Original Article

Predictive risk factors of complications in reduction mammoplasty—analysis of three different pedicles

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Background: Reduction mammoplasty can be performed in several different techniques. Understanding the complication profile and risk factors in different reduction methods can help in choosing a technique, which serves the patient best. The authors present their experience of three different reduction techniques [superomedial pedicle (SMP), superior pedicle (SP) and inferior pedicle (IP)] with an emphasis on predictors of complications.

Methods: A retrospective review of a prospectively maintained database of breast reductions between 2014 and 2020 was performed. Patient's demographics [age, body mass index (BMI), comorbidities, smoking, nipple to sternal notch distance (N-SN)], operative details (pedicle, tissue resected, drains, operating surgeon) and complications according to Clavien-Dindo classification were assessed. Study variables were compared against overall complication rates for the three techniques.

Results: In total, 760 patients underwent reduction mammoplasty, including 578 (76%) bilateral and 182 (24%) unilateral operations. Of patients, 477 (63%) were operated with SMP, 201 (26%) with IP and 82 (11%) with SP. An average weight of resected tissue per breast was 460 g. Overall complication rate was 38%. The rate was higher in IP group (50%) compared to SMP (36%) and SP (22%) groups (P<0.001). Complications were mainly minor and related to delayed wound healing. The rate for major complications was 4%. Multivariable analysis showed that complications were associated independently with IP [odds ratio (OR) 1.89, 95% confidence interval (CI): 1.33–2.69], age <50 years (OR 1.87, 95% CI: 1.32–2.65), bilateral operation (OR 1.67, 95% CI: 1.00–2.76) and resected tissue weight ≥650 g per breast (OR 2.02, 95% CI: 1.36–2.99). Each factor contributed 1 point in the creation of a risk-scoring system. The overall complication rate was increased as the presence of statistically significant risk factors (IP, age <50, bilateral operation and/or resected tissue ≥650 g per breast) increased (31%, 38%, 59% and 90% for number of 1, 2, 3 and 4 risk factors respectively, P<0.001).

Conclusions: The rate of complication can be predicted by a risk-scoring system. In increasing variety of patients undergoing reduction mammoplasty, careful consideration of the best operation technique is important to prevent complications and costs.

Keywords: Reduction mammoplasty; superomedial pedicle (SMP); inferior pedicle (IP); superior pedicle (SP); complications

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Introduction

Several different vascular pedicles and skin incisions have been described for reduction mammoplasty. They all have their own characteristics and outcomes. Different methods may be more optimal for certain patients and thus a pedicle selection and skin excision pattern should be always considered independently. Inferior pedicle (IP) with Wise pattern has demonstrated reliable results in management of glandular excess, nipple position and vascular reliability (1,2). However, this technique has gained critics of its long-term aesthetic drawbacks including squaring of the breast contour and a tendency to produce bottoming out of the breasts over time as well as the heavy scar burden of inverted-T skin incision (3). The superior pedicle (SP) technique preserves breast upper-pole fullness and has less tendency to bottom-out. Reduction with SP is usually performed with vertical skin incision and a long transverse inframammary fold scar could be avoided (4). The SP technique, on the other hand, has been associated with compromised nipple viability especially for a long pedicle (2). Critic has led to the pursuit of alternative methods including the superomedial pedicle (SMP) reduction. With the incorporation of more medial parenchyma into the SP, the SMP reduction has been noted to ensure adequate vascularity of the nipple areola complex and to provide better cosmetic durability. The SMP technique can also be used either with a Wise or vertical skin incision pattern (5). Studies have demonstrated safety with SMP also in larger breast reductions and complication rate equivalent to that of the IP technique. Advantages of the SMP technique includes also decreased operation time, better cosmetic durability with less bottoming out or pseudoptosis and fuller medial volume (2).

The characteristics of the patients seeking reduction mammoplasty vary significantly. Surgical indications for reduction mammoplasty and patient selection issues have been debated, including evaluation of various predisposing factors (e.g., age, obesity, smoking, comorbidities) and risk analyses (6). Delayed wound healing is the most common postoperative complication after reduction mammoplasty and has been correlated with breast resection volume, smoking, and advanced age (7-9). Prior studies have also reported that the risk of surgical complications and tissue necrosis gradually increases with an increase in the severity of obesity (6,10,11). Pedicle selection has also an impact on postoperative complications because the direction of the pedicle affects the location and weight of tissue resection and blood supply to the remaining breast tissue and nipple-areola complex (12). A role of skin incision in the postoperative complications after reduction mammoplasty has also been studied. A meta-analysis declaring the differences in complications after the vertical scar versus the inverted-T scar reduction techniques reported that the vertical scar method had significantly lower overall incidence of complications. However, no significant differences in seroma, hematoma, nipple necrosis, fat necrosis and reoperations were noted (12).

The aim of this review of 760 reduction mammoplasty patients (1,338 breasts) was to assess the distribution of complications graded with Clavien-Dindo classification following breast reduction in three different techniques. We also aimed to determine predictive risk factors of complications to decrease them and a burden of healthcare costs and facilitate discussion of options with women seeking breast reduction. We present the following article in accordance with the STROBE reporting checklist (available at https://gs.amegroups.com/article/view/10.21037/gs-22-116/rc).

