



Review of the microdebrider excision and liposuction technique (MELT) for the treatment of gynecomastia

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Received 21 October 2018; accepted 9 September 2019

KEYWORDS

Gynecomastia;
Microdebrider;
Liposuction;
MELT;
Breast disc

Summary Introduction: Numerous advancements have been made in the surgical treatment of gynecomastia. However, one of the greatest challenges faced is the complete excision of the fibrous breast disc. We aim to review and compare the outcomes of the microdebrider excision and liposuction technique (MELT) with other techniques employed at our institution.

Methodology: We reviewed patients who underwent treatment for idiopathic gynecomastia at our institution from 2002 to 2017. They were divided into 4 groups: Microdebrider Excision and Liposuction Technique (MELT), liposuction only (LO), open excision only (EO), and liposuction and open excision technique (LET). Complications requiring a revision surgery were recorded (residual breast disc, hematoma formation, and nipple-areolar scars). Phone interviews were conducted to evaluate patient satisfaction.

Results: A total of 304 patients underwent treatment between 2002 and 2017. Out of which, 51.3% patients were treated by MELT, 17.1% patients by LO, 15.8% patients by EO, and 15.8% patients by LET. The subgroup analysis on patients with clinically palpable breast disc was performed. Patients who underwent LO were 2.58 times more likely to have a revision surgery ($p=0.030$) and 4.05 times more likely to have residual breast disc requiring revision surgery ($p=0.006$) compared to the MELT group. Patients who underwent LET were 3.26 times more likely to have hematomas compared to the MELT group ($p=0.047$). Patients from the EO group were most concerned by scars ($p=0.003$).

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Conclusion: The MELT is a useful technique for the treatment of gynecomastia especially for patients with palpable breast discs. It can achieve good clinical and satisfaction outcomes as compared to other traditional techniques via a small single incision.

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Introduction

Gynecomastia refers to excessive breast tissue in men. It has an incidence of 32-36%.¹⁻³ There are important physical and psychological impacts of the disease. The etiology of gynecomastia is multifactorial but commonly idiopathic. Where the etiology is unknown, medical management has limited success in the treatment of gynecomastia; hence, surgical management has become the accepted standard for treatment.

The first surgical treatment was described in the 6th century AD by Paulus Aegineta who described a reduction mammoplasty using a semi-lunar infra-mammary incision. Since then, surgical treatment of gynecomastia has seen numerous advancements, with a shift from the open approach to minimally invasive techniques. Currently, the mainstays of treatment are open excision, liposuction, or a combination of the two methods.^{2,4-6}

A challenge faced in the treatment of gynecomastia is achieving an adequate removal of the fibrous breast disc. While open excision allows for a tissue resection, it results in longer or additional scars and creates dead space. This could be complicated by seroma and hematoma. Newer approaches such as the ultrasound-assisted liposuction have been advocated by some because of its mechanical advantages in treating the fibrous breast disc.^{1,7,8} However, liposuction alone does not always address the problem of removing the fibrous breast disc entirely and patients commonly need to undergo an additional open excision to remove the residual breast disc.^{9,10} This has led some surgeons to use a combination of open excision and liposuction to manage gynecomastia.^{5,6,10}

In the recent decade, techniques employing the use of arthroscopic cartilage shavers have been described by Prado¹¹ and Benito-Ruiz.³ Their techniques combine the

use of an arthroscopic cartilage shaver with liposuction to effectively remove the fibrofatty and glandular tissue of the male breast. We first described the combined microdebrider and liposuction technique (MELT) in 2010.¹² The microdebrider (Figure 1A and B) is a rotatory shaving device with a sharp cutting blade that is commonly used by otolaryngologists to excise nasal polyps in functional endoscopic sinus surgery.

Our institution commonly employs the use of the power-assisted liposuction (PAL) in combination with a microdebrider for the surgical management of patients with gynecomastia. The microdebrider allows controlled, precise, and sharp excision of the fibrous breast disc through a single 5 mm incision via a closed technique. In our study, we aim to assess the outcomes of the microdebrider excision and liposuction technique (MELT) compared to other traditional techniques for the treatment of gynecomastia in our institution.

Methodology

Data collection and analysis

With centralized institutional review board approval (CIRB Ref: 2017/2909), we conducted a retrospective study on male patients who had undergone surgical treatment for idiopathic gynecomastia at Singapore General Hospital (SGH) from 2002 to 2017.

