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A cost-utility analysis comparing large volume displacement oncoplastic surgery to mastectomy with free flap reconstruction in the treatment of breast cancer[☆]



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ABSTRACT

Purpose: Breast cancer surgical treatment may include large volume displacement oncoplastic surgery (LVOS) or mastectomy with free flap reconstruction (MFFR). We investigated the cost-utility between LVOS versus MFFR to determine which approach was most cost-effective.

Methods: A literature review was performed to calculate probabilities for clinical outcomes for each surgical option (LVOS versus MFFR), and to obtain utility scores that were converted into quality adjusted life years (QALYs) as measures for clinical effectiveness. Average Medicare payments were surrogates for cost. A decision tree was constructed and an incremental cost-utility ratio (ICUR) was used to calculate cost-effectiveness.

Results: The decision tree demonstrates associated QALYs and costs with probabilities used to calculate the ICUR of \$3699/QALY with gain of 2.7 QALY at an additional cost of \$9987 proving that LVOS is a cost-effective surgical option. One-way sensitivity analysis showed that LVOS became cost-ineffective when its clinical effectiveness had a QALY of less than 30.187. Tornado Diagram Analysis and Monte-Carlo simulation supported our conclusion.

Conclusion: LVOS is cost-effective when compared to MFFR for the appropriate breast cancer patient.

Clinical question/level of evidence: II

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Introduction

Two traditional surgical options in breast cancer treatment include breast conservation (using lumpectomy techniques) and mastectomy. Oncoplastic surgery is a newer breast conservation option that entails removing a larger area of tissue (with a lumpectomy) and simultaneously reconstructing this void with the remaining ipsilateral tissue using mastopexy or breast reduction techniques.^{1,2} Clinical trials have shown that there is no survival difference between breast conservation and mastectomy.^{3,4} For patients who have moderate to large sized breasts, two specific

treatment options include mastectomy with free flap reconstruction (MFFR) and large volume displacement oncoplastic surgery (LVOS). Not surprisingly, these treatment options vary with regards to clinical outcomes, including positive margin rates^{5,6} and post-operative complication rates.^{7–9} Variability in operative technique and adjuvant treatment plans also may lead to differences in clinical effectiveness and costs for each treatment option. For this reason, our goal was to perform a cost-utility analysis to see if there is cost-utility benefit in performing MFFR versus LVOS in the treatment of unilateral breast cancer in patients with macromastia.

Depending on institutions, both MFFR and LVOS have varying clinical outcomes and variability in costs. There have been meta-analysis and literature reviews looking at clinical outcomes separately for MFFR and LVOS.^{5,6,9} However, there has been no cost-utility or effectiveness analysis performed in the literature comparing MFFR to LVOS. Cost-utility or effectiveness analysis

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compares the clinical benefit of a particular surgical technique versus another while also considering the costs, and represents a measure of value. Our cost-utility analysis will comprise of costs, probabilities, and utilities of various health outcomes (health states) that are used to evaluate MFFR versus LVOS.^{10–18}

Patients and methods

Perspective

The perspective of the third party payer was adopted for the decision analysis. This is a well-established perspective that has been used in multiple empirical cost-utility studies^{9,19–22} and provides a fair and equally balanced cost burden to each treatment option being studied. Without acknowledgement of cost perspective, there is a potential for bias and abuse in the conclusion of any cost-analysis research.^{23,24}

Literature review and health states

A literature search for accumulating complication rates and clinical outcomes specific to LVOS were used.^{5,6} The positive margin rate was 10.9% for LVOS. For MFFR, the positive margin rate was assumed to be 0%. Of the LVOS patients who needed further surgery, 27.6% had additional re-resection and 72.4% had completion mastectomy. Similarly, early and late postoperative complication rates were obtained for each treatment option using the literature review. LVOS had an overall complication rate (17%)^{6,7} compared to MFFR that had an overall complication rate of 30%.⁹ Examples of complications included were seroma, hematoma and skin necrosis. Revision surgery (including donor site regions when applicable) were included in complication presuming the need for debridement and associated costs in addition to clinical impact. Positive margin rates for each approach in addition to completion mastectomy rates were included in our decision tree analysis. These clinical outcomes were defined as “health states” with associated probabilities, costs, and utilities for use in the decision model. Of note, a “successful surgery” health state by itself is defined as one without complications.

Costs

Medicare current procedure terminology (CPT) codes and diagnosis related groups (DRG) codes were used to assess the costs for successful oncologic and reconstructive breast surgeries, and complications that included positive margins which required further surgery including completion mastectomy. Some cost numbers were acquired from previous studies specifically studying MFFR.⁹ LVOS incurred an additional whole breast radiation therapy cost which was not placed to the mastectomy arm. Mastectomy endpoints presumed free flap reconstruction with associated costs. Costs for a complication included the cost of a successful surgery plus the cost of a specific complication. Costs for the contralateral “balancing” operation i.e. mastopexy were included as this is performed contemporaneously with LVOS. All payment data was based on 2012 Medicare CPT and DRG reimbursement national averages.^{25,26}

Recovery

Assumptions were made regarding the appropriate follow-up for health states based on the current practice of surgeons at our institutions. In terms of complications, patients having a complication that involved a positive tumor margin requiring additional surgery were presumed to recover within 4 weeks of experiencing

this complication. While recovery could vary based on complications, the time length associated to each complication was the same for each treatment arm in the decision tree.

