

Endoscopy-assisted breast-conserving surgery for breast cancer patients

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Abstract: Breast-conserving surgery (BCS) combined with postoperative radiotherapy is a standard therapy for early-stage breast cancer patients. In addition, recent developments in oncoplastic surgery have improved cosmetic outcomes and patient satisfaction. Therefore, a breast surgeon's current role in BCS is not only to perform a curative resection of cancerous lesions with adequate surgical margins, but also to preserve the shape and appearance of the treated breast. Endoscopy-assisted breast-conserving surgery (EBCS), which has the advantage of a less noticeable scar, was developed more than ten years ago. Recently, some clinical studies have reported the feasibility, oncological outcomes, aesthetic outcomes, and patient satisfaction of EBCS. Herein, we will review the EBCS clinical studies that have been conducted so far and discuss current issues regarding this operative method.

Keywords: Endoscopy assisted; breast cancer; breast surgery; breast-conserving surgery (BCS); endoscope

Submitted Oct 29, 2013. Accepted for publication Dec 17, 2013.

doi: 10.3978/j.issn.2227-684X.2013.12.04

View this article at: <http://www.glandsurgery.org/article/view/3628/4711>

Introduction

Breast-conserving surgery (BCS) combined with postoperative radiotherapy is widely accepted as standard therapy for early breast cancer patients with survival equivalent to that of mastectomy (1-3). Moreover, oncoplastic breast cancer surgery techniques have developed over the recent years, and patients' concern regarding the postoperative aesthetic outcome has also been increasing. Therefore, the current goal of BCS is not only to achieve a curative partial resection but also to preserve the cosmetic appearance of the breast. Endoscopy-assisted breast conserving-surgery (EBCS), which has the advantage of a less noticeable scar, was developed more than ten years ago and performed in some Asian countries (4-13). Although a shortage of clinical studies exists, achievement of oncological safety, as well as better cosmetic outcomes, with EBCS has been demonstrated in some institutions recently. However, achieving both tasks (curative operation and satisfaction with the aesthetic outcome) together with EBCS can be challenging and sometimes result in failure because of

difficulty in repairing the excised breast volume. In this article, we will review the EBCS clinical studies that have been conducted so far and discuss current issues regarding this operative method.

Overview of the studies

A literature search was performed using the PubMed/Medline database. The following MeSH headings were used: "Endoscopy assisted", "Breast Cancer", "Breast Surgery", "Breast-Conserving Surgery", "Endoscope" and "Quadrantectomy". We reviewed six case series and four cohort studies published between December 2001 and August 2013 as representative EBCS studies. The following items will be discussed in this review:

- (I) Indication and contraindication;
- (II) Preoperative diagnostic imaging and marking;
- (III) Operative method;
- (IV) Surgical outcomes;
- (V) Oncological outcomes;
- (VI) Aesthetic estimation and patient satisfaction rating.

Indications and contraindications for EBCS (Tables 1,2)

As for the clinical T-factor, all studies limited their indication to T1 or T2 tumors (average tumor size, 0.6-2.2 cm), and patients who had invasion to the skin, pectoralis muscle, or chest wall were contraindicated. In addition, multicentricity seemed to be contraindicated, similar to that of conventional breast-conserving surgery (CBCS) (6). One study limited resection of the mammary gland region to less than 20% of the total area (13). Clinically positive axillary nodes were also contraindicated in five studies (4,6,9-11).

Preoperative diagnostic imaging and marking (Tables 1,2)

For preoperative diagnosis or marking, five studies used not only mammography (MMG) and ultrasonography (US), but also magnetic resonance imaging (MRI) (6-9,13). Three studies did not mention any diagnostic imaging tools. One study demonstrated a method for preoperative marking using US-guided planning of the resection range and mobilization range of the mammary gland according to the MRI findings. For nonpalpable tumors with calcification identified using MMG, a hook wire was initially inserted into the calcification by stereo-guided insertion. After this, US-guided planning was performed. During marking, patients were laid in an operative position. The surgical margin was marked 1.5-2 cm from the tumor edge. The authors of this study also marked the penetrating branch of the internal thoracic vessels in the parasternal area on the tumor side by US (13).

Operative method (Tables 3,4)**Setting an intraoperative surgical margin and injection of a colored dye**

In five studies, an intraoperative surgical margin was set 2 cm from the tumor border (4,7-10). In other four studies, the margin was set at 1, 1.5-2, and <2 cm (5,11,13), and one study did not demonstrate a surgical margin (6). On the other hand, injection of a colored dye along the resection margin was performed in nine studies with various color dyes, and one study did not discuss the usage of a colored dye.

Skin incision placement

As for the site for a skin incision, axillary, periareolar, midline, and lateral mammary lines were adopted. A combination of an axillary incision with a periareolar incision was commonly used. A small axillary incision (2.5-3 cm)

was mainly used for dissection of the posterior surface of the mammary gland in six studies (*Figure 1A*) (6,7,9-11,13). A periareolar incision was used for the development of a skin flap and the removal of a resected specimen from the breast in nine studies (4-6,8-13). In case of tumors located in the outer upper or outer inner region, a single midaxillary incision or a combination of a small lateral incision (2.5-3 cm) and a small axillary incision was used (8,13). In one study, a single, large axillary incision was used for the partial resection of the mammary gland and for the harvesting of a latissimus dorsi mini-flap (LDF) in order to reconstruct the breast (8).

Dissection of the posterior surface of the breast

Endoscopic dissection of the posterior surface was performed with various retraction devices (Vein harvest, Ultra Retractor, Vein Retractor, Endosector LE etc.; *Tables 3,4*) and a bipolar scissor. These retraction devices allow for a magnified view and the performance of an extensive posterior breast dissection (*Figure 1A*). In one study, a preperitoneal distention balloon was also effectively used via a periareolar incision (12).