Demographic data such as age, race, body mass index (BMI), and grade of gynecomastia using the Simon¹³ grading system were recorded. The incidence of complications such as hematoma formation, residual breast disc and nipple-areola scars that required revision surgery were also recorded.

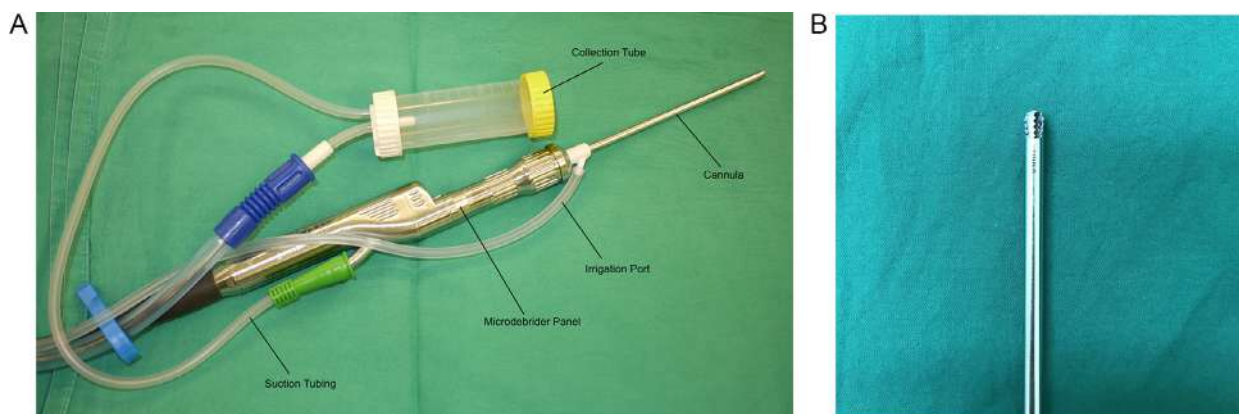


Figure 1 (A) Microdebrider control panel and microdebrider. (B) Close up of microdebrider cannula tip.

Table 1 Table showing personal satisfaction questionnaire.

Personal satisfaction questionnaire*
1. How would you rate your overall satisfaction level of the surgery?
2. How much are you concerned by the scars postsurgically?
3. How would you rate your satisfaction level of the shape of your chest after the surgery?
4. Prior to the surgery how would you rate your confidence level?
5. After the surgery, how would you rate your confidence level?

* Answers rated on a scale of 1 to 10, (1 being lowest and 10 the highest).

We conducted phone interviews to evaluate the impact on the quality of life for patients after the surgery. Patient satisfaction was measured with a standard questionnaire, based on a linear analog scale with a maximum score of 10 points (Table 1). If the patients were uncontactable at the first attempt, they were called three times, subsequently, at different times of the day for each call, once in the morning, afternoon, and night, before they were deemed not contactable.

Descriptive statistics were reported as the number (percentage) or mean (SD). Statistical analysis of the measurement data (using one-way analysis of variance, ANOVA), enumeration data (using the Chi-square test) and logistical regression analysis was performed with the Statistical Package for the Social Sciences (SPSS 21.0) (SPSS Inc Chicago, IL). Significance was set at 0.05.

Microdebrider excision and liposuction technique (MELT) (Figure 2A and B) (Video, supplementary digital content 1, which demonstrates the MELT)

Detailed history and physical examination with hormonal profiling were done prior to proceeding with each treatment to ensure that all patients had idiopathic gynecomastia. The breast disc and surrounding adipose tissue were palpated and marked out preoperatively in a standing position.