Probabilities

The probabilities for each health state associated with clinical outcomes were taken from past published literature reviews.^{5,6,9} This data was cross-referenced with other past literature reviews to establish consistency of health state outcomes and associated probabilities.^{5,27}

Utilities

For LVOS utility scores, twenty surgical experts who were familiar with breast surgery and associated post-operative complications were surveyed. These surgeons regularly performed breast surgery and were familiar with treating associated complications. To increase generalizability of our results, surveys were multi-institutional (9 in total) with each institution having a comprehensive breast cancer center. Half of the surveys were performed by fellowship trained breast surgical oncologists and the other half were completed by plastic surgeons. For MFFR utility scores, 10 plastic surgeons were surveyed who were familiar with the operation and treating associated complications.⁹ These experts were posed with identical scenarios involving each health state and were asked to rank their preferences such that the quality of life for each health state was marked on a “feeling thermometer”, a diagrammatic vertical ladder ascending from a score of 0 (death) to 100 (perfect health). The overall utility of each health state was obtained by averaging the expert opinion.

Utilities were then converted to quality-adjusted life years (QALY) by multiplying the utility of a specific health state with the health state duration (4 weeks) and combining this in sum to the remaining life years multiplied by the utility of a successful procedure. The value of remaining life years is based on the assumptions, previously published, that a female operative candidate for breast reconstruction has a life expectancy of 81.1 years (per National Center for Health Statistics) and is 45 years old with a total life expectancy of 36.1 years. The minor complication rate such as an infection in the MFFR arm, for example, assumes the patient will have an operative washout and will recover within 4 weeks. The minor complication health state after a MFFR operation assumes that the “minor complication” would be identified, operatively corrected and recovered in a 4 week period. The average utility for experiencing a “minor complication” is 0.75, and the utility of a successful surgery without complication is 0.85.⁹

Number of health years remaining = average life expectancy – average age of patient

81.8 years–45 years = 36.1 years

Duration of health state:

4 weeks/52 weeks = 0.08 years

QALY:

(Utility of health state) x (duration of health state) + (utility of successful procedure) x (remaining life years)

(0.75)(0.08) + (0.85)(36.1–0.08) = 30.68

Decision analysis

A decision model was created for this data (Fig. 1) with the two main branches (or arms of the decision tree) being LVOS and MFFR in the treatment of breast cancer in ptotic or patients with macromastia. The costs and QALYs for each health state were incorporated into this model along with the probabilities of all the health states relevant to the surgery. Expected values for costs and outcomes were derived by multiplying the probability of a health state by its cost and QALY. These expected values were summed for both main arms of the decision tree to derive the overall expected cost and utility (QALY) for the surgical treatment of breast cancer. The incremental cost-utility ratio (ICUR) was then calculated using the formula below:

$$ICUR = \frac{(\text{Expected cost of MFFR} - \text{Expected cost of LVOS})}{(\text{Expected QALY of MFFR} - \text{Expected QALY of LVOS})}$$

This represents the added cost to prolong a patient's life by one year of perfect health.²⁸ A novel intervention is “cost effective” if the ICUR is greater than 0 and less than the “willingness to pay (WTP)” for an added year of perfect health which we defined as \$50,000 as described below:²⁹

Cost Effective: ICUR > 0 and < WTP, WTP = \$50,000

If an arm of the tree is more clinically effective and costs less than this arm or breast cancer treatment choice, by definition, dominates the competing arm or breast cancer treatment choice and the ICUR is negative.³⁰ One-way sensitivity analysis was performed to determine if the baseline decision analysis was robust by varying the clinical utility scores independently for both LVOS and

MFFR (and hence their QALYs) and observing how this affected the ICUR. Where applicable, a threshold analysis was performed showing the threshold point for a variable where the cost-effectiveness may favor the alternate surgical approach. All of the above statistical calculations were performed using TreeAge Pro 2016 (Williamstown, MA). Additionally, to analyze which variables impacted our results, we performed a tornado analysis and also used these high impact variables when performing a Monte-Carlo simulation that allowed variation in multiple variables to see if our results were robust to support our conclusion.

The sensitivity analyses described above are essential to prove the “robustness” or degree of accuracy of the conclusion. Real life variations exist among clinical outcomes and utility scores and such variations may lead to contradictory conclusions depending on sampling errors, etc. To prevent such error and chance for abuse, sensitivity analyses attempt to minimize weak conclusions.

This study was done in accordance with the principles outlined in the Declaration of Helsinki.