Skin flap development

In five studies, a skin flap was made using a bladeless trocar equipped with an endoscope and bipolar scissors, harmonic scalpels, or an electric cautery (*Figure 1B*) (6-8,10,12). First, the skin was separated from the mammary gland by a bladeless trocar under video guidance, and multiple tunnels were created. The thickness of the skin can be adjusted by the intensity of the light transmitted from the skin. This method is the so-called "subcutaneous tunneling method". After that, the septa between the tunnels were dissected using bipolar scissors, harmonic scalpels, or an electric cautery with or without light guidance. Under light- or endoscopic guidance, a skin flap was also made with an electric cauterizer and a bipolar scissor in three studies (5,9,11) and one study (4), respectively. Additionally, in one study, a skin flap was made using subcutaneous hydrodissection and dissecting scissor (13).

Wound protector

To protect the periareolar wound and ensure adequate visualization, a wound protector was used in four studies (4,7,10,13).

Resection of the mammary gland and specimen retrieval

Resection of the mammary gland and specimen retrieval

Table 1 Case series on endoscopic-assisted breast conserving surgery, patient characteristics

Author	Year of publication	Tumor size limit (cm)	Number of patients	Average tumor size (cm, range or ± SD)	Clinical T-factor, n [%]	Imaging tools for preoperative marking	Preoperative therapy, n (%)
Tamaki <i>et al.</i> (4)	2001	<2	6	1.6 (1.3-2.2)	T1: 6 [100]	US etc.	No data
Owaki <i>et al.</i> (5)	2005	≤1.5 (invasive tumor)	6	Invasive lesion: 0.6; non-invasive lesion: 0.27 (by pathological diagnosis)	Tis: 1 [17]; T1: 5 [83]	No data	No data
Lee <i>et al.</i> (6)	2006	<3	20	2.2 (0.2-4.0)	Tis: 4 [20]; T1: 8 [40]; T2: 8 [40]	MMG, US, MRI	No data
Yamashita and Shimizu (7)	2008	6.5	20	2.2	T1: 13 [65]; T2: 7 [35]	MRI etc.	No data
Nakajima <i>et al.</i> (8)	2009	4 (5*) (* depend on patient's desire)	551	Tis: 2.5±1.9; T1: 1.5±0.5; T2: 3.6±0.7	Tis: 47 [8.5]; T1: 190 [34.5]; T2: 314 [57.0]	US, MRI etc.	T1: 2 (1.1); T2: 46 (14.7); Total: 48 (8.7)
Saimura <i>et al.</i> (9)	2013	<2	61	1.4 (0.6-2.0)	Tis: 4 [6.6]; T1: 56 [91.8]; T2: 1 [1.6]	MMG, US, MRI	No data

Table 2 Cohort studies on endoscopic-assisted breast conserving surgery, patient characteristics

Author	Year of publication	Tumor size limit (cm)	Number of patients		Average tumor size (cm, range or ± SD)	P	Clinical T-factor or Stage, n [%]		P	Imaging tools for preoperative marking		Preoperative therapy, n (%)	
			EBCS	CBCS			EBCS	CBCS		EBCS	CBCS	EBCS	CBCS
Yamashita and Shimizu (10)	2006	No data	82 [§]	34	1.8 (0.1-6.5)	1.7 (1.5-4.0)	0.737	Stage 0: 5 [6]; Stage I: 46 [56]; Stage IIA: 21 [26]; Stage IIB: 10 [12]	Stage 0: 1 [3]; Stage I: 15 [44]; Stage IIA: 13 [38]; Stage IIB: 5 [15]	0.468	No data	No data	No data
Park <i>et al.</i> (11)	2011	<5	40	681	1.5±0.7	1.5±0.7	0.94	Tis: 1 [2.5]; T1: 30 [75.0]; T2: 9 [22.5]	Tis: 131 [19.3]; T1: 442 [65.0]; T2: 107 [15.7]	0.02	No data	0	0
Takemoto <i>et al.</i> (12)	2012	3	60	51	No data	No data	No data	Tis: 5 [8.3]; T1: 40 [78.4]; T2: 6 [11.8]	Tis: 5 [8.3]; T1: 45 [75.0]; T2: 10 [16.7]	0.753	US etc.	No data	No data
Ozaki <i>et al.</i> (13)	2013	<3	73	90	No data	No data	No data	Tis: 14 [19.2]; T1: 44 [60.3]; T2: 15 [20.5]	Tis: 11 [12.2]; T1: 60 [66.7]; T2: 19 [21.1]	0.614	MMG, US, MRI, second-look US	Stage II: 19 (12.3); PR: 17; CR: 5	Stage II: 10 (11.1); PR: 5; CR: 5

[§], two cases were converted to mastectomy. EBCS, endoscopy-assisted breast-conserving surgery; CBCS, conventional breast-conserving surgery.

Table 3 Case series on endoscopic-assisted breast conserving surgery, operative methods and outcomes