Patients received general anesthesia with appropriate skin preparation. Tumescent infiltration was performed with lignocaine with adrenaline diluted in saline (1:80,000). Infiltration was made into the area of the breast disc and adipose tissue. An average of 200-400 ml of infiltrate was injected per chest. This infiltration helps to vasoconstrict and also hydrodissect a plane for access to the breast disc.¹²

We published our combined microdebrider excision and liposuction technique (MELT) in 2010.¹² Since then, we have made some modifications to our technique. We used to site the incision at the mid-axillary line for ergonomic ease of access to both the chest and breast disc. However, due to the incidence of hypertrophic scars in our Asian patient population, we have now placed a 5 mm incision within the nipple-areolar complex (NAC). Through this incision, we are still able to access the entire chest wall and breast disc while concealing the scars. A skin protector made from the flange of a nasogastric tube spigot is inserted through the incision to protect the skin. Next, liposuction is performed

to remove the adipose tissue that has been marked. Once the liposuction is assessed to be adequate, the breast disc is palpated again and the microdebrider (powered by the Medtronic IPC® (Integrated Power Console) System, Minneapolis, United States) is then used to excise the fibrous breast disc through the same incision (Figure 2A and B). The microdebrider is moved in a smooth scraping action under the breast disc, from deep to superficial, using gentle pressure applied to the breast disc between the fingers and the thumb of the surgeon.

The microdebrider is a rotatory shaving device with a sharp cutting blade that is commonly used to excise nasal polyps in functional endoscopic sinus surgery. The cannula has a hollow tube that is connected to an irrigation source and a suction tube (Figure 1A and B). The rotatory action of the serrated blades in the cutting tip allows sharp dissection of tissue in a precise, controlled manner and this suction enables the debrided tissue to be removed concurrently. This closed technique allows for easy intra-operative assessment of the symmetry of the chest.

A final pinch test is done, just prior to closure, to ensure that the chest contour is flat and there is no remnant breast disc. At the end of the procedure, the liposuction cannula (without suction) is used to feather the edges and to smoothen out the interface between the NAC, chest adipose tissue, and muscle. The debrided breast tissue is sent routinely for histopathology. The specimens taken for histopathology were in the cases where the MELT was used or from the excised breast disc for open techniques. In LO, no histology was sent.

Post operatively, 3M™ Reston™ Self-Adhering Foam and Elastoplast® dressings were applied immediately. Patients are then fitted with pressure garments (Male Garment Style #640, Veronique™) on post-operative day 1; the garments are worn for at least 6 weeks. The patients were reviewed in the clinic by the primary surgeon on postoperative day 5 when the dressings were removed and subsequently reviewed again in 1 month's time if no significant issues are of concern.

Results

Demographic details

A total of 304 patients underwent gynecomastia treatment at our institution from 2002 to 2017. They were divided into 4 groups: Microdebrider with Liposuction Technique (MELT), liposuction only (either power-assisted liposuction or ultrasound-assisted liposuction) (LO), open excision only (EO) and liposuction with open excision technique (LET). In our institution, the EO is an open technique where the excess breast tissue and breast disc are excised via a crescentic periareolar incision. The LET is a combination of liposuction and open excision to achieve the desired breast contour via the same periareolar incision.

In all, 51.3% (n = 156) of patients underwent gynecomastia treatment with MELT, 17.1% (n = 52) by LO, 15.8% (n = 48) by EO, and 15.8% (n = 48) by LET. All specimens had the histological confirmation of normal breast tissue. The patients were followed up for a minimum of 12 months.

The mean age of patients in the MELT, LO, EO, and LET groups were 26, 27, 30, and 25 years, respectively. The