Methods

This retrospective study was conducted using data from Tampere University Hospital (Finland) prospectively maintained reduction mammoplasty database. We identified all performed reduction mammoplasties between 1 January 2014 and 30 November 2020. Follow-up was performed until 31 May 2021. Oncoplastic reductions were excluded from the study. By reviewing the clinical records, we ensured that there were no duplicates. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by institutional scientific center ethics board of Tampere University Hospital (No. R20548). Individual consent for this retrospective analysis was waived.

We collected data on patient characteristics, surgical technique, operating surgeon, weight of resected tissue, complications and late corrective operations (e.g., dog-ear excision). Patient characteristics included: age, body mass index (BMI), smoking status, comorbidities and nipple to sternal notch distance (N-SN). Age was calculated in years on the day of the reduction mammoplasty. BMI was calculated in kg/m^2. Smoking status was dichotomized as "smoker" or "non-smoker". "Non-smokers" were patients who never smoked and "smokers" were patients who smoked or stopped for a period of four weeks prior to reduction. In our clinic, we generally recommend that patients refrain

from smoking at least four weeks before surgery, which is a common recommended protocol (10,13). Comorbidities were divided into diabetes, cardiovascular disease (CVD), asthma/COPD (chronic obstructive pulmonary disease) and other (hypothyreosis and other). Operations were divided into IP, SMP and SP techniques. Operating surgeon was the first operator: resident or plastic surgeon. The weight of reduction specimen from each breast were measured intra-operatively. All postoperative complications were scored using Clavien-Dindo classification. Minor complications included seroma, wound healing problem treated without antibiotics and wound problem with infection requiring per oral antibiotics, but without surgical intervention. Major complications included deep infection, hematoma, skin or fat necrosis requiring surgical intervention in the operating theatre. Number of late corrective operations (e.g., "dog-ear" excisions, minor symmetry corrections) was recorded.

In our clinic, IP and SMP reductions are mainly performed with Wise pattern (inverted T) skin resection and SP reduction mainly with vertical scar technique (LeJour, "keyhole" markings). Preoperative markings are applied in the surgical holding area. The diameter of a new nipple-areolar complex diameter is 38–42 mm. The width of the pedicle varies between of 6–10 cm. The length of the vertical limbs [the length of the new nipple-areolar complex (NAC)-inframammary fold (IMF) distance] is typically 6–8 cm depending on the size of reduction. Pedicle is de-epithelialized leaving an intact NAC. Dermatoglandular resections are performed. Care is maintained to ensure that no tension or kinking is placed upon the pedicle. A closed suction drain may be used if the operating surgeon desired. The evidence-based clinical practice guideline released by the American Society of Plastic Surgeons recommends that drains should not be routinely used in breast reduction (14). We have followed this guideline and reduced the use of drains in our clinic during last few years. We use postoperative drains nowadays only rarely.

Wounds are closed in two layers with interrupted deep dermal and running intracutaneous resorbable sutures. In the inverted T incision, a deep dermal trifurcation suture to the tripod zone is performed. Deep dermal sutures are performed with triclosan-coated multifilament or monofilament 3-0 sutures (per surgeon preference). Running barbed resorbable sutures (4-0) are employed intracutaneously. All patients receive one dose of cephalosporine (1.5 g) intravenously at the anesthetic induction. If cephalosporin is contraindicated, clindamycin (600 mg) is administered instead. Sterile tapes are placed on the suture lines. Sterile gauze padding and brasserie with anterior closure are applied to the chest.

The datasets analyzed during the current study are available from the corresponding author on reasonable request.

Statistical analysis

Differences between reconstruction techniques were tested using Pearson Chi-Square test or Fisher's Exact test and using Mann-Whitney or Kruskall-Wallis test. Randomly missing data were categorized as not known class. Multivariable adjusted logistic regression analyses were applied to estimate odds ratios (ORs) and 95% confidence intervals (CIs) to analyze the occurrence of overall complications. Risk-scoring system to stratify risk for postoperative complication was developed by using statistically significant variables (age <50 years, bilateral operation, IP and resected tissue weight ≥650 g per breast) from the multivariable logistic regression analysis. Each factor contributed 1 point. Risk score was defined as the sum of the presence for each component. A P value <0.05 was considered statistically significant. IBM SPSS Statistics version 26.0 for Windows software (SPSS Inc., Chicago, IL, USA) was used for statistical analyses.

Results

In total, 760 patients underwent reduction mammoplasty between years 2014 and 2020. Bilateral reduction was performed to 578 (76%) and unilateral reduction to 182 (24%) of patients. Unilateral reductions were mainly symmetrizing operations. The SMP technique was used in 477 (63%) patients, IP in 201 (26%) patients and SP in 82 (11%) patients. Overall median follow-up time in the study was 2.7 years (range, 1.5–4.6 years).