Author	Design of surgical margin, cm	Injected colored dye for marking of surgical margin	Incision placement	Wound protector	Posterior dissection	Subcutaneous dissection	Average operative duration [minutes, range or ± SD]	Reconstruction
Tamaki <i>et al.</i> (4)	2	Pyoktatin	Periareolar	Silicon ring	Retractor and bipolar scissor	Bipolar scissor	Total: 241 [190-315]; partial mastectomy: 84 [69-113]	Mobilization
Owaki <i>et al.</i> (5)	≤2	No data	5 cm axilla and periareolar for inner lesion	No data	Electrocauterizer	Two wire retractors and electrocauterizer	165 [45-260]	Mobilization
Lee <i>et al.</i> (6)	No data	Methylene blue dye	2.5 cm axillary fold and periareolar	No data	Vein harvest* and bipolar scissor	Tunneling method and bipolar scissor	163 [115-205]	Mobilization
Yamashita and Shimizu (7)	2	Gentiana violet liquid	2.5 cm axillary	Lap protector	Ultra retractor or vein retractor	Tunneling method and harmonic scalpel	45 min. longer than CBCS	Mobilization, LTF, absorbable fiber mesh or cellulose cotton
Nakajima <i>et al.</i> (8)	2	Gel containing blue dye	Midaxillary or periareolar	No data	Hirotech retractor	Tunneling method and bipolar scissor	T1: 238±47; T1: 223±39; T2: 239±52	Resection rate of the breast (<30%); mobilization; Resection rate of the breast (≥30%): LTF or LDMF; T1: mobilization =25.5%, LTF =19.1%, LDMF =55.3%; T1: mobilization =60.0%, LTF =19.5%, LDMF =20.5%; T2: mobilization =42.0%, LTF =19.4%, LDMF=38.5%
Saimura <i>et al.</i> (9)	2	Indigo carmine and xylocaine jelly	3.0 cm axillary fold and periareolar semicircular	No data	Vein retractor and bipolar scissor	Electrocauterizer	Total: 167 [105-260]	Mobilization

Vein harvest (Johnson & Johnson, US), currently sold as Optical Vessel Dissector (SORIN GROUP USA, US). Ultra retractor (Johnson & Johnson, US), currently sold as Small Ultra-Retractor (SORIN GROUP USA, US). Vein retractor (Karl Storz, Germany). Hirotech retractor (Mizuho, Japan). Lap protector (Hakko Co., Japan). LTF, lateral thoracic adipose tissue flap; LDMF, latissimus dorsi miniflap.

Table 4 Cohort studies on endoscopic-assisted breast conserving surgery, operative methods and outcomes

Author	Design of surgical margin for EBCS (cm)	Injected colored dye for marking of surgical margin	Incision placement	Wound protector	Posterior dissection	Subcutaneous dissection	Average operative duration (minutes, range or \pm SD)		P	Reconstruction
							EBCS	CBCS		
Yamashita and Shimizu (10)	2	Gentiana violet liquid	2.5 cm axillary and periareolar	Lap protector	Ultra retractor or vein harvest	Tunneling method and harmonic scalpel	173 \pm 45	149 \pm 32	0.131	Mobilization, LTF, absorbable fiber mesh
Park <i>et al.</i> (11)	1	Gentiana violet liquid	3 cm axillary fold and periareolar	No data	Endosector LE	Electrocauterizer	BCS + SNB: 102.1 \pm 22.9; BCS + Ax: 139.5 \pm 30.3	BCS + SNB: 102.38 \pm 28.8; BCS + Ax: 122.49 \pm 40.5	0.96; 0.24	Mobilization
Takemoto <i>et al.</i> (12)	No data	Diagnogreen	Axilla and periareolar	No data	Preperitoneal distention balloon	Tunneling method and bipolar scissor	69 [55-104]	93 [77-106]	0.018	Absorbable fiber mesh
Ozaki <i>et al.</i> (13)	1.5-2	Indigo carmine and xylocaine jelly	2.5 cm axillary fold and periareolar semicircular or lateral mammary line	Lap protector	Vein retractor and bipolar scissor	Tumescent technique	BCS: 130.5 \pm 32.4; BCS + SNB: 148.1 \pm 42.7; BCS + Ax: 189.7 \pm 40.0	BCS: 80.4 \pm 21.8; BCS + SNB: 118.3 \pm 46.4; BCS + Ax: 145.2 \pm 48.1	<0.01; 0.029; 0.020	Mobilization

Vein harvest (Johnson & Johnson, US), currently sold as Optical Vessel Dissector (SORIN GROUP USA, US). Ultra retractor (Johnson & Johnson, US), currently sold as Small Ultra-Retractor (SORIN GROUP USA, US). Vein Retractor (Karl Storz, Germany). Preperitoneal distention balloon (US surgical Co, US). Endosector LE (Curexo, Korea). Lap protector (Hakko Co., Japan). EBCS, endoscopy-assisted breast-conserving surgery; CBCS, conventional breast-conserving surgery; BCS, breast-conserving surgery; SNB, sentinel lymph node biopsy; Ax, axillary lymph nodes dissection; LTF, lateral thoracic adipose tissue flap.