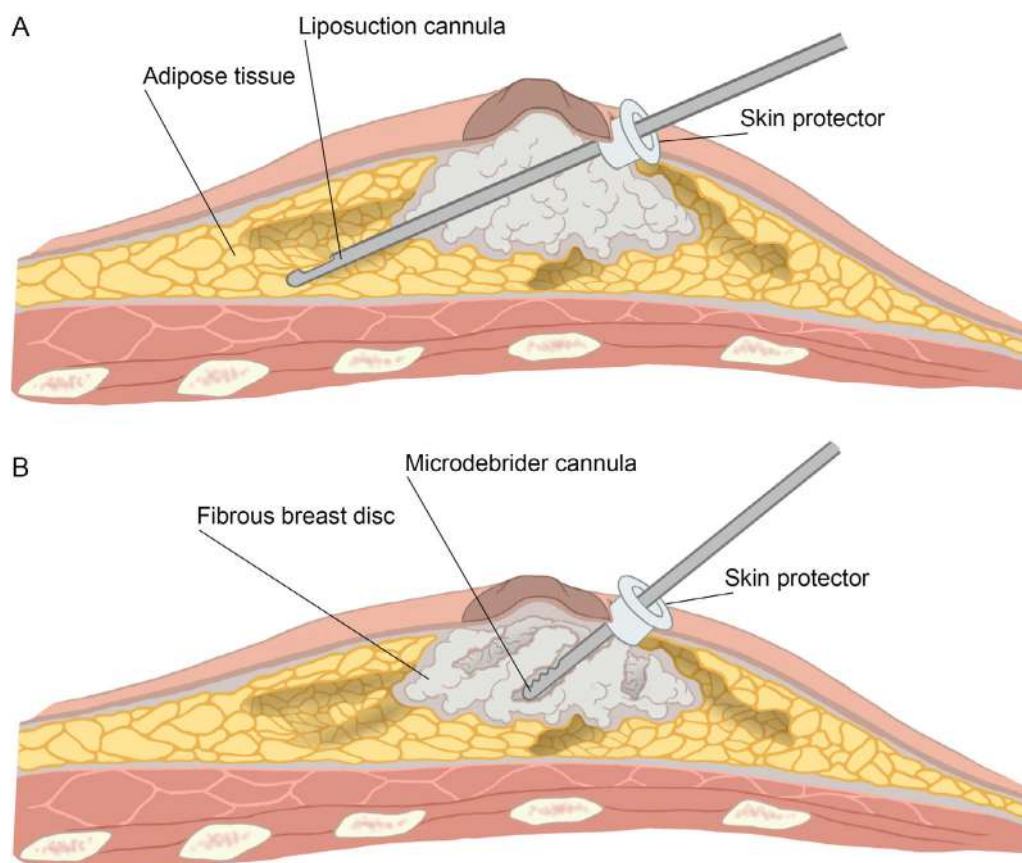


Figure 2 Cross-sectional schematic description of the MELT. (A) Liposuction is first applied to the breast. (B) The microdebrider is subsequently used to excise the fibrous breast disc. We would like to thank Miss Madeline Ngai for her illustrations.

Table 2 Table showing demographic distribution of patients who underwent treatment for gynecomastia in our institution from 2002 to 2017.

	Total (n = 304)	MELT (n = 156)	LO (n = 52)	EO (n = 48)	LET (n = 48)
Age (in years)					
Mean (SD)	27 (9.27)	26 (7.81)	27 (8.97)	30 (14.0)	25 (7.48)
Range	12-78	14-51	12-49	13-78	16-49
BMI					
Mean (SD)	25.7 (3.97)	25.2 (3.56)	27.3 (4.60)	24.3 (4.40)	27.4 (3.72)
Median (IQR)	26 (23.0-28.0)	24.9 (22.5-27.1)	27.0 (23.5-30.2)	23.7 (21.0-26.2)	28.0 (24.0-29.0)
Range	17.6-38.2	17.6-38.2	19.2-36.6	18.2-35.0	20.2-36.2
Grade (%)					
1	126 (41.4)	55 (37.9)	17 (37.0)	33 (82.5)	21 (43.8)
2	112 (36.8)	72 (49.7)	18 (39.1)	6 (15.0)	16 (33.3)
3	36 (11.8)	18 (12.4)	11 (23.9)	1 (2.5)	6 (12.5)

mean BMI of the patients undergoing MELT, LO, EO, and LET were 25.2, 27.3, 24.3, and 27.4, respectively (Table 2).

The distribution of patients who were smokers, had type 2 diabetes, hyperlipidemia, and hypertension was not statistically significant.

The overall racial distribution was 44.7% Chinese, 15.1% Malay, 31.3% Indian and 8.9% others. 41.4% of the patients have Simon Grade 1 gynecomastia; 36.8% and 11.8% of patients are Grade 2 and 3, respectively. 9.9% of patients were not graded preoperatively.

Majority of patients in the MELT and LO groups had Simon Grade 2 gynecomastia, whereas majority of patients in the EO and LET groups had Simon Grade 1 gynecomastia (Table 2).