Demographics of all breast reduction patients according to the pedicle are presented in the *Table 1*. There was no statistically significant difference in comorbidities or smoking status between groups. Median (Md) age was higher in a SP group [55.5 years, interquartile range (IQR), 45.5–64] compared to IP (52 years, IQR, 40.5–61) and SMP (50 years, IQR, 40–59) groups (P=0.020). BMI was lower in SP group (Md 26.8, range, 17.5–38.4) compared to IP (Md 28.0, range, 19.8–39.7) and SMP (Md 28.0, range, 18.3–38.3) groups (P=0.002). N-SN or weight of resected tissue did not differ between SMP and IP groups but were lower in SP group (P<0.001). Late corrective operations

Table 1 Demographics of breast reduction patients according to pedicle

	Total (N=760)	SMP (n=477)	IP (n=201)	SP (n=82)	P value
Age, years					
Median [IQR]	51 [40–60]	50 [40–59]	52 [40.5–61]	55.5 [45.5–64]	0.020
<50, n (%)	335 (44.0)	223 (47.0)	87 (43.0)	25 (30.0)	0.023
≥50, n (%)	425 (56.0)	254 (53.0)	114 (57.0)	57 (70.0)	
BMI, Md [range]	27.8 [17.5–39.7]	28.0 [18.3–38.3]	28.0 [19.8–39.7]	26.8 [17.5–38.4]	0.002
BMI, kg/m^2, n (%)					0.005
<25	132 (17.0)	81 (17.0)	26 (13.0)	25 (32.0)	
25–29	436 (57.0)	277 (59.0)	117 (59.0)	42 (53.0)	
≥30	181 (24.0)	113 (24.0)	56 (28.0)	12 (15.0)	
Not known	11 (1.0)	6 (1.0)	2 (1.0)	3 (4.0)	
N-SN, cm, Md [range]					
Right breast	30.0 [17.5–47.0]	30.5 [19.0–44.0]	30.5 [21.0–47.0]	28.0 [17.5–35.5]	<0.001
Left breast	30.0 [16.5–47.0]	30.5 [19.0–44.0]	31.0 [22.0–47.0]	27.0 [16.5–35.5]	<0.001
Tissue resected, g, Md [IQR]					
Right breast	464 [322–640]	479 [349–658]	491 [373–653]	217 [114–322]	<0.001
Left breast	460 [315–658]	480 [332–670]	500 [344–694]	242 [155–353]	<0.001
Smoking					0.549
No	655 (86.0)	414 (87.0)	175 (87.0)	66 (81.0)	
Yes	46 (6.0)	26 (5.0)	13 (7.0)	7 (8.0)	
Not known	59 (8.0)	37 (8.0)	13 (7.0)	9 (11.0)	
Comorbidities, n (%)					
Cardiovascular diseases	161 (21.0)	100 (21.0)	48 (24.0)	13 (16.0)	0.319
Asthma	53 (7.0)	32 (7.0)	17 (8.0)	4 (5.0)	0.525
Diabetes Mellitus	35 (5.0)	25 (5.0)	8 (4.0)	2 (2.0)	0.474
Other diseases	163 (21.0)	107 (22.0)	40 (20.0)	16 (19.0)	0.690
Laterality, n (%)					<0.001
Bilateral	578 (76.0)	388 (81.0)	162 (81.0)	28 (34.0)	
Unilateral	182 (24.0)	89 (19.0)	39 (19.0)	54 (66.0)	
Drain, n (%)					0.080
No	396 (52.0)	256 (54.0)	92 (46.0)	48 (59.0)	
Yes	364 (48.0)	221 (46.0)	109 (54.0)	34 (41.0)	
Late corrective operations, n (%)					0.045
No	675 (89.0)	423 (89.0)	173 (86.0)	79 (96.0)	
Yes	85 (11.0)	54 (11.0)	28 (14.0)	3 (4.0)	

Table 1 (*continued*)

Table 1 (*continued*)

	Total (N=760)	SMP (n=477)	IP (n=201)	SP (n=82)	P value
Complication, n (%)					<0.001
No	470 (62.0)	305 (64.0)	101 (50.0)	64 (78.0)	
Minor	259 (34.0)	147 (31.0)	94 (47.0)	18 (22.0)	
Major	31 (4.0)	25 (5.0)	6 (3.0)	0 (0.0)	
Operating surgeon, n (%)					
Resident	293 (39.0)	188 (39.0)	83 (41.0)	22 (27.0)	
Plastic surgeon	467 (61.0)	289 (61.0)	118 (59.0)	60 (73.0)	
Follow-up time, years, Md [IQR]	2.7 [1.5–4.6]	2.3 [1.2–4.5]	3.2 [2.0–4.7]	3.1 [2.2–4.7]	

Differences between pedicle groups were tested using Kruskall-Wallis or Pearson Chi-Square test. N, number of participants; n, number of participants in the subgroup; Md, median; IQR, interquartile range; SMP, superomedial pedicle; IP, inferior pedicle; SP, superior pedicle; BMI, body mass index; N-SN, nipple to sternal notch distance.