Results

Utility scores with subsequent QALYs and associated costs for each health state are shown in Fig. 1. There were small standard deviations in utility scores amongst surgeons surveyed on high clinical effectiveness questions such as the utility of successful oncologic surgery (SD: 6.6). From a clinical effectiveness standpoint, the decision tree analysis showed a clinical benefit of 2.7 QALYs favoring LVOS (33.16 QALYs) versus MFFR (QALY 30.47). Further decision tree analysis showed a cost benefit of \$9987 favoring MFFR. The ICUR which compared cost of each treatment option over their clinical effectiveness was valued at \$3699/QALY

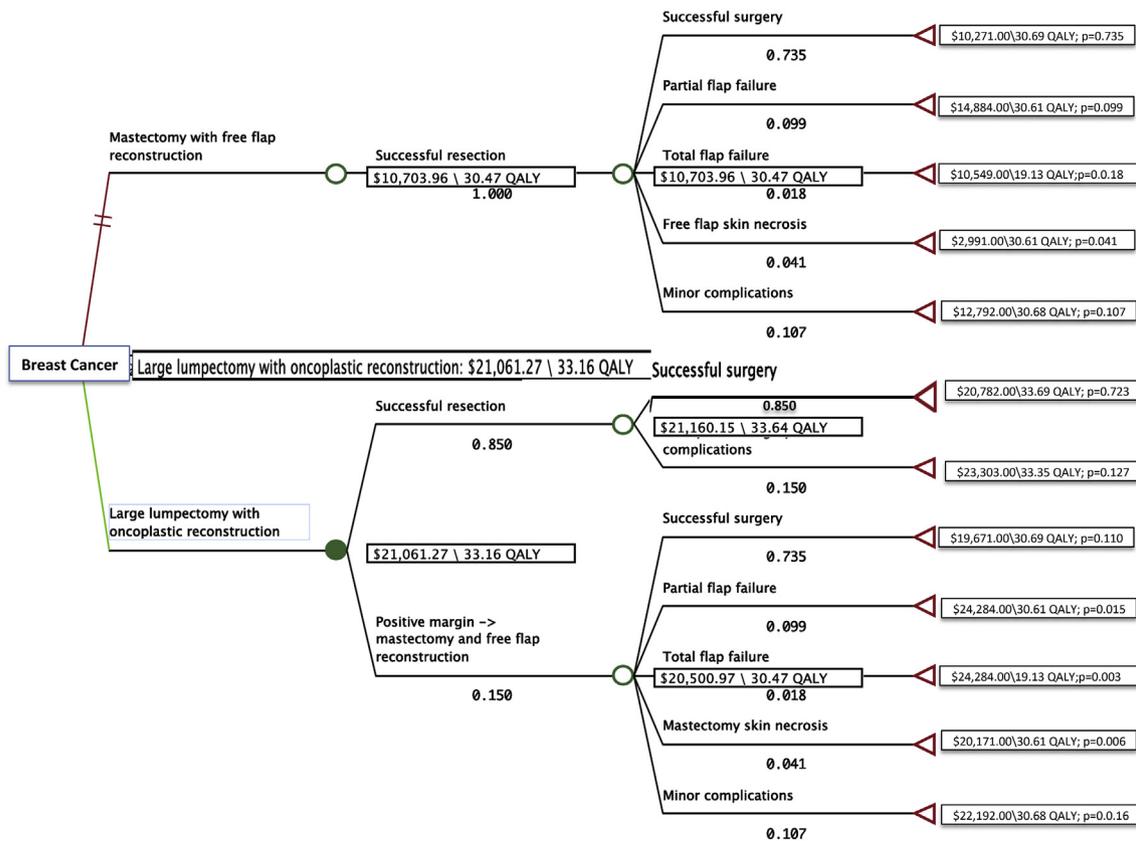


Fig. 1. Decision analysis tree comparing mastectomy with free flap reconstruction against large lumpectomy with oncoplastic reconstruction.

deemed LVOS cost-effective. We analyzed the most likely variables to influence the results by using a Tornado Diagram Analysis (A diagram that depicts the sensitivity of a result of each variable and the effect on the output by varying the range for the input variables). and noted that the clinical effectiveness of successful LVOS and MFFR variables had the greatest impact (Fig. 2). Subsequent sensitivity analysis and threshold analysis showed that at a clinical effective QALY value of 34.67 or higher, MFFR becomes a more cost-effective option (Fig. 3a). Similarly, below a QALY of 30.18, LVOS becomes a cost-ineffective option (Fig. 3b). Of note, the QALY of 30.18 would derive from a utility score of 83.6 which is lower than one standard deviation seen in utility scores for successful LVOS thus reinforcing our results (that showed LVOS as cost-effective). Further supporting LVOS as a cost-effective option was the Monte Carlo scatter distribution (Fig. 4a) after micro-simulation assuming a willingness to pay of \$50,000. After entering reasonable variation for major impact variables the Monte Carlo simulation favored LVOS 80% of the time (Fig. 4b).

Discussion

LVOS is a well-established surgical option for the appropriate breast cancer patient, and is often described as Level 2 vol displacement oncoplastic surgery.^{2,5,6} Its ability to remove up to 50% of the breast allows it to push the limits of breast conservation surgery while making loco-regional recurrence rates and survival rates equivalent to that of mastectomy.^{31,32} Interest in oncoplastic surgery has been increasing,³³ and this adds another breast conservation option that is especially relevant given that there may be