Clinical outcomes

We analyzed the complications that required a revision surgery such as residual breast disc, hematoma, and

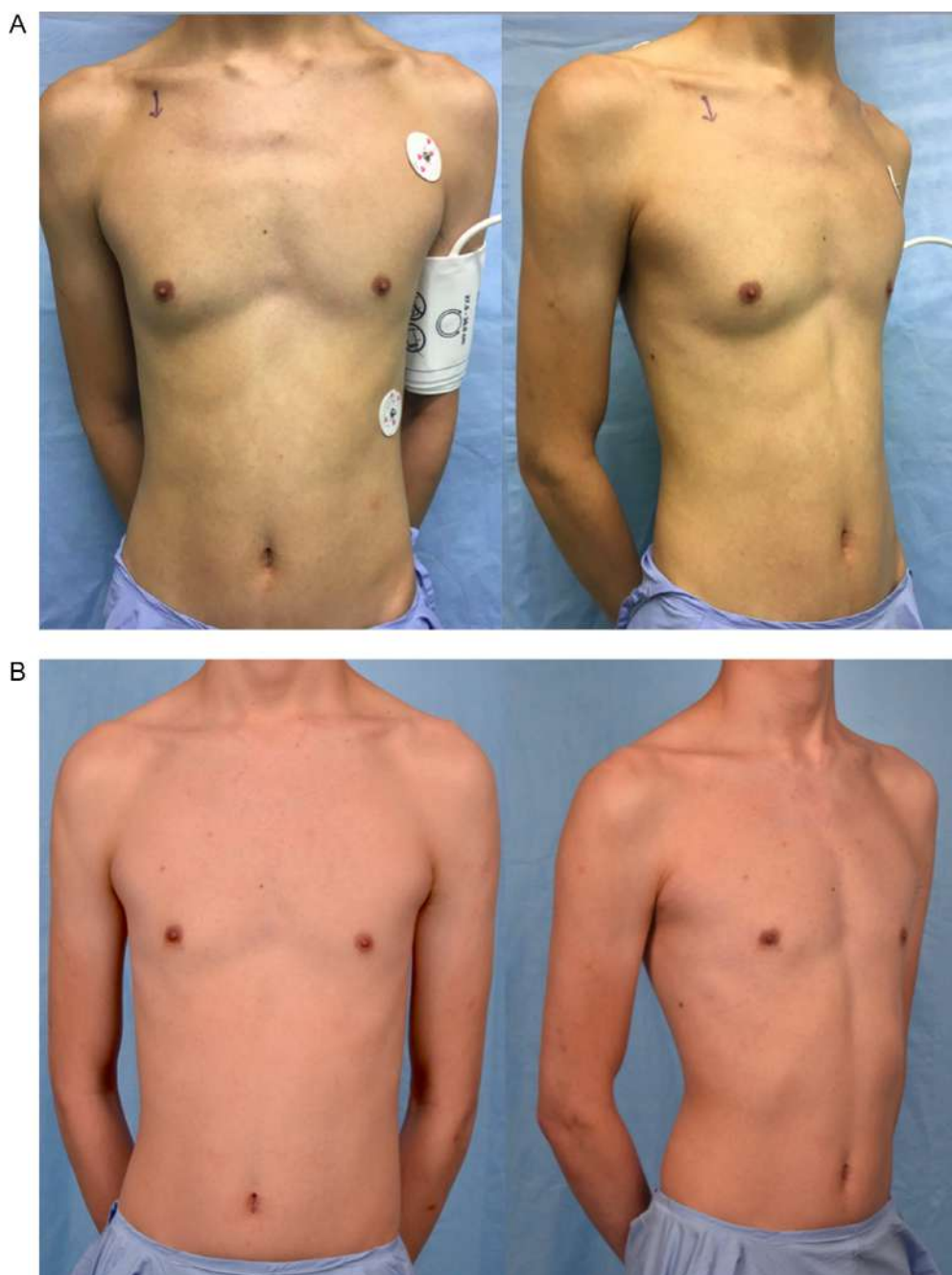


Figure 3 Case study 1. (A) A 24-year-old male with unilateral right-sided gynecomastia with prominent fibrous breast disc and minimal excess adipose tissue treated by MELT. (B) Postoperative results at 6 months.

nipple-areolar scars (hypertrophic, keloidal or scar-related complications such as pigmentation, pain, and itch). Complications such as hematomas usually required emergency clot evacuations in the immediate postoperative period. Patients who sought revision for residual breast disc and nipple-areolar scars were treated within a year from the initial surgery for gynecomastia.

