
224	51	Right	169	150	No reconstruction	Prophylactic: Contralateral carcinoma
225	51	Left	190	200	No reconstruction	Grade 2 IDC
226	31	Right	349	350	TSF 365	Prophylactic: BRCA 1/2-positive. Contralateral carcinoma
227	31	Left	275	300	TSF 365	IDC
228	55	Right	686	700	Becker50-300	Prophylactic: BRCA 1/2-positive. Previous contralateral carcinoma
229	47	Right	226	250	HP 325	Prophylactic: BRCA 2-positive.
230	47	Left	233	250	HP 325	Prophylactic: BRCA 2-positive.
231	42	Left	1388	1200	Becker25-500, no 600 on shelf	Post-chemotherapy 50 to 35 mm grade 3 IDC
232	25	Right	510	600	Becker 25-600	Prophylactic: Contralateral carcinoma.
233	25	Left	606	600	Becker 25-600	Grade 3 IDC. post chemotherapy
234	48	Right	662	600	Becker 25-500	Multifocal grade 2 IDC
235	47	Left	298	300	Becker 25 - 350	Multifocal grade 1 IDC
236	62	Right	617	600	No reconstruction	Central 3 cm grade 2 mucinous carcinoma
237	49	Right	320	300	Becker 50-300	Multifocal IDC. post chemotherapy
238	46	Left	980	1000	Becker 25-600	Recurrent multifocal grade 3 IDC
239	64	Left	442	450	Becker 50-400	4.5 cm Grade 2 IDC
240	60	Right	586	650	No reconstruction	Multifocal grade 2 ILC over 6.1 cm
241	60	Left	588	650	No reconstruction	Prophylactic: Contralateral carcinoma
242	45	Left	488	480	Becker 50-500	Grade 2 IDC
243	53	Left	326	300	Mod plus 325	Extensive grade 3 IDC. Post chemotherapy
244	55	Right	365	350	Becker25-300	Multifocal grade 2 ILC, LCIS
245	37	Left	352	350	Becker 25-300, L>R breast	3.9 cm Grade 2 IDC
246	45	Right	292	300	No reconstruction	Multifocal grade 3 IDC
247	39	Right	145	125	TSM265	Prophylactic: Previous carcinoma left breast
248	39	Left	154	125	TSM265	Prophylactic: Previous carcinoma left breast
249	45	Right	611	600	Becker 50-500	Prophylactic: Previous grade 1 IDC on left breast
250	45	Left	669	650	Becker 50-5000	Prophylactic: Previous grade 1 IDC on left breast
251	39	Left	638	600	Becker 25-500	Previous IDC
252	60	Right	600	600	Becker 25-500	Multifocal grade 2 IDC
253	42	Left	324	320	No reconstruction	DCIS
254	57	Left	1100	1000	Becker 25-500	Multifocal grade 2 IDC with intermediate-grade DCIS
255	35	Right	170	180	Becker 25-250	Multiple papillary syndrome
256	90	Left	85	100	No reconstruction	1.7 cm grade 2 IDC
257	54	Left	375	350	No reconstruction	Multifocal grade 2 IDC and high-grade DCIS
258	56	Right	476	510	No reconstruction	Grade 3 IDC (multifocal)
259	50	Right	830	800	Becker 50-500	Extensive DCIS
260	50	Left	640	650	Becker 50-500	Right DCIS left risk reduction
261	56	Right	568	600	Becker 35-460	2.2 cm Grade 1 IDC (recurrent)
262	49	Left	1640	1500	Becker 25-600 plus LD	Multifocal grade 3 IDC with intermediate-grade DCIS
263	36	Left	295	300	Becker 50-300	IDC
264	48	Left	894	900	HP800	Prophylactic: Contralateral carcinoma
265	81	Right	722	700	No reconstruction	High-grade DCIS
266	50	Left	750	700	Becker 25-500	4.4 cm grade 2 IDC. Post chemotherapy with poor response.
267	62	Left	390	400	Becker 25-400	Multifocal grade 3 IDC
268	43	Left	220	220	Becker 25-250	2.5 cm Central grade 2 IDC plus separate UOQ mucinous carcinoma
269	43	Right	416	400	Becker 25-400	3.5 cm Grade 3 IDC
270	47	Right	696	700	Becker 50-600	7.5 cm DCIS with grade 2 IDC
271	48	Right	295	300	Becker 25-350	1.7 cm Grade 2 IDC
272	37	Right	384	350	TSF 415	Prophylactic: Contralateral carcinoma
273	37	Left	435	400	TSR 415	Grade 3 IDC
274	47	Right	356	350	HP 600 removed implant 225	DCIS multifocal grade 1 IDC
275	69	Right	760	800	No reconstruction	1.5 cm Grade 2 IDC
276	51	Left	356	300	Becker 35-400	Prophylactic
277	41	Right	600	600	TSF 520	2 cm Grade 2 IDC
278	41	Left	613	600	TSF 520	Prophylactic: Contralateral carcinoma

BRCA: Breast cancer type 1 susceptibility protein; BWV: breast weight to volume ratio; CHEK2: checkpoint kinase 2; DCIS: ductal carcinoma *in situ*; IDC: invasive ductal carcinoma; ILC: invasive lobular carcinoma; LCIS: lobular carcinoma in situ; LIQ: lower inner quadrant; LOQ: lower outer quadrant; MUTYH: mutY DNA glycosylase; MHS2: MutS protein homolog 2; PTEN: phosphatase and tensin homolog; UIQ: upper inner quadrant; SNB: sentinel node biopsy; WLE: wide local excision.