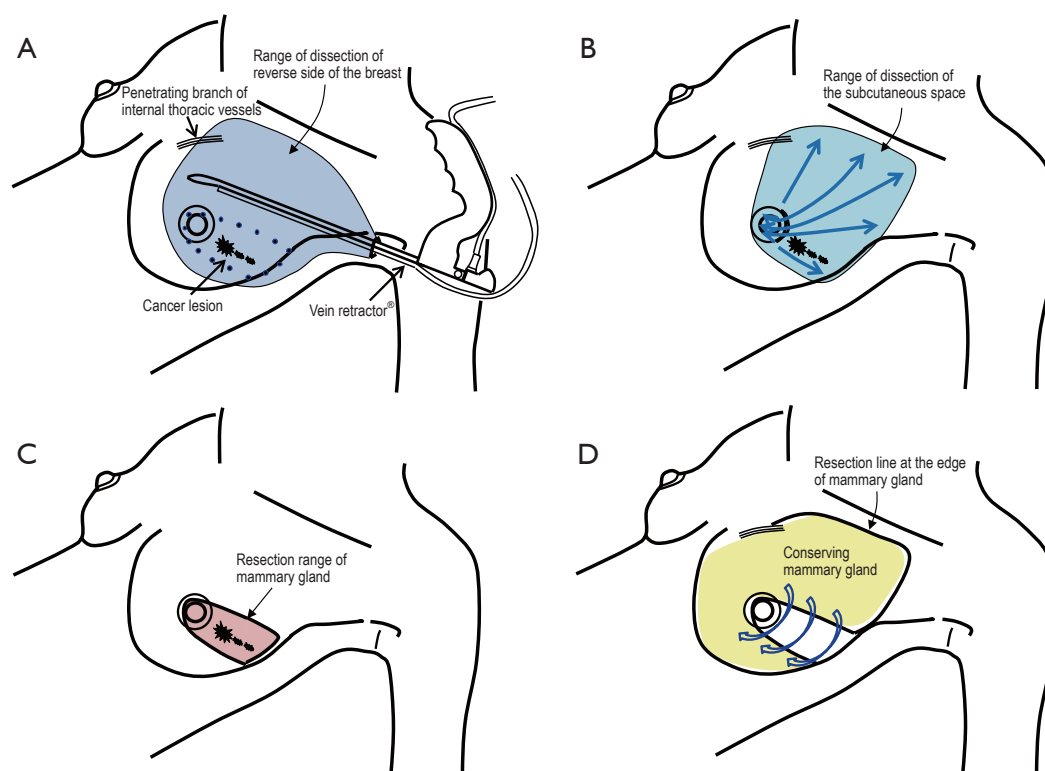


Figure 1 Operative procedure of endoscopic-assisted breast-conserving surgery. (A) Dissection of the posterior surface of the breast; (B) skin flap development; (C) resection of the mammary gland under light guidance from a periareolar incision; (D) repair of the defect by mobilization of the conserved breast tissue from a periareolar incision.

were performed via a periareolar incision (*Figure 1C*) or midaxillary incision. In one study, a small axillary incision was used not only for resection of the mammary gland, but also for retrieval of the specimen using Endocatch (Autosuture, US) (7).

Placement of surgical clips

To inform the radiation oncologists of accurate surgical margins, surgical clips should be placed in each margin. In two studies, surgical clips were placed in the margins (11,13). The other eight studies did not discuss these data.

Reconstruction of the breast

To repair the defect of the excised breast tissue, volume displacement using the remnant breast tissue, volume replacement using an LDF, and a filling method were used as follows.

Volume displacement

To repair the breast, remnant breast tissue was dissected and

mobilized to the defect and sutured via an incision under light guidance (*Figure 1D*) (4-6,8,9,11,13).

Volume replacement

In one study, if the defect in the breast tissue reached more than 30% of the total breast volume, reconstruction was performed using an LDF harvested under endoscopic guidance or lateral thoracic adipose tissue flap (LTF) via a midaxillary line incision (8).

Filling method

Three studies showed a unique method of filling the breast tissue defect using an absorbent synthetic fiber mesh (Vicryl mesh, Johnson & Johnson Co, US) wrapped in an absorbable adhesion barrier (INTERCEED, Johnson & Johnson Co, US) or oxidized cellulose cotton (Surgicel, Johnson & Johnson Co, US) (7,10,12,14).

Postoperative drainage

Postoperative drainage was routinely performed in four

studies (6,10,11,13) and only in case of axillary dissection in two studies (4,9). The other four studies did not discuss these data. As the incision for the drainage tube placement was tiny, it would not seem to affect the aesthetic outcome.

Skin closure and care of the operative scar

The skin incision was closed with a monolayer suture by a buried subcuticular suture or bilayer suture by a buried subcuticular and skin suture or Dermabond (Ethicon Endo-Surgery, US). In one study, after suture removal, the wound was sealed and covered with Micropore (3M Health Care, US) for three months after surgery to keep the wound inconspicuous (13).

Surgical outcomes (Tables 5,6)

Operative duration

According to the results of the four cohort studies, an average operative duration for EBCS was equal, 30-50 min longer, or 24 min shorter than that of the CBCS group (10-13). However, these different results can be attributed to the difference in the reconstruction method for each EBCS operative method. Therefore, to compare the operative duration between EBCS and CBCS, standardization of the operative method for EBCS was necessary in the first place.

Intraoperative blood loss

In the three cohort studies, intraoperative blood loss was not significantly different between EBCS and CBCS. The intraoperative blood loss associated with EBCS with a filling method to repair the excised breast volume was significantly less than that associated with CBCS (12). It was assumed to be because of less dissection of the breast tissue.

Complications

Complications associated with EBCS did not frequently occur, but partial wound necrosis and skin flap necrosis occurred in a few cases. Using a wound protector and retaining a thick skin flap might help to prevent them.

Surgical margin

A positive surgical margin rate seen with EBCS was not inferior to that of CBCS in these studies. However, margin involvement varied from 0% to 28.3%. In nine studies, a colored dye was injected into the mammary gland along the resection margin, but the actual practice of presurgical marking and usage of an intraoperative US were poorly shown, except for one study (13). In a recent analysis, data

showed that a tumor-free margin distance of 2 mm should be adopted as an adequate excision margin for invasive breast cancer and ductal carcinoma in situ to minimize the risk of local recurrence (15,16).

Oncological outcomes (Tables 5,7)

Local recurrence

Six studies reported rates of local recurrence. Although the average follow-up time was not enough (12-38.4 months), local recurrence infrequently occurred from 0% to 4.2% (4,8-11,13). According to one study, a local recurrence was more likely to occur with a large tumor (Tis, 0%; T1, 3.7%; T2, 5.1%) (8).

Distant metastasis

Three studies reported the rate of postoperative distant metastases. Possibly because of the short observational period (12-18.1 months) (8,11,13), a distant metastatic lesion was not detected in two studies (11,13). In one case series, the frequency of distant metastases detected over the duration follow-up was related to the tumor size [rate of distant metastases (average follow-up period); Tis, 0% (29.1 months), T1, 3.7% (40 months); T2, 5.1% (39.5 months)] (8).

Overall survival

Five studies reported overall survival. Even though the follow-up period was short, the overall survival was excellent in each study (8-11,13). On the basis of tumor size, one study reported the following result: Tis, 100%; T1, 97.3%; and T2, 95.7% (8). Thus, overall survival seemed to be influenced by tumor size, similar to that of distant metastasis.