Residual breast disc requiring a revision surgery was the most common complication with an incidence of 13.4% across all four groups. The incidence of hematoma and nipple-areolar scars requiring revision surgery was 6.6% and 1.6%, respectively (Table 3). The most common

complication among the MELT, LO, and EO groups was residual breast disc (11.5%, 19.2%, and 12.5%, respectively), while hematoma (12.5%) was the most common in the LET group. The incidence of nipple-areolar scars (hypertrophic, keloidal, or scar related complications such as pigmentation, pain, and itch) was 0 in the LO group and similar across the MELT, EO, and LET groups. However, these results were not significant.

We conducted a further logistical regression analysis on a subgroup of patients with clinically prominent breast discs (38, 38, 29, and 29 patients, respectively, in the MELT, LO, EO, and LET groups). Breast discs are defined as palpable



Figure 4 Case study 2. (A) A 23-year-old male with bilateral gynecomastia with prominent fibrous breast disc and significant adipose tissue treated by MELT. (B) Postoperative results at 3 months.

Table 3 Table showing distribution of patients with complications requiring revision surgery.

Complications (%)	Total (n = 304)	MELT (n = 156)	LO (n = 52)	EO (n = 48)	LET (n = 48)	p-value
Residual breast disc	38 (13.4)	18 (11.5)	10 (19.2)	6 (12.5)	4 (8.3)	0.384
Hematoma	20 (6.6)	7 (4.5)	3 (5.8)	4 (8.3)	4 (12.5)	0.246
Nipple-Areola Scars	5 (1.6)	3 (1.9)	0	1 (2.1)	1 (2.1)	0.787

firm discs located directly underneath the nipple-areolar complex. We assessed the likelihood of these patients (in the LO, EO, and LET groups) encountering complications that required revision surgery compared to those in the MELT group.

Patients with a prominent breast disc who underwent LO were 2.58 times more likely to have a revision surgery

compared to patients who underwent MELT ($p = 0.030$). The patients in the EO and LET groups were 1.63 and 1.29 times more likely to have a revision surgery, respectively, compared to the MELT group. However, this was not significant (Table 4).

Patients with a prominent breast disc who underwent LO were 4.05 times more likely to have a residual breast



Figure 5 Case study 3. (A) A 19-year-old male with bilateral gynecomastia with prominent fibrous breast disc and significant adipose tissue treated by MELT. (B) Postoperative results at 1 year.

Table 4 Table showing subgroup analysis on the outcomes of patients with preoperatively palpable breast disc.

Dependent variable	Overall complications		Residual breast disc		Hematoma	
	OR	<i>p</i> -value	OR	<i>p</i> -value	OR	<i>p</i> -value
LO (<i>n</i> = 38)	2.58	0.030	4.05	0.006	1.68	0.498
EO (<i>n</i> = 29)	1.63	0.256	1.91	0.224	1.80	0.388
LET (<i>n</i> = 29)	1.29	0.539	1.05	0.923	3.26	0.047
MELT (<i>n</i> = 38)	Null	Null	Null	Null	Null	Null

disc that required revision surgery compared to the MELT group ($p = 0.006$). Patients in the EO group were 1.91 times more likely to have a residual breast disc that required revision surgery but this was not significant. Patients who underwent LET were equally likely to have residual breast disc requiring revision surgery compared to those who underwent MELT. However, this was not significant.

Patients with a prominent breast disc who underwent LET were 3.26 times more likely to have hematoma requiring emergency clot evacuation compared to patients who underwent MELT ($p = 0.047$). Patients in the LO and EO

groups were 1.68 times and 1.80 times more likely than patients in the MELT group to have hematoma, respectively. However, this was not significant.

Case studies

Case study 1 (Figure 3A and B)

The patient is a 24-year-old male who has a body mass index (BMI) of 18.3 (height, 1.83 m; weight, 61.2 kg). He presented with unilateral right-sided gynecomastia for

a 5-year duration. He had Simon grade 1 gynecomastia. His-hormonal profile was normal and there were no obvious causes for his gynecomastia. The gynecomastia was predominantly due to a prominent and fibrous breast disc with minimal excess adipose tissue and no excess skin. He underwent MELT and recovered well. The periareolar scar is hardly noticeable and the chest symmetry was restored.

Case study 2 (Figure 4A and B)

The patient is a 23-year-old male who has a body mass index (BMI) of 22.6 kg/m² (height, 1.79 m; weight, 72.3 kg). He presented with bilateral idiopathic gynecomastia. He had Simon grade 1 gynecomastia. His-hormonal profile was normal. There was significant adipose tissue on both chests as well as prominent breast discs. He underwent MELT and recovered well (Video, Supplemental Digital Content 1, which describes the MELT).