Table 2 Detailed analysis of complications according to the pedicle, n (%)

	Total (n=760)	SMP (n=477)	IP (n=201)	SP (n=82)	P value
No complication	470 (62.0)	305	101	64	
Minor complications	259 (34.0)	147	94	18	0.035
Seroma	17 (7.0)	15 (10.0)	1 (1.0)	1 (6.0)	
Wound problem, no antibiotics	179 (69.0)	94 (64.0)	71 (76.0)	14 (78.0)	
Wound problem, antibiotics required	63 (24.0)	38 (26.0)	22 (23.0)	3 (17.0)	
Major complications	31 (4.0)	25	6	0	0.153
Hematoma	24 (77.0)	21 (84.0)	3 (50.0)		
Tissue necrosis	4 (13.0)	2 (8.0)	2 (33.0)		
Deep infection	3 (10.0)	2 (8.0)	1 (17.0)		

Differences between pedicle groups were tested using Kruskall-Wallis or Fisher's exact test. SMP, superomedial pedicle; IP, inferior pedicle; SP, superior pedicle.

(e.g., dog-ears) were most commonly performed in IP group (14.0%) compared to SMP (11.0%) and SP (4.0%) (P=0.045). Overall complication rate in this study was 38%. The IP technique was associated most commonly with complications (50%), of which 94% were minor complications. The corresponding rates were 36%/85% in SMP group and 22%/100% in SP group (P<0.001).

Detailed analysis of complications according to the pedicle is presented in *Table 2*. The overall rate for minor complications was 34.0%. Wound problem healed without antibiotics was the most common minor complication (69.0%) followed by wound healing problem requiring antibiotics (24.0%) and seroma (7.0%). The overall major complication rate was 4.0%. Of major complications, postoperative hematoma was the most common (77.0%) followed by tissue necrosis (13.0%) and deep infection (10.0%). There was no total nipple-areola-complex loss.

A wound healing problem was located at tripod zone in 35% of SMP and 37% of IP patients and in the middle of the inframammary fold in 35% of SP patients (P=0.244). Multifilament and monofilament suture was used in 77%/23% of SMP cases, 75%/25% of IP cases and in 59%/41% of SP cases correspondingly (P=0.284).

The multinomial regression analysis of complications according to the pedicle and patient characteristics was performed (*Table 3*). In all tested models, the IP technique was associated with higher rate of minor complications. No difference was seen in major complications.

Table 3 Multinomial logistic regression analysis (N=760)

	Complications, OR (95% CI)	
	Minor (n=259)	Major (n=31)
Unadjusted		
Superomedial pedicle	1.00	1.00
Inferior pedicle	1.93 (1.37–2.72)	0.73 (0.29–1.82)
Superior pedicle	0.58 (0.33–1.02)	–
Model 1		
Superomedial pedicle	1.00	1.00
Inferior pedicle	2.03 (1.43–2.89)	0.77 (0.30–1.94)
Superior pedicle	0.66 (0.37–1.16)	–
Model 2		
Superomedial pedicle	1.00	1.00
Inferior pedicle	1.92 (1.35–2.72)	0.73 (0.29–1.83)
Superior pedicle	0.76 (0.43–1.35)	–
Model 1+2		
Superomedial pedicle	1.00	1.00
Inferior pedicle	2.03 (1.41–2.91)	0.75 (0.29–1.92)
Superior pedicle	0.85 (0.47–1.53)	–

Reference for minor and major complications was no complications (n=470). Differences between complication groups were tested using multinomial logistic regression analysis. Model 1 was adjusted for age, body mass index, and comorbidity (cardiovascular disease, asthma/COPD, DM, other). Model 2 was adjusted for operative details [laterality, resected tissue (resg upper quartile), drain, operating surgeon]. N, number of participants; n, number of participants in the subgroup; OR, odds ratio; CI, confidence interval; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus.

We performed a multivariable-adjusted logistic regression analysis to identify predictors for occurrence of overall complications (*Table 4*). Independent risk factors for complications were IP technique (OR 1.89, 95% CI: 1.33–2.69), age <50 years (OR 1.87, 95% CI: 1.32–2.65), bilateral operation (OR 1.67, 95% CI: 1.00–2.76) and resected tissue weight ≥650 g per breast (OR 2.02, 95% CI: 1.36–2.99). No statistically significant effect on the complication rate could be found according to BMI, comorbidity, N-SN, drain or operating surgeon. We also modelled the interactions of categorical age, BMI, and resected tissue with pedicle in the multivariable-adjusted model on complications. None of those interactions was statistically significant.

We analyzed also differences in patient and operative characteristics according to age (<50 *vs.* ≥50 years) in patients with some complication (*Table 5*). The BMI was higher [Md 28.5 (range, 20.0–39.7) kg/m^2] in patients ≥50 years than in patients <50 years [Md 27.5 (range, 25.3–29.7) years], P=0.005. Older patients had also more commonly comorbidities (P<0.001). Younger patients had more commonly bilateral operation (P<0.001) and their operation was more commonly performed with the SMP technique (P=0.023). No statistically significant difference between groups was observed in N-SN, resected tissue, or operating surgeon.

In multivariable analyses (*Table 4*) we found that independent risk factors for complications were IP, age <50 years, bilateral operation, and resected tissue weight ≥650 g per breast. We calculated risk factor scores as the sum of the presence for fore mentioned risk factors. Presence of any of those risk factors contributed 1 point in the creation of a risk-score for complications. The overall complication rate was increased as the risk score increased (31%, 38%, 59% and 90% for 1, 2, 3 and 4 risk scores respectively, P<0.001) (*Table 6*).