a relatively high rate of mastectomy operations being performed in certain regions.³⁴ Few cost-effectiveness analysis have been done studying oncoplastic surgery.^{35,36} Yet, the clinical advantages with LVOS compared to MFFR include the ability to use the remaining breast tissue with mastopexy or breast reduction designs to create an aesthetically pleasing result without the burden of a flap donor site. The LVOS operation is shorter and does not require the microsurgical expertise intraoperatively or post-operative intensive monitoring. Patients recover after LVOS at a rate similar to those who have had a reduction mammoplasty, and at our institution typically spend one night versus several nights after MFFR. Additionally, while there is a complication rate as high as 17%, most of these complications in the authors' experience are minor such as T junction dehiscence that resolve with a short course of antibiotic ointment treatment over a less than three week period that does not delay adjuvant breast cancer therapy. Compared to a standard lumpectomy, LVOS has a much lower positive margin rate.⁶ In patients with macromastia who do have positive margins after LVOS, their subsequent completion mastectomies can often be nipple sparing using a 2 staged technique (with the initial stage already performed which was the reduction mammoplasty).³⁷ Nipple sparing mastectomy would otherwise not be an option in a patient with large or ptotic breasts. Disadvantages with LVOS, just like any breast conservation option, would be the need for adjuvant radiation which may not be needed for MFFR depending on the size of the tumor or the number of lymph nodes infiltrated with tumor. This adds significant cost to the patient as does the contralateral symmetry mastopexy operation that is most often needed when performing LVOS. The ICUR of \$3699/QALY concludes that LVOS is a

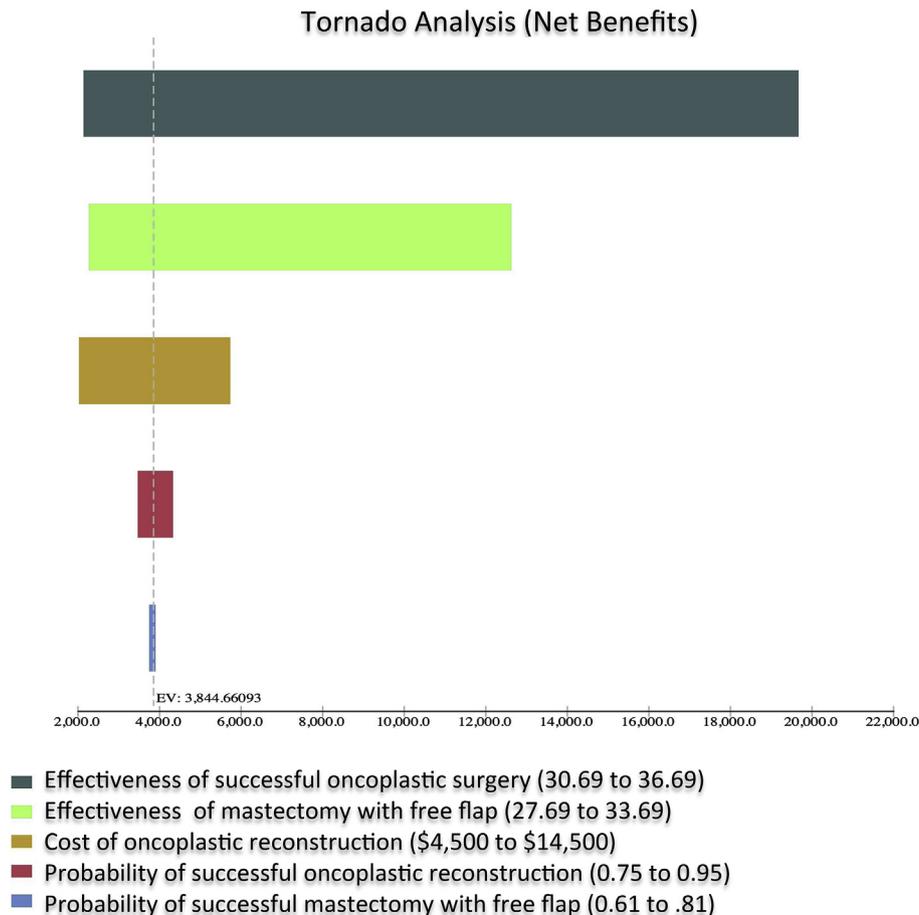


Fig. 2. Tornado diagram analysis.