Case study 3 (Figure 5A and B)

The patient is a 19-year-old male who has a body mass index (BMI) of 26.6 kg/m² (height, 1.78 m; weight, 84.4 kg). He presented with bilateral idiopathic gynecomastia. He had Simon grade 2 gynecomastia. His-hormonal profile was normal. There was significant adipose tissue on both the chest and skin excess. He also had bilateral prominent breast discs. He underwent MELT and recovered well. He did not undergo any skin excision surgery, as the chest wall contour was flat and symmetrical after surgery.

Patient satisfaction

A total of 171 patients (59.8%) responded to the questionnaire. 101 patients in the MELT group (59.1%), 31 patients in the LO group (18.1%), 21 patients in the EO group (12.3%) and 18 patients in the LET group (10.5%) responded to the questionnaire. Around 12 patients declined to participate in the survey while 121 patients were not contactable. The scores were recorded on a 10-point scoring system, with 1 being the least favorable and 10 being the most favorable, except for the level of concern by scars, where 1 is the most favorable and 10 is the least favorable.

The mean overall satisfaction level was comparable among all 4 groups (8, 7, 7, and 7 points, respectively, out of a 10-point scale) ($p = 0.590$). The mean satisfaction level for the shape of the chest postoperatively is similar at 7 out of 10 across all 4 groups ($p = 0.840$).

The mean level of concern by scars for the MELT, LO, EO, and LET groups were 2, 2, 4, and 3, respectively ($p = 0.004$). Patients in the EO group were the most concerned by their postoperative scars. While a Tukey-Kramer pairwise comparison shows that the only difference in concern for scars is between the EO group and MELT/LO groups (Table 1, Supplementary Material). This suggests that the EO group is significantly more concerned about scars than the MELT or LO groups. Patients in all 4 groups had a similar increase in confidence levels postoperatively ($p = 0.100$).

Discussion

Gynecomastia refers to a benign breast enlargement in men. Spontaneous regression is unlikely and the loose

periductal tissue undergoes irreversible dense fibrosis and hyalinization that does not regress.¹ Therefore, surgery remains the mainstay of treatment.^{1,3} The aim of surgery is to restore the chest contour with complete excision of the excess breast tissue. However, complete excision of the fibrous breast disc remains one of the biggest challenges in the treatment of gynecomastia.⁹⁻¹² Even with the use of liposuction techniques, extra incisions⁵ or a “pull-through” technique^{9,10} are commonly required in cases where the fibrous breast disc cannot be completely removed. Open excision techniques with skin removal are usually reserved for patients with high-grade gynecomastia, where there is severe hypertrophy or excess skin laxity with ptosis.

We present our solution to the problem with the combined Microdebrider Excision and Liposuction Technique (MELT) - where precise excision of the fibrous breast disc is performed through a single incision hidden within the nipple-areolar complex.

Traditional methods of gynecomastia treatment usually involve liposuction, direct surgical excision, or a combination of both. However, liposuction alone is not sufficient to remove the fibrous glandular tissue.¹ In the subgroup analysis of patients with preoperatively palpable breast discs, we note that in patients who underwent LO, they were more likely to have residual breast disc requiring revision surgery compared to patients in the MELT group ($p = 0.006$).

Bastrich and Ofodile¹⁴ observed problems of seroma and hematoma formation in patients who underwent the treatment of accessory breast tissue with the combined liposuction and excision technique because of the creation of large amounts of dead space and disruption of lymphatic channels. From our experience, liposuction often requires forceful passes to remove the fibrous breast disc. Of note, patients with preoperatively palpable breast disc who underwent LET were 3.26 times more likely to have hematoma compared to patients with palpable breast discs who underwent MELT ($p = 0.047$).