Discussion

We evaluated the preoperative clinical and surgical variables for the different breast reduction techniques in 760 patients of our clinical database to predict postoperative complications after operation. We found that age under 50 years, IP technique, bilateral operation, and tissue resection ≥650 g per breast were associated with increased risk of developing complications after breast reduction surgery. By using these four variables, we stratified risk scores for postoperative complications after reduction mammoplasty.

Current literature has demonstrated complication rates in reduction mammoplasty to vary significantly (range from 4–63%) (7,15,16). Complications are reported to be most commonly minor and related to delayed wound healing (1,15). In our study, a complication occurred in 38% of patients and a complication profile was comparable with prior studies. The rate for major complications was 4%, which also compares well with prior studies' 3–6% (7,15,16).

When comparing our complication rates of different techniques separately to prior studies, our rates and profile of major complications are comparable, but rates for minor complications are higher. The prior study by Bauermeister *et al.* in 2019 with 938 reduction mammaplasties with

Table 4 Multivariable-adjusted logistic regression analysis to identify predictors for occurrence of overall complications (N=760)

	The occurrence of overall complications			
	N	n (%)	OR	(95% CI)
Pedicle				
Superomedial	477	172 (36.0)	1.00	
Inferior	201	100 (50.0)	1.89	(1.33–2.69)
Superior	82	18 (22.0)	0.92	(0.50–1.68)
Age, years				
<50	335	161 (48.0)	1.87	(1.32–2.65)
≥50	425	129 (30.0)	1.00	
BMI				
<25	132	45 (34.0)	1.00	
25.0–29.9	436	169 (39.0)	1.07	(0.69–1.66)
≥30	181	74 (41.0)	1.11	(0.65–1.89)
Not known	11	2 (18.0)	0.65	(0.13–3.36)
Cardiovascular disease				
No	599	240 (40)	1.00	
Yes	161	50 (31.0)	0.84	(0.54–1.29)
Laterality				
Unilateral	182	38 (21.0)	1.00	
Bilateral	578	252 (44.0)	1.67	(1.00–2.76)
Resected tissue*/one breast				
<650 g	567	191 (34.0)	1.00	
≥650 g	189	99 (52.0)	2.02	(1.36–2.99)
Not known	4	0 (0.0)	–	
N-SN				
<33 cm	497	204 (41.0)	1.00	
≥33 cm	230	80 (35.0)	0.87	(0.58–1.32)
Not known	33	6 (18.0)	0.64	(0.23–1.79)
Drain				
No	396	141 (36.0)	1.00	
Yes	364	149 (41.0)	1.21	(0.88–1.67)
Operating surgeon				
Resident	293	133 (45.0)	1.00	
Plastic surgeon	467	157 (34.0)	0.74	(0.53–1.02)

Results were shown using OR with 95% CI, with number of participants (N) and number (n) of any complications. *, upper interquartile range (see *Table 1*). OR, odds ratio; CI, confidence interval; BMI, body mass index; N-SN, nipple to sternal notch distance.

Table 5 Comparison of patient and operative characteristic according to age in patients with some complication

Characteristic	Patients' age		P value
	<50 years (n=335)	≥50 years (n=425)	
BMI, kg/m^2, median [range]	27.5 [25.3–29.7]	28.5 [20.0–39.7]	0.005
<25, n (%)	68 (20.0)	64 (15.0)	0.114
25.0–29.9, n (%)	193 (58.0)	243 (57.0)	
≥30.0, n (%)	71 (21.0)	110 (26.0)	
Laterality, n (%)			<0.001
Unilateral	37 (11.0)	145 (34.0)	
Bilateral	298 (89.0)	280 (66.0)	
Pedicle, n (%)			0.023
Superomedial	223 (67.0)	254 (60.0)	
Inferior	87 (26.0)	114 (27.0)	
Superior	25 (7.0)	57 (13.0)	
N-SN, median [range]	60 [22–80]	60 [23–94]	0.875
Tissue resected, median [interquartile range]	848 [566–1,207]	821 [391–1,203]	0.128
Comorbidity, n (%)			
Cardiovascular disease	11 (3.0)	150 (35.0)	<0.001
Diabetes mellitus	5 (2.0)	30 (7.0)	<0.001
Asthma/COPD	10 (3.0)	43 (10.0)	<0.001
Other disease	61 (18.0)	102 (24.0)	0.053
Operating surgeon, n (%)			0.075
Resident/trainee	141 (42.0)	152 (36.0)	
Plastic surgeon	194 (58.0)	273 (64.0)	

BMI, body mass index; N-SN, nipple to sternal notch distance; COPD, chronic obstructive pulmonary disease.