The potential role of breast imaging modalities such as ultrasonography, computed tomography and magnetic resonance imaging in predicting breast volume preoperatively has been investigated with variable results (3). Ultrasound has the limitation of reduced objectivity and reproducibility. Computed tomography involves radiation exposure and in the supine position does not reflect breast geometrics accurately. Magnetic resonance imaging assessment of breast volume has demonstrated a significant correlation with actual breast weight, with breast density influencing the correlation (3).

The correlation between the intraoperative breast specimen weight and volume was previously investigated by other authors (4, 5). Parmar et al. reported non-significant difference of 6.6% between the weight of intraoperative breast specimens and volume, with the difference being smaller in postmenopausal women most likely due to lower breast density in this group. The study was relatively small (69 specimens) and predominantly included breast reduction specimens (4). Lee and colleagues designed equations to calculate the breast volume on the basis of the breast weight, incorporating adjustment for breast density (5).

The strength of our study arises from using adequate sample size, use of intraoperative mastectomy specimens and presence of malignant pathology, which represents the most common indication for mastectomy. The main limitation is the lack of data regarding breast density, where the fibroglandular-to-adipose ratio might affect the correlation. Furthermore, our methodology does not provide a means of predicting breast volume preoperatively in order to guide reconstructive surgery planning.

We utilized our simple approach in selecting the best implant for breast reconstruction following skin-sparing mastectomy after carrying out an adjustment for the use of SurgiMend™ (Integra Life Sciences, Plainsboro, NJ, USA), a foetal bovine acellular dermal matrix (ADM) with the following dimensions: 16 cm × 8 cm × 0.1 cm. The volume of the ADM after integration was estimated to be 32 cc, assuming an additional thickness of 1.5 mm of granulation tissue. The required implant size was, therefore, calculated as follows:

*Volume of implant = mastectomy weight (g) - 32*

We previously reported an excellent subjective patient satisfaction and objective independent aesthetic assessment scores (9 out of 10) after oncoplastic breast reconstruction (6, 7). We are currently extrapolating our methodology to the evolving technique of pre-pectoral ADM-assisted implant-based immediate breast reconstruction following skin-sparing mastectomy (8).

In conclusion, our study provides evidence that intraoperative measurement of the weight of mastectomy specimens accurately reflects the breast volume and this simple approach can be used to guide implant selection during breast reconstruction.

## Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The data in this manuscript were presented in a poster at the San Antonio Breast Cancer Symposium on Dec-8, 2017.

## Conflicts of Interests

The Authors have no conflicts of interest to report pertaining to this study. The Senior Author (KM) provides clinical and academic advisory services to Q Medical Technologies.

## Acknowledgements

The Authors would like to thank Ivanna Naumets for her help with the statistical analysis.

## References

- 1 Sbitany H, Piper M and Lentz R: Prepectoral breast reconstruction: A safe alternative to submuscular prosthetic reconstruction following nipple-sparing mastectomy. *Plast Reconstr Surg* 140(3): 432-443, 2017.
- 2 Baek WY, Byun IH, Kim YS, Lew DH, Jeong J and Roh TS: Patient satisfaction with implant based breast reconstruction associated with implant volume and mastectomy specimen weight ratio. *J Breast Cancer* 20(1): 98-103, 2017.
- 3 Yoo A, Minn KW and Jin US: Magnetic resonance imaging-based volumetric analysis and its relationship to actual breast weight. *Arch Plast Surg* 40(3): 203-208, 2013.
- 4 Parmar C, West M, Pathak S, Nelson J and Martin L: Weight versus volume in breast surgery: An observational study. *JRSM Short Rep* 2(11): 87, 2011.
- 5 Lee JH, Yeo CH, Kim T, Chung KJ, Lee SJ, Kang SH and Choi JE: Conversion from weight to volume of mastectomy specimen: Convenient equations. *J Plast Reconstr Aesthet Surg* 70(6): 792-794, 2017.
- 6 Headon H, Kasem A, Manson A, Choy C, Carmichael AR and Mokbel K: Clinical outcome and patient satisfaction with the use of bovine-derived acellular dermal matrix (surgimend) in implant based immediate reconstruction following skin sparing mastectomy: A prospective observational study in a single centre. *Surg Oncol* 25(2): 104-110, 2016.
- 7 El Hage Chehade H, Headon H, Wazir U, Carmichael AR, Choy C, Kasem A and Mokbel K: Nipple-sparing mastectomy using a hemi-periareolar incision with or without minimal medial-lateral extensions; clinical outcome and patient satisfaction: A single centre prospective observational study. *Am J Surg* 213(6): 1116-1124, 2017.
- 8 Wazir U and Mokbel K: The evolving role of pre-pectoral adm-assisted implant-based immediate breast reconstruction following skin-sparing mastectomy. *Am J Surg* 216(3): 639-640, 2018.

*Received September 30, 2018*

*Revised October 24, 2018*

*Accepted October 29, 2018*