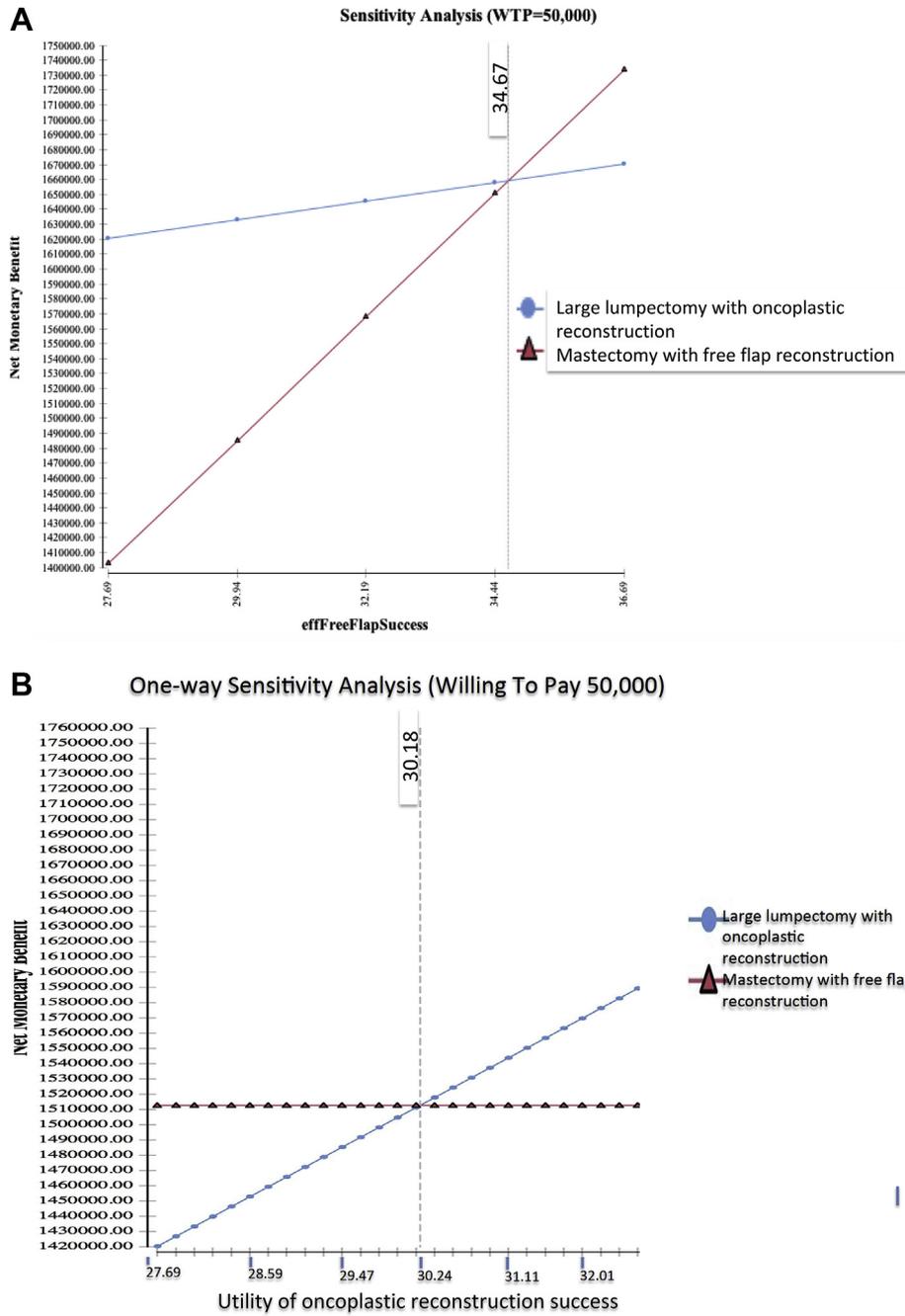


Fig. 3. One-way sensitivity analyses looking at threshold points for clinical effectiveness at which point mastectomy with free flap reconstruction becomes more cost-effective.

cost-effective option. While LVOS is applicable for women with larger breast cancers that involve one or possibly more quadrants^{38,39} these results do not justify its use in small breasts with high tumor burden relative to size, inflammatory breast disease or breasts that have previously been radiated. Women also have to be committed to a smaller breast size. Therefore, the decision to perform LVOS versus MFFR should be performed after discussion by a patient with her breast oncologic and plastic surgeon on a case by case basis.

Limitations

One limitation inherent in cost-utility analysis is its reliance on

data acquired through literature review. Health outcome rates that include positive margin rates and completion mastectomy rates can vary and the literature review gives an overall assessment on rates. We acknowledge that especially with recent guidelines favoring a 2 mm margin for DCIS and a no tumor at ink margin for invasive breast cancer,^{40,41} past literature reviews and meta-analysis can be inconsistent. However, there is consistent meta-analysis data showing that LVOS has a low positive margin rate (especially when compared to a standard lumpectomy) which makes anatomical sense since LVOS allows the breast surgeon to remove a large volume of breast tissue.^{5,6} We also compensated for these uncertainties by running the Monte Carlo simulation (A probability microsimulation in which individual patients run through the