Table 6 Rate of complications according to risk factor score (0–4), including age <50 years, bilateral operation, inferior pedicle and resected tissue weight ≥650 g per breast

	Risk sum score				
	0	1	2	3	4
Number of the patients, n (% of all patients)	102 (13.4)	195 (25.7)	300 (39.5)	143 (18.8)	20 (2.6)
Overall complications, n (% of risk sum scores)					
No complications (n=470)	88 (18.7)	135 (28.7)	186 (39.6)	59 (12.6)	2 (0.4)
Minor complication (n=259)	13 (5.0)	54 (20.8)	98 (37.8)	76 (29.3)	18 (6.9)
Major complication (n=31)	1 (3.2)	6 (19.4)	16 (51.6)	8 (25.8)	0
Total complications, n (% of patients)	14 (13.7)	60 (30.8)	114 (38.0)	84 (58.7)	18 (90.0)

Differences between risk factor sum score and overall complications (P<0.001) were tested by Fisher's exact test.

the SMP technique combined with Wise pattern incision reported the overall complication rate of 16%, of which 10% were minor (2). Our complication rates for minor and major complications in the SMP technique were 31%/5% correspondingly. Considering the SP technique with vertical skin incision, we had 22% rate for complications, which all were minor. Klinger *et al.* in 2020 have reported an analysis of 832 patients undergoing SP breast reduction. In that study, the rate for seroma was 2%, deep infection 1%, hematoma 0.5%, necrosis 3% and wound dehiscence 5.1% (17). Several studies have also evaluated complication rates in IP with Wise pattern. Antony *et al.* in 2013 reported this technique to have 3% major and 24% minor complication rate (18). In a study by Bustos *et al.* in 2021, the overall complication rate for IP was 14.8% including seroma 3.3%, hematoma 1.6%, deep infection 2.1%, 5.6% wound dehiscence and necrosis 2% (19). In our study, the overall complication rate for IP with Wise pattern was 50%. Of these 47% were minor complications.

This difference in complication rates might be the result of standard study variability, study population heterogeneity or differing thresholds for the diagnosis of a complication. We were able to see our patients with postoperative problems in our consulting room and scored all postoperative complications using Clavien-Dindo classification, which defines a complication as any deviation from the normal postoperative course. Larger-cohort database studies may not even capture conservatively managed small wound healing problems and therefore likely underestimates patients with these issues (7). Yet, every operation and hospital visit involve the use of healthcare resources.

Prior studies have also reported results comparing complications associated with vertical and Wise pattern skin incisions. In the study by Cunningham *et al.* in 2005, vertical incision technique was associated with an increased complication frequency (20). An overall incidence of complications was 43% including delayed wound healing 21.6%, spitting sutures 9.2%, hematoma 3.7%, necrosis 5.4%, seroma 1.2% and infection 1.2%. In this study, IP technique was used in 78% and SP in 32% of patients. Kulkarni *et al.* in 2019 reported also higher complication rate for vertical incision (36.4%) compared to Wise pattern (20.4%) incision. In this study, Wise pattern incision was combined either with IP or SMP and vertical pattern with SP (1). On the other hand, a meta-analysis performed by Li *et al.* in 2021 reported that a vertical scar approach resulted in a statistically lower rate of overall complications and wound dehiscence. In that study, the used pedicle was not identified (12). Our results agree with this study.

The wound complications have been reported to occur commonly at the point of greatest stress or tension on the closure. Especially in the IP with inverted T skin incision the tension lies to skin over the breast parenchyma to maintain the desired shape. The use of suspended gland in SP technique reduces the strain on the skin, which results the benefit to avoiding wound dehiscence and promoting wound healing. In the SMP technique combined with inverted T incision the main support is also glandular but the closure of skin flaps at a single point creates excess tension and possibility for wound break down at that point (12). In our study, 35–37% of wound healing problems were located in the middle of the inframammary fold. There were no statistically significant difference between groups.

A suture material used in the wound closure may also have an influence in complication rates. In our study, interrupted deep dermal multifilament sutures were most commonly used in all groups. In prior studies, monofilament sutures have been associated with a lower surgical site infection than multifilament sutures, probably because bacteria can escape phagocytosis within the filament interstitials. However, studies have indicated positive effects of triclosan-coated sutures on the prevention of surgical site infection. Triclosan is an antibacterial substance that has been shown to reduce bacterial load. No significantly different rate for surgical site infection between multifilament and monofilament sutures coated with triclosan have been reported. Suture's absorption time seemed not have an impact on incidence of complications either (21).

We used also barbed intracutaneous running suture. In a prior study, barbed sutures have been associated with slightly higher rates of minor wound complications compared to nonbarbed monofilament sutures (25.2% *vs.* 23.1%) in plastic surgery (22). Barbed suture was associated with higher rate of suture extrusion when sutures were placed for upper dermal approximation (22). Over 60% of our wound complication were located other place than tripod zone. Whether this is due to suture materials or approximation of suture remains to be studied.