Aesthetic estimation and patient satisfaction rating (Tables 5,6)

Aesthetic outcome was estimated in five studies with three methods as follows:

- (I) Four-point scoring system (excellent, good, fair, or poor) (17);
- (II) Five-item-by-4-step method (ABNSW), consisting of five items (Asymmetry, Breast shape, Nipples shape, Skin condition, and Wound scar). Each item was evaluated with four steps (0, poor; 1, fair; 2, good; and 3, excellent). Scores greater than 11 points were considered good or excellent (10);
- (III) Japanese Breast Cancer Society (JBSC) classification, consisting of eight items (breast size, breast

Table 5 Case series on endoscopic-assisted breast conserving surgery, surgical outcomes, aesthetic outcomes, patient satisfaction rating and oncological outcomes

Author	Post-operative drainage (mL or g)	Intraoperative blood loss (mL or g)	Complications, n (%)	Aesthetic outcome, n (%)	Patient satisfaction rating	Average follow up time, months	Positive surgical margin, n [%]	Local recurrence, n (%)	Metastatic disease, n (%)	Overall survival, %
Tamaki <i>et al.</i> (4)	Only in the case of ALND	192 [60-290]	0	No data	All cases are satisfied	No data	1 [16.6]	0	No data	No data
Owaki <i>et al.</i> (5)	No data	150±96.9 mL	No data	No data	All cases are satisfied	No data	No data	No data	No data	No data
Lee <i>et al.</i> (6)	(+) No data	184±130 mL	0	4-point scoring system: excellent = 7 (36.9); good = 10 (52.6); fair = 2 (10.5); poor = 0	89.5% are satisfied	No data	1 [5]	No data	ALN(+): 2 [10]	No data
Yamashita and Shimizu (7)	No data	No data	No data	ABNSW: all cases are more than 14 points (good or excellent). Full score: 15 points	No data	No data	0	No data	No data	No data
Nakajima <i>et al.</i> (8)	No data	Tis: 116±23; T1: 107±27; T2: 141±34	Skin necrosis: 22 (4.0) fat and/or muscle flap necrosis: 17 (3.1)	No data	Overall degree: good = 366 (76.1); fair = 66 (13.7); poor = 49 (10.2); Surgical scar: good = 401 (83.4); fair = 43 (8.9); poor = 37 (7.7). Shape of the breast: good = 347 (72.1); fair = 62 (12.9); poor = 72 (15.0)	Tis: 29.1 [5-73]; T1: 40 [5-96]; T2: 39.5 [5-95]	Tis: 16 [34.0]; T1: 35 [18.4]; T2: 62 [19.5]; Total: 113 [20.5]	Tis: 0; T1: 7 (3.7); T2: 18 (5.7); Total: 25 (4.5)	Tis: ALN(+): 2 (4.3), distant: 0; T1: ALN(+): 24 (12.6), distant: 7 (3.7); T2: ALN(+): 97 (30.9), distant: 16 (5.1)	Tis: 100; T1: 97.3; T2: 95.7
Saimura <i>et al.</i> (9)	Only in the case of ALND	27 [5-80]	Skin burn: 3 (1.6)	4-point scoring system: excellent = 21 (36.8); good = 26 (45.6); fair = 4 (7.0); poor = 6 (10.5). JBCS classification: average total score = 9.1	No data	No data	0	0	ALN(+): 7 (11.5)	100

ABNSW, scoring system consists of five items: asymmetry (A), breast shape (B), nipple shape (N), skin condition (S), and wound scar (W). JBCS classification, scoring system consists of eight items: breast size, breast shape, breast scar, hardness, nipple/areolar size and shape, nipple/areolar color, nipple position, inframammary line.

Author	Post-operative drainage	Intraoperative blood loss (mL or g)		P	Complications, n [%]		Aesthetic outcome or patient satisfaction rating, n [%]		P	
		EBCS	CBCS		EBCS	CBCS	EBCS	CBCS		
		Aesthetic outcome or patient satisfaction rating, n [%]			Aesthetic outcome or patient satisfaction rating, n [%]					
Yamashita and Shimizu (10)	(+)	174±118	147±118	0.909	Bleeding: 7 [8.8]; hematoma: 2 [2.5]	No data	ABNSW: more than 11 points (good or excellent) in 90% cases. Full score: 15 points. Almost all patients were satisfied	No data	No data	
Park <i>et al.</i> (11)	(+)	No data	No data	No data	Seroma: 2 [5]; cellulitis: 1 [2.5]; bleeding or hematoma: 1 [2.5]; wound necrosis: 1 [2.5]	Seroma: 7 [1.0]; cellulitis: 6 [0.8]; bleeding or hematoma: 8 [1.1]; wound necrosis: 8 [1.1]	No data	No data	No data	
Takemoto <i>et al.</i> (12)	(-)	45 [10-80]	100 [58-150]	<0.001	Mesh infection: 7 [11.7]	No data	Patient satisfaction rating: inner upper, 10 [76.9]; inner lower, 7 [70]; outer upper, 22 [78.6]; outer lower, 4 [44.4]	Patient satisfaction rating: inner upper, 7 [70]; inner lower, 1 [12.5]; outer upper, 17 [68]; outer lower, 2 [25.0]	1.000; 0.025; 0.384; 0.402	
Ozaki <i>et al.</i> (13)	(+)	BCS: 51.6±35.9; BCS + Ax: 106.0±50.4	BCS: 35.3±29.7; BCS + Ax: 89.5±48.4	0.054, 0.424	Partial wound necrosis, 4 [5.4]; partial skin flap necrosis: 2 [2.7]; postoperative bleeding: 1 [1.4]	No data	4-point scoring system: excellent =39 [53.4]; good =21 [28.8]; fair =10 [13.7]; poor =3 [4.1]. JBCS classification: average total score =10.14±1.61	4-point scoring system: excellent =13 [14.4]; good =27 [30.0]; fair =46 [51.1]; poor =4 [4.4]. JBCS classification: average total score =8.27±2.03	<0.01; <0.01	
<p>ABNSW, scoring system consists of five items: asymmetry (A), breast shape (B), nipple shape (N), skin condition (S), and wound scar (W). JBCS classification, scoring system consists of eight items: breast size, breast shape, breast scar, hardness, nipple/areolar size and shape, nipple/areolar color, nipple position, inframammary line. EBCS, endoscopy-assisted breast-conserving surgery; CBCS, conventional breast-conserving surgery.</p>										