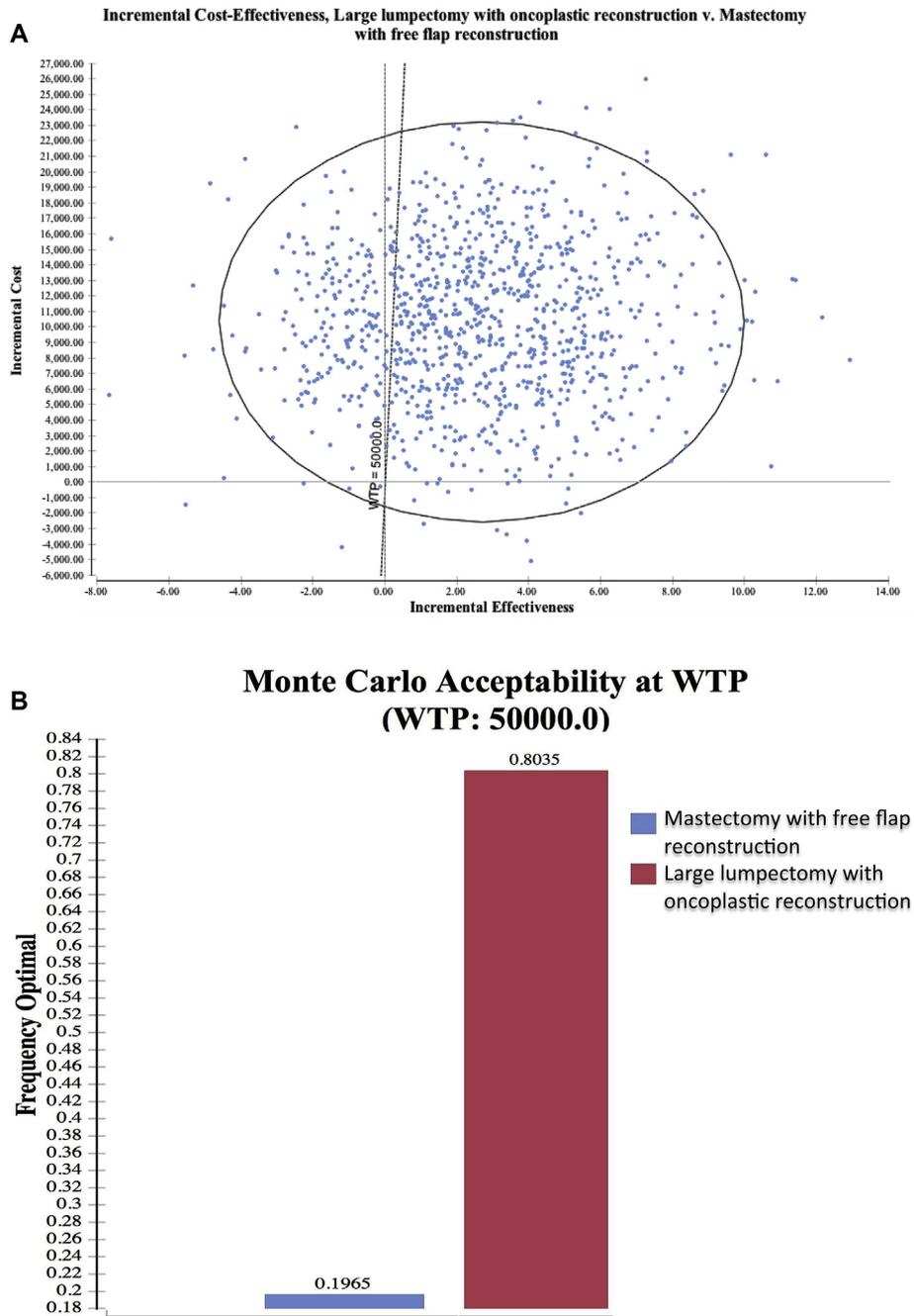


Fig. 4. Monte-Carlo simulation showing cost-effectiveness of LVOS 80% of the time over MFFR.

model accumulating cost and effectiveness and repeat this for many patients and mean values). with distributions of several variables that still showed the greater cost-effective option as LVOS. Nevertheless, inherent flaws are present when pooling data from a literature review given the variability of data collection, patients being operated on and surgeons performing the surgeries.

A second limitation involves the perspective of this paper which is a third party payer perspective described earlier in the methodology. A societal perspective was not performed, and extrapolating conclusions in such would be outside the scope of our analysis. A societal view would have to incorporate the total costs to the patient which would include indirect costs. The third party payer perspective is a well-established and empirically

used^{9,21,42–45} approach in cost-utility analysis and is particularly applicable to the US health care system. Additionally, while our utility scores that translated into QALYs had variability, this was not significant enough to change our conclusion. For example, as we noted using one-way sensitivity analysis and threshold analysis that a utility score less than 83.6 for successful surgery (which translated to a QALY of 30.17) would lead to LVOS being cost-ineffective. Only 2 of our 20 surgeons surveyed gave successful LVOS a utility score less than 83.6 further suggesting our results as robust. Lastly, these results do not advocate for the indiscriminant use of oncoplastic surgery. For example, an inappropriate use of LVOS (when compared to MFFR) would be a patient who does not want smaller breasts or one that has extensive multicentric breast

disease. The goal of this study was to evaluate the cost-effectiveness of LVOS and MFFR for appropriately selected patients.

Conclusion

LVOS is a cost-effective treatment for treating breast cancer in patients with macromastia. It provides yet another treatment choice in a surgeon's armamentarium when discussing surgical options with a breast cancer patient.