A pedicle selection and skin excision pattern should be considered independently. It is important to consider what patient characteristics predict a high rate of success with certain reduction techniques, as different methods may be more optimal for certain patient populations. In this retrospective study, surgeon's decision-making could

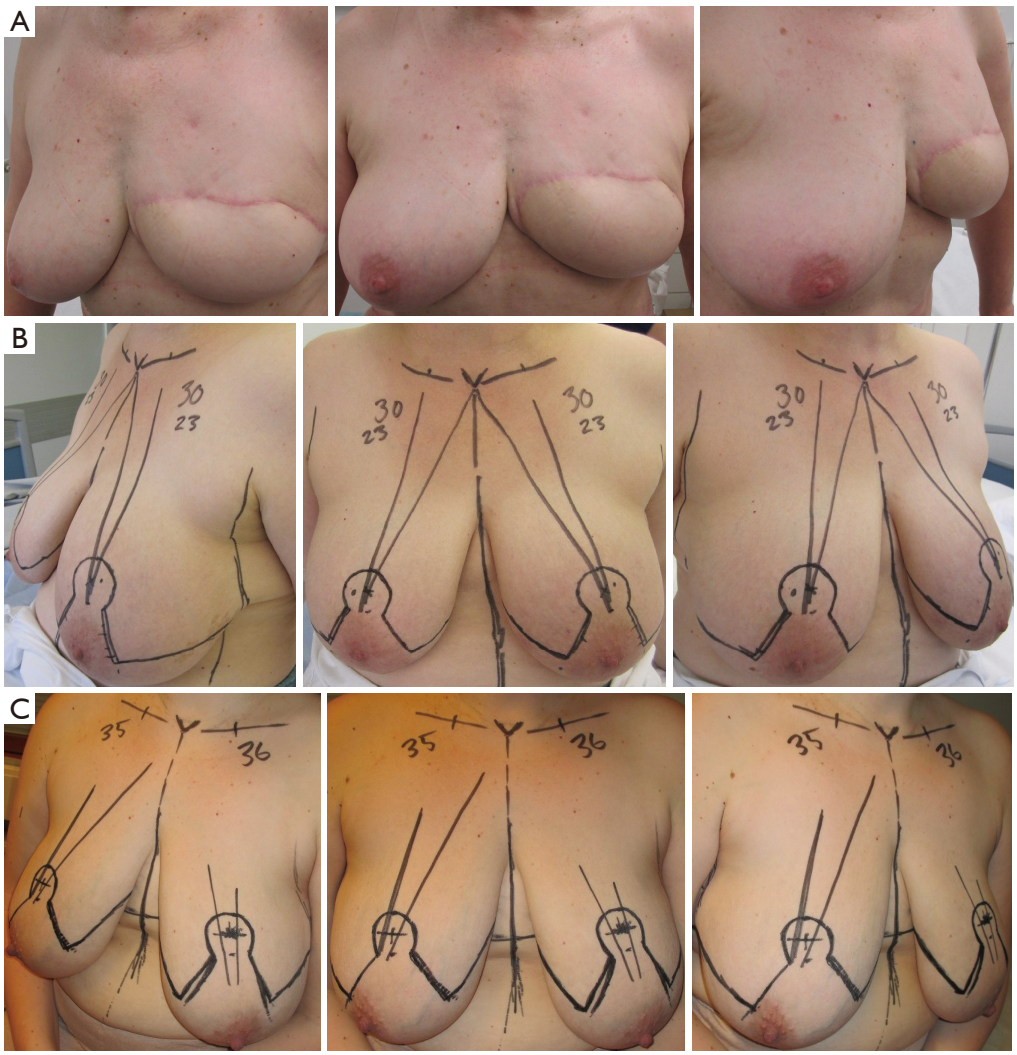

Figure 1 A typical patient for reduction with superior pedicle (A), superomedial pedicle (B) and inferior pedicle (C) techniques.

not be directly analyzed, yet trends did appear with the selection of alternative pedicle with patient characteristics. A typical patient for IP and SMP technique was 50 to 52 years old, overweight (BMI: 28 kg/m^2) woman having ptotic breasts with N-SN of 31 cm seeking bilateral reduction mammoplasty (*Figure 1*). A typical patient in the SP group was a few years older (56 years) woman with slight overweight (BMI: 26.8 kg/m^2) and shorter N-SN (27 cm). This patient was more commonly seeking unilateral symmetrizing operation with smaller volume reduction (*Figure 1*). This pedicle selection agrees with a common trend according to which the larger and more ptotic the breast, the less appropriate vertical techniques become (4).

We used inverted-T incision both in IP and SMP techniques. We found that the weight of resected tissue was equal in SMP and IP techniques, but the complication rate was lower in SMP technique, which is also in agreement with a prior study (2). These findings suggest that the SMP is a safe alternative to the IP technique. The combination of the SMP with the traditional Wise-pattern skin resection has gained increasing popularity for its versatility and ability to achieve significant reduction of breast parenchyma and skin envelope with improved contour and lasting results (23). It has also become the most used technique in our clinic. Postoperative results are shown in *Figure 2*.

The variety of patients undergoing reduction mammoplasty is broad and can range from the young to the elderly (8) and from healthy to patients with multiple medical