Table 7 Cohort studies on endoscopic-assisted breast conserving surgery, surgical outcomes and oncological outcomes

Author	Average follow up time [months]		Positive surgical margin, n (%)		P	Local recurrence, n (%)		Metastatic disease, n [%]		P	Overall survival, (%)	
	EBCS	CBCS	EBCS	CBCS		EBCS	CBCS	EBCS	CBCS		EBCS	CBCS
Yamashita and Shimizu (10)	25 [up to 50]	No data	0	No data	No data	0	No data	No data	No data	No data	100	No data
Park <i>et al.</i> (11)	12	12	2 (5.0)	11 (1.6)	0.2	0	No data	0	No data	No data	100	No data
Takemoto <i>et al.</i> (12)	No data	No data	17 (28.3)	13 (25.5)	No data	No data	No data	ALN(+): 7 [13.7]	ALN(+): 10 [11.7]	0.745	No data	No data
Ozaki <i>et al.</i> (13)	18.1±5.6 [12-30]	43.7±22.9 [14-70]	1 (1.4)	17 (18.9)	<0.01	0	1 (1.1)	ALN(+): 15 [21]; Distant meta.: 0	ALN(+): 26 [29]	No data	100	100

EBCS, endoscopy-assisted breast-conserving surgery; CBCS, conventional breast-conserving surgery.

shape, breast scar, hardness, nipple/areolar size, shape, nipple/areolar color, nipple position, and inframammary line). Each item was evaluated with a 3-point system (2 points, good; 1 point, fair; and 0 points, poor) or 2-point system (1 point, good; 0 point, poor), and total scores were defined as “excellent” for scores of 11-12, “good” for scores of 8-10, “fair” for scores of 5-7, and “poor” for scores of 0-4 (18).

In three studies, 82.2% to 89.5% patients in the EBCS group were estimated as excellent or good on a 4-point scoring system (6,9,13). In one cohort study, the points for breast scars in the EBCS group were significantly higher than that of the CBCS group (13). The patient satisfaction rating was estimated in five studies (4-6,10,12), and more than 90% of the patients were satisfied with their aesthetic outcome with EBCS in three studies (4,5,10). The satisfaction rating with the surgical scar was high (83.4%) in one study (8) and higher (55.0%) than that of CBCS (31.4%) in another study (12). As for the satisfaction rating for each location, one study with a filling method using Vicryl mesh demonstrated a low satisfaction rating (44.4%) in the outer quadrant than those of the other quadrants (12). However, these surveys were performed less than three years after surgery or radiotherapy.

Discussion

Advantages and disadvantages of EBCS

One advantage of EBCS is its less noticeable scar. However,

even if a cancerous breast lesion were resected with a clear margin and a less noticeable scar, the aesthetic outcome would be poor, if the shape of the breast could not be maintained. Thus, the goal of EBCS is not only to perform a curative operation, but also to maintain the postoperative shape of the breast using oncoplastic techniques such as volume displacement or volume replacement.

Disadvantages of EBCS are a longer operative duration, because of its limited small operative field and the additional costs related to the usage of disposable devices. As for the operative duration, a certain amount of learning curve, simplification, and ingenuity with respect to the surgical procedures might be helpful. In one study, the surgeons developed a skin flap using a tumescent technique and could shorten the time in this step of BCS (13). On the other hand, currently, disposable endoscopic devices that are often used for other oncological surgeries are not approved by health insurance providers for breast cancer surgery; thus, usage of these devices may be problematic if EBCS becomes widespread. To improve this issue, in combination with endoscopy, retractors that were not disposable devices were used in five studies for a posterior dissection or for creation of a skin flap of the breast in order to minimize the usage of disposable devices (4,5,8,9,13).

Results from EBCS studies so far

Surgical outcomes

As shown, the overview of the EBCS studies and their surgical outcomes (operative duration, intraoperative blood

loss, complication, and surgical margin) seem to be equal to that of CBCS, but these factors vary depending on each operative method (10-13). Therefore, standardization of the operative method should be established.

Oncological outcomes

As for the oncological outcomes (local recurrence, distant metastasis, and overall survival), the EBCS studies suggest an equivalent risk of local recurrence and distant metastasis (4,8-11,13). Therefore, EBCS might not influence the oncological outcomes. Moreover, with EBCS, overall survival also demonstrated favorable results (8-11,13). However, the follow-up durations for the oncological outcomes were within 12-40 months; therefore, it was too short to regard EBCS as comparable to that of CBCS with respect to oncological safety.

Aesthetic estimation and patient satisfaction rating

Most of the EBCS studies demonstrated a favorable aesthetic outcome, and two studies had a better aesthetic outcome than that of CBCS (12,13). In particular, the score for the surgical scar was significantly higher (13), and this result reflected the benefit of EBCS. On the other hand, the patient satisfaction rating was also high and superior to that of CBCS for rating of the surgical scar (12). Nevertheless, the follow-up period for the estimation was not long enough, and the estimation methods for cosmesis, as well as for the patient satisfaction rating, were different among the studies or not clear. Ideally, these kinds of surveys should also be performed at least three years after radiotherapy with standardized and objective methods such as a 4-point scoring system for the aesthetic estimation combined with a European Organisation for Research and Treatment of Cancer (EORTC) breast cancer-specific quality of life questionnaire (EORTC-QLQ-BR23) or Functional Assessment of Cancer Therapy-Breast (FACT-B) for the patient satisfaction rating (19,20).