Most excisional techniques are effective in the removal of both glandular and fibrotic breast tissue. However, it results in long unsightly scars and creates a significant amount of dead space.¹⁵ In our study, patients who underwent EO were most concerned by their postoperative scars. This has led to some advocates for the combined liposuction and open excision technique.^{5,6,10} Yet, the difficulty of the complete removal of the fibrous breast disc has been alluded to by some authors. Lista et al. studied 96 patients who underwent the combined liposuction and open excision technique via an inframammary incision. None of their patients required revision surgery; however, they noted that in 5 patients who had preoperatively palpable breast disc, they encountered difficulty in excising the breast disc entirely, especially the tissue deep to the areolar. They thus required an additional periareolar incision to excise the breast disc in these patients.⁵ Morselli¹⁰ who first described the “pull-through” technique in 1996 for removing the fibrous breast disc in conjunction with liposuction in the treatment of gynecomastia described the use of two separate incisions to remove the fibrous breast disc. Moreover, the incisions measured 10-12 mm to aid parenchyma pull-through. Though the combined liposuction and open excision technique is a popular option for the complete excision of the fibrous breast disc, limitations arise as there is usually the need for

a longer scar and creation of an additional incision to aid in the excision of the breast disc. This is avoided in the use of the MELT as the liposuction and microdebrider cannula are applied through a single 5 mm incision.

Overall in the subgroup analysis of patients with preoperatively palpable breast discs, we observe more positive outcomes in MELT. We believe that the presence of the fibrous breast disc should be a guiding factor in including the microdebrider in the treatment of gynecomastia.

Petty,² Prado,¹¹ and Benito-Ruiz³ described a combined approach using liposuction with an arthroscopic cartilage shaver that permitted the removal of both glandular and fibrous tissues of the enlarged male breast. These authors reported few complications such as infection, asymmetry, hematoma, or scarring. Similarly, we note the low rates of complications in patients in the MELT group. We first described this technique in 2008 and it has since been applied in a similar concept for the excision of accessory axillary breast by Sun et al¹⁶ with desirable results.

There are several limitations of the MELT. While it can be very effective at excision, it also has the potential to cause bleeding and skin damage. Pre-operative tumescent infiltration with adrenaline is important for vasoconstriction. Direct visualization and identification of the tip through the skin is important to ensure that there is no button-hole through the skin. We also had incidences of accidental laceration of the skin with the microdebrider tip. This usually happens when the microdebrider cannula exits the skin with the blades still attached engaged. To prevent this, we use a skin protector to avoid contact of the cannula with the skin and ensure that the foot pedal is fully released before the withdrawal of the cannula. At the completion of surgery, the surgeon would be able to assess if there is significant bleeding before closing. Spraying of fibrin glue (*Tisseel*TM) and drains can be applied in cases where there is a high suspicion of bleed. A pressure garment is applied immediately after operation. In our series of patients undergoing MELT, we have 7 patients (4.5%) with hematoma requiring evacuation.

Apart from the presence of the fibrous breast disc, the selection of the modality for treatment of gynecomastia is also largely influenced by factors such as BMI and grade of the disease. For patients with high-grade gynecomastia associated with skin excess and ptosis, minimally invasive techniques usually yield poor aesthetic results due to the residual excess skin. Additional techniques such as skin excision are usually necessary. Patients belonging to such groups are often overweight or obese. Our data is limited by a small sample size of patients who are obese or have Simon grade 3 gynecomastia to make an adequate statistical observation of such a relationship. The non-randomized retrospective nature of this study is also a potential limitation.

The equipment for the MELT is readily available in tertiary centers with basic otolaryngological capabilities. Over the past decade, our institution has gradually shifted to the use of the microdebrider in combination with a PAL. We feel that this technique has become the standard for treatment in our institution for patients with gynecomastia as it provides better aesthetic outcomes with equal if not better patient satisfaction. We have also recently improvised our technique to minimize the risk of skin abrasions and nipple lacerations with the use of 1cc syringe from the flange of a nasogastric tube as a cannula sheath.¹⁷

Conclusion

The MELT is a safe technique for the treatment of patients with gynecomastia and especially so if they have a palpable breast disc. It has a lower incidence of residual breast disc and similar safety profile compared to other traditional techniques while achieving desirable results.

Declaration of Competing Interest

The authors do not have any conflict of interest or funding to declare.

Acknowledgments

We would like to thank Miss Madeline Ngai for her illustrations (Figure 2A and B).

Funding/Financial Disclosures

The authors do not have any financial disclosures with Medtronic, 3 M, or Veronique.

Ethical Approval

This study was conducted with the approval of the centralized institutional review board (CIRB Ref.: 2017/2909).

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:[10.1016/j.bjps.2019.09.003](https://doi.org/10.1016/j.bjps.2019.09.003).

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