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References

1. Losken A, Hart AM, Chatterjee A. Updated evidence on the oncoplastic approach to breast conservation therapy. *Plast Reconstr Surg.* 2017;140(5S Advances in Breast Reconstruction):145–225.
2. Clough KB, Kaufman GJ, Nos C, Buccimazza I, Sarfati IM. Improving breast cancer surgery: a classification and quadrant per quadrant atlas for oncoplastic surgery. *Ann Surg Oncol.* 17(5):1375–1391.
3. van Dongen JA, Voogd AC, Fentiman IS, et al. Long-term results of a randomized trial comparing breast-conserving therapy with mastectomy: european Organization for Research and Treatment of Cancer 10801 trial. *J Natl Cancer Inst.* 2000;92(14):1143–1150.
4. Fisher B, Anderson S, Bryant J, et al. Twenty-year follow-up of a randomized trial comparing total mastectomy, lumpectomy, and lumpectomy plus irradiation for the treatment of invasive breast cancer. *N Engl J Med.* 2002;347(16):1233–1241.
5. Cruz MLDL, Blankenship MSA, MPH, MS, Chatterjee MA, Geha MR, et al. Outcomes after Oncoplastic Breast-Conserving Surgery in Breast Cancer Patients: A Systematic Literature Review. 0(0):1–12.
6. Losken A, Dugal CS, Styblo TM, Carlson GW. A meta-analysis comparing breast conservation therapy alone to the oncoplastic technique. *Ann Plast Surg.* 72(2):145–149.
7. Pyfer B, Chatterjee A, Chen L, Nigriny J, Czerniecki B, Tchou J, et al. Early postoperative outcomes in breast conservation surgery versus simple mastectomy with implant reconstruction: a NSQIP analysis of 11,645 patients. *Ann Surg Oncol.* 23(1):92–98.
8. Chatterjee A, Pyfer B, Czerniecki B, Rosenkranz K, Tchou J, Fisher C. Early postoperative outcomes in lumpectomy versus simple mastectomy. *J Surg Res.* 198(1):143–148.
9. Chatterjee A, Krishnan NM, Van Vliet MM, Powell SG, Rosen JM, Ridgway EB. A comparison of free autologous breast reconstruction with and without the use of laser-assisted indocyanine green angiography: a cost-effectiveness analysis. *Plast Reconstr Surg.* 131(5):693e–701e.
10. Cavaliere CM, Chung KC. A cost-utility analysis of nonsurgical management, total wrist arthroplasty, and total wrist arthrodesis in rheumatoid arthritis. *J Hand Surg Am.* 2010;35(3):379–391 e2.
11. Chung KC, Saddawi-Konefka D, Haase SC, Kaul G. A cost-utility analysis of amputation versus salvage for Gustilo type IIIB and IIIC open tibial fractures. *Plast Reconstr Surg.* 2009;124(6):1965–1973.
12. Chatterjee A, Krishnan NM, Rosen JM. Complex ventral hernia repair using components separation with or without biologic mesh: a cost-utility analysis. *Ann Plast Surg.* 2015 Apr;74(4):471–478.
13. Chatterjee A, Krishnan NM, Rosen JM. Complex ventral hernia repair using components separation with or without synthetic mesh: a cost-utility analysis. *Plast Reconstr Surg.* 2014;133(1):137–146.
14. Chatterjee A, Krishnan NM, Van Vliet MM, Powell SG, Rosen JM, Ridgway EB. A comparison of free autologous breast reconstruction with and without the use of laser-assisted indocyanine green angiography: a cost-effectiveness analysis. *Plast Reconstr Surg.* 2013;131(5):693e–701e.
15. Krishnan NM, Chatterjee A, Rosenkranz KM, Powell SG, Nigriny JF, Vidal DC. The cost effectiveness of acellular dermal matrix in expander-implant immediate breast reconstruction. *J Plast Reconstr Aesthetic Surg.* 2014 Apr;67(4):468–476.
16. Krishnan NM, Chatterjee A, Van Vliet MM, Powell SG, Rosen JM, Nigriny JF. A comparison of acellular dermal matrix to autologous dermal flaps in single-stage, implant-based immediate breast reconstruction: a cost-effectiveness analysis. *Plast Reconstr Surg.* 2013;131(5):953–961.
17. Thoma A, Khuthaila D, Rockwell G, Veltri K. Cost-utility analysis comparing free and pedicled TRAM flap for breast reconstruction. *Microsurgery.* 2003;23(4):287–295.
18. Ziolkowski NI, Voineskos SH, Ignacy TA, Thoma A. Systematic review of economic evaluations in plastic surgery. *Plast Reconstr Surg.* 2013;132(1):191–203.
19. Chatterjee A, Kosowski T, Pyfer B, Fisher CS, Tchou JC, Maddali S. A cost-utility analysis comparing the sartorius versus the rectus femoris flap in the treatment of the infected vascular groin graft wound. *Plast Reconstr Surg.* 135(6):1707–1714.
20. Chatterjee A, Krishnan NM, Rosen JM. Complex ventral hernia repair using components separation with or without biologic mesh: a cost-utility analysis. *Ann Plast Surg.* 74(4):471–478.
21. Chatterjee A, Krishnan NM, Rosen JM. Complex ventral hernia repair using components separation with or without synthetic mesh: a cost-utility analysis. *Plast Reconstr Surg.* 133(1):137–146.
22. Chatterjee A, Ramkumar DB, Dawli TB, Nigriny JF, Stotland MA, Ridgway EB. The use of mesh versus primary fascial closure of the abdominal donor site when using a transverse rectus abdominis myocutaneous flap for breast reconstruction: a cost-utility analysis. *Plast Reconstr Surg.* 135(3):682–689.