Key points for the success of EBCS

Patient selection on the basis of clinical examination and breast imaging

One of the most important things for a successful EBCS is the selection of a suitable patient for EBCS. According to the recent studies on oncoplastic breast surgery, when considering a patient for EBCS, the following points should be considered.

Ratio of excised breast tissue volume to the total breast volume

In general, with an excision of up to 20% of the breast volume, some degree of volume displacement by sufficiently undermining the surrounding breast tissue would provide an acceptable cosmetic result (21). It can be achieved in case of EBCS. On the other hand, with an excision of up to 20-40% of the total breast, volume displacement alone may not be sufficient, and therefore, volume replacement by autologous tissue transfer may be necessary (21). In case of EBCS, an LDF is harvested via an axillary fold or a midaxillary incision under endoscopic assistance that could be used for repairing a defect of the outer breast tissue (8,22).

Tumor location

The location of the tumor is also an important factor in the selection of the patient for EBCS. A defect located in the inner or lower pole of the breast is difficult to repair by mobilization via a periareolar incision, an axillary incision, or other small incisions. Thus, if the tumor is located in these two regions, EBCS is not usually recommended, and other oncoplastic breast surgeries via a large enough incision are suitable (13,21).

Glandular density

Glandular density is the third factor in selecting a suitable patient for EBCS. Low-density breast tissue with a major fatty composition has a high risk of fat necrosis after extensive undermining. Therefore, estimation of the breast density based on the Breast imaging Reporting and Data System (BIRADS) that can predict the fatty composition of the breast should be performed (21). This kind of objective estimation determines the possibility of performing a satisfactory EBCS without complications.

For selected patients who would be suitable for EBCS, creating a surgical plan and performing an accurate preoperative assessment regarding the extent of disease is critical for the success of EBCS. MRI is the imaging modality with the highest sensitivity for invasive breast cancer, as well as for ductal carcinoma *in situ* (DCIS) (23-27), and has a better correlation with the histopathological map concerning cancer extension in the breast (23,24). Actually, a recent study demonstrated that a preoperative MRI could reduce the rate of tumor-positive resection margins and reoperations for BCS (28). In this study, the MRI examination was discussed in detail with a multidisciplinary team of surgeons, pathologists, and radiologists who all specialized in breast cancer. This type of preoperative

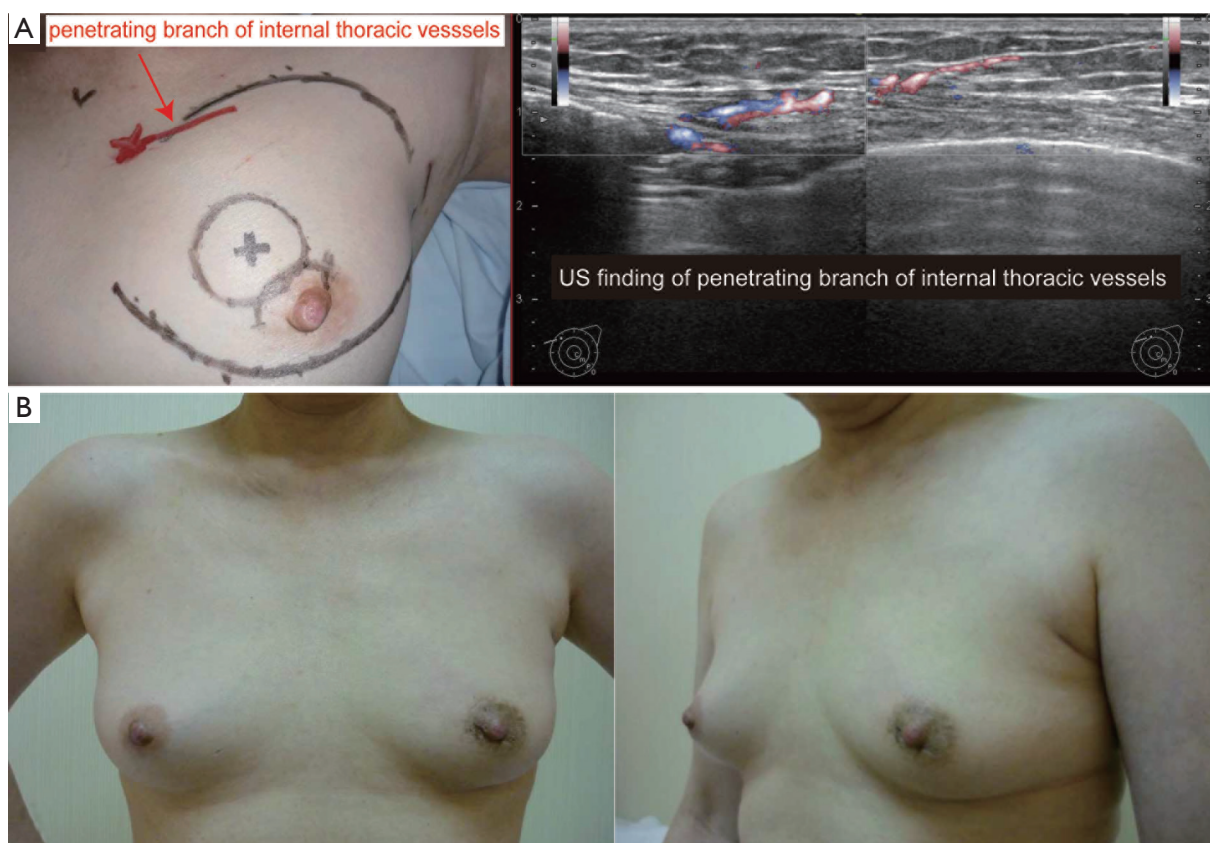


Figure 2 A 54-year-old woman with left breast cancer in the upper inner area. The operation method was endoscopy-assisted lumpectomy plus sentinel lymph node biopsy. (A) Penetrating branch of internal thoracic vessels were marked by ultrasonography (US); (B) postoperative aesthetic appearance (6 months after postoperative radiotherapy).

discussion is recommended for mapping the exact location and true extent of the cancerous lesion within a breast.

Precise presurgical marking

EBCS is performed via a small incision, and the breast lesion is often located far from the incision. Therefore, precise presurgical marking on the breast skin is critical to resect the breast lesion with a suitable margin accurately. Therefore, MRI is an essential modality for EBCS. A problem associated with the use of MRI for presurgical marking for BCS is the deviation of the breast caused by being in a prone position (29). Thus, usually, presurgical marking is performed under second-look US guidance on the basis of MRI findings obtained in the supine position. Using this kind of protocol, one study demonstrated a low rate of positive surgical margins (1.4%, 1/73) (13). Currently, in Japan, because of the shortage of breast radiologists, most breast surgeons learn to read MMGs and breast MRI findings and acquire appropriate skills in

breast US. Therefore, on the basis of the diagnostic breast imaging, operating breast surgeons themselves usually perform the preoperative marking and intraoperative marking. Such a situation might be ideal and contribute to low positive margin rates. During the presurgical marking, design for repair of the resected volume is also necessary to reshape the breast. Moreover, to retain blood flow in the remnant breast tissue, identification of the branches passing from the internal thoracic or thoracodorsal vessels is important (*Figure 2*).

Intraoperative ultrasound scan

Intraoperative marking performed by an intraoperative US scan and a colored dye injection along with the resection line marked on the breast skin is useful for EBCS. Recent studies proved that the intraoperative usage of a US is worthwhile for the identification of tumor localization, achievement of clear margins, and reduction of the re-excision rate (30-32). In addition to these benefits, a

reduction in the volume of resected breast tissue was achieved, and thus, the surgical accuracy can enhance the cosmetic outcome of the treated breast (30). The colored dye injected into the breast tissue during EBCS guides the resection of the breast tissue via a small incision.

Accurate resection of a cancer lesion along with intraoperative marking, specimen radiography, and usage of a frozen section analysis

To perform an accurate resection of a cancer lesion with a clear surgical margin, the surgical armamentarium consists of a wound protector, light guided-retractor, and retractor set to lift the skin flap and show the resection line (9,13). To secure the operative view and to protect the skin incision from physical contact, a wound protector is useful. Using these operative devices, an accurate resection based on the intraoperative marking can be performed. Moreover, a specimen radiograph and a frozen section assessment of the margins may contribute to a decrease in the re-excision rate. According to recent studies, a tumor-free margin distance of more than 2 mm is necessary to minimize the risk of a local recurrence (15,16).

Defect repair and reshaping of the treated breast

In most cases in which the excision volume is 20% or less, mobilization of the surrounding breast tissue can be used to repair the defect of the breast during BCS. Ogawa *et al.* (33) reported that in cases of small dense breasts, in spite of a 30% resection volume, favorable breast shape was obtained using this technique. On the other hand, as for the patients who have a cancerous lesion in the outer upper quadrant and require a large resection of up to 40% or less volume, LDF can be harvested and used for the repair of the defect via an axillary fold incision or a midaxillary incision under endoscopic guidance (8,22). Moreover, if nipple deviation or retraction occurs, it is necessary to undermine the nipple areolar complex (NAC) extensively and perform a round block technique or modified round block technique (34,35). Using these oncoplastic techniques, reshaping of the treated breast can be achieved.

Current issues with EBCS

Until recently, EBCS studies demonstrated technical feasibility and favorable short-term results with respect to the oncological outcomes, aesthetic outcomes, and patient satisfaction ratings. However, there is a lack of long-term follow-up evidence regarding the above-

mentioned factors and quality of life (QOL). Moreover, there is no standardized guideline for performing EBCS or general estimation methods for the aesthetic outcomes, patient satisfaction ratings, and QOL in clinical studies. Therefore, under the present circumstances, establishment of standardized guidelines for EBCS and estimation of the postoperative outcomes are urgently needed. Ideally, high-quality comparison studies between EBCS and CBCS should be performed to investigate the feasibility, surgical safety, and aesthetic outcomes and demonstrate the oncological safety, superior patient satisfaction ratings, and QOL.

Prospects of EBCS in the future

EBCS has the advantage of being less noticeable and having a small operative scar, whereas the indication of this method should be limited because of the difficulty in repair of a mammary gland defect via a small incision. On the other hand, recent advances in oncoplastic surgery such as lipofilling (36,37) or a volume replacement technique using an LDF harvested via an axillary incision under endoscopic guidance (22) has the potential to improve the aesthetic outcomes and might expand the indication for EBCS. However, such novel oncoplastic techniques require an adequate number of studies to assess the operative feasibility, long-term oncological outcomes, and aesthetic outcomes.

Conclusions

EBCS has the potential to improve cosmetic outcomes and patient satisfaction for BCS without compromising oncological safety. However, in order to place EBCS as one of the standard breast conservation surgeries, long-term follow-up studies are necessary to investigate oncological outcomes, aesthetic outcomes, and patient satisfaction rating. Moreover, setting clear practice guidelines for the indication, standardized operative procedures, objective assessment methods for aesthetic outcomes, and QOL should be performed promptly.

Acknowledgements

Disclosure: The authors declare no conflict of interest.

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Cite this article as: Ozaki S, Ohara M. Endoscopy-assisted breast-conserving surgery for breast cancer patients. *Gland Surgery* 2014;3(2):94-108. doi: 10.3978/j.issn.2227-684X.2013.12.04