23. Blank MM, Chen L, Papageorge M, Driscoll D, Graham R, Chatterjee A. The underreporting of cost perspective in cost-analysis research: a systematic review of the plastic surgery literature. *J Plast Reconstr Aesthetic Surg.* 2018;71(3):366–376.
24. Blank MM, Papageorge M, Chen L, Driscoll D, Graham R, Chatterjee A. Hidden bias in cost-analysis research: what is the prevalence of under-reporting cost perspective in the general surgical literature? *J Am Coll Surg.* 2017;225(6):823–828. e12.
25. Ingenix. DRG. *Expert. ICD-*. 10 ed. Ingenix; 2012.
26. Services UDOHaH. Physician Fee Schedule Search. In: Services CfMaM, editor. 2012.
27. Haloua MH, Krekel NM, Winters HA, Rietveld DH, Meijer S, Bloemers FW, et al. A systematic review of oncoplastic breast-conserving surgery: current weaknesses and future prospects. *Ann Surg.* 257(4):609–620.
28. Thoma A, Veltri K, Khuthaila D, Rockwell G, Duku E. Comparison of the deep inferior epigastric perforator flap and free transverse rectus abdominis myocutaneous flap in postmastectomy reconstruction: a cost-effectiveness analysis. *Plast Reconstr Surg.* 2004;113(6):1650–1661.
29. Grosse SD. Assessing cost-effectiveness in healthcare: history of the \$50,000 per QALY threshold. *Expert Rev Pharmacoecon Outcomes Res.* 2008;8(2):165–178.
30. Chen NC, Shauer MJ, Chung KC. A primer on use of decision analysis methodology in hand surgery. *J Hand Surg Am.* 2009;34(6):983–990.
31. Clough KB, Lewis JS, Couturaud B, Fitoussi A, Nos C, Falcou MC. Oncoplastic techniques allow extensive resections for breast-conserving therapy of breast carcinomas. *Ann Surg.* 2003;237(1):26–34.
32. De Lorenzi F, Loschi P, Bagnardi V, Rotmensz N, Hubner G, Mazzarol G, et al. Oncoplastic breast-conserving surgery for tumors larger than 2 centimeters: is it oncologically safe? A matched-cohort analysis. *Ann Surg Oncol.* 23(6):1852–1859.
33. Chatterjee A, Gass J, Burke MB, et al. Results from the American society of breast surgeons oncoplastic surgery committee 2017 survey: current practice and future directions. *Ann Surg Oncol.* 2018;25(10):2790–2794.
34. Tan M. Is there an ideal breast conservation rate for the treatment of breast cancer? *Ann Surg Oncol.* 23(9):2825–2831.
35. Chatterjee A, Il ACO, Asban A, et al. A cost-utility analysis comparing oncoplastic breast surgery to standard lumpectomy in large breasted women. *Adv Breast Cancer Res.* 2018;07(02):14.
36. Asban A, Homsy C, Chen L, Fisher C, Losken A, Chatterjee A. A cost-utility analysis comparing large volume displacement oncoplastic surgery to mastectomy with single stage implant reconstruction in the treatment of breast cancer. *Breast.* 2018;41:159–164.
37. Spear SL, Rottman SJ, Seiboth LA, Hannan CM. Breast reconstruction using a staged nipple-sparing mastectomy following mastopexy or reduction. *Plast Reconstr Surg.* 129(3):572–581.
38. Bauman L, Barth RJ, Rosenkranz KM. Breast conservation in women with multifocal-multicentric breast cancer: is it feasible? *Ann Surg Oncol.* 17 Suppl 3:325–329.
39. Giacalone PL, Roger P, Dubon O, et al. Comparative study of the accuracy of breast resection in oncoplastic surgery and quadrantectomy in breast cancer. *Ann Surg Oncol.* 2007;14(2):605–614.
40. Morrow M, Van Zee KJ, Solin LJ, Houssami N, Chavez-MacGregor M, Harris JR, et al. Society of surgical oncology-American society for radiation oncology-American society of clinical oncology consensus guideline on margins for breast-conserving surgery with whole-breast irradiation in ductal carcinoma in situ. *Ann Surg Oncol.* 23(12):3801–3810.
41. Moran MS, Schnitt SJ, Giuliano AE, Harris JR, Khan SA, Horton J, et al. Society of Surgical Oncology-American Society for Radiation Oncology consensus guideline on margins for breast-conserving surgery with whole-breast irradiation in stages I and II invasive breast cancer. *Ann Surg Oncol.* 21(3):704–716.
42. Chatterjee A, Krishnan NM, Rosen JM. Complex ventral hernia repair using components separation with or without biologic mesh: a cost-utility analysis: reply. *Ann Plast Surg.* 72(5):610–611.
43. Chatterjee A, Macarios D, Griffin L, Kosowski T, Pyfer BJ, Offodile AC, 2nd, et al.

- Cost-utility analysis: sartorius flap versus negative pressure therapy for infected vascular groin graft management. *Plast Reconstr Surg Glob Open*.3(11): e566.
44. Krishnan NM, Chatterjee A, Rosenkranz KM, Powell SG, Nigriny JF, Vidal DC. The cost effectiveness of acellular dermal matrix in expander-implant immediate breast reconstruction. *J Plast Reconstr Aesthetic Surg*.67(4):468-476.
 45. Krishnan NM, Chatterjee A, Van Vliet MM, Powell SG, Rosen JM, Nigriny JF. A comparison of acellular dermal matrix to autologous dermal flaps in single-stage, implant-based immediate breast reconstruction: a cost-effectiveness analysis. *Plast Reconstr Surg*.131(5):953-961.