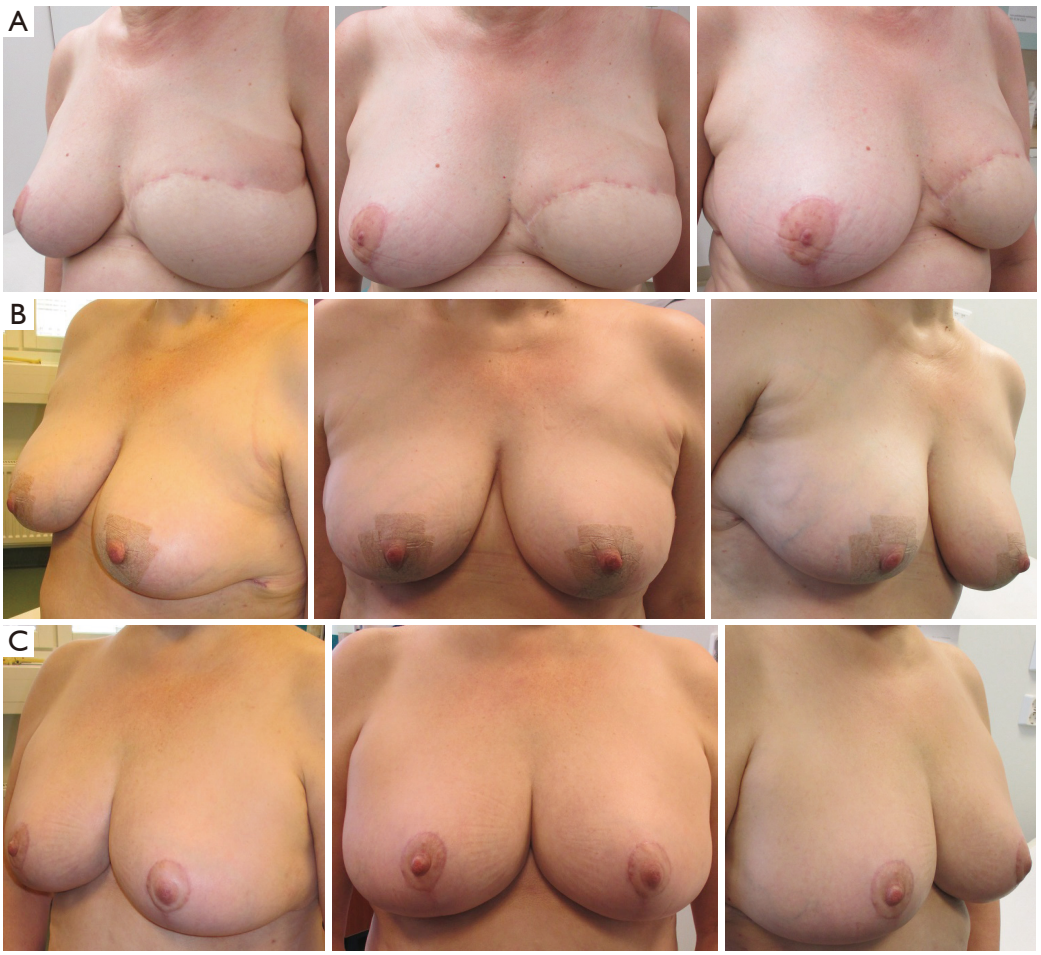

Figure 2 Postoperative result after reduction with superior pedicle (A), superomedial pedicle (B) and inferior pedicle (C) techniques. In (A) right breast operated with the superior pedicle technique (A) and fat injections performed to left reconstructed breast. Right breast operated with the superior pedicle technique (C) and fat injections performed to left reconstructed breast.

comorbidities (7). Mixed results considering the age and complications have been published. Many studies have reported a complication rate to be higher in patients older than 50–60 years than younger patients (8,9,13). It has been suggested that comorbid conditions (8,13) or hormonal deficiency (9) may partially account for these findings. On the other hand, a study by Nelson *et al.* in 2014 with 3,537 patients (comparing patients <60 and ≥60 years of age) reported no association between age and complication rate (24). Some smaller studies have published the opposite results. In studies by Cunningham [2005] (20) and Roehl [2008] (25), age younger than 50 years was associated with increased complications, which agrees with our study results. In fact, the study by Cunningham *et al.* reported that every additional year of age was associated with a 7% reduction in the risk of delayed healing (20). The study by Roehl *et al.* demonstrated that complications were most common in the 30- to 39-year group (25). It has been speculated that the younger age group may include patients with a higher average BMI and/or larger breast resection, which have been suggested to impair outcomes and to be factors that probably stimulate women to seek breast reduction at a relatively younger age (9). In our study, the median BMI was higher in patients ≥50 years of age and they also had more comorbidities. There was no difference in the weight of resected tissue between groups. Younger patients had more commonly bilateral operation, which might have some impact on the results. The reason why complications were more common in patients <50 years of age remains to be

determined, and any reasoning would be purely speculative.

The weight of resected breast tissue has been correlated with an increased complication frequency (20,25), which is also supported by our study. In prior studies, a mean resection weight from 700 to 1,500 g has been reported to be associated with increased complication rate (20,25). In our study, a resection weight ≥650 g per breast was an independent risk factor for complications. Opposite results have also been published by Roehl *et al.* as in their study, no significant correlation between the size of breast reduction and the incidence of complications was observed in gigantomastic patients who had resection over 1,500 g (25).

There have been conflicting opinions as to whether obesity is associated with the higher complication rate (6,16). Several studies have demonstrated an increased risk of complications in obese patients (6,10,11). The risk of surgical complications has been reported to gradually increase with an increase in the severity of obesity. In BMI 30–35 kg/m^2 risk ratio (RR) of surgical complications was 1.45, 95% CI: 1.21–1.75, while in BMI >35 kg/m^2, RR was 1.71 (95% CI: 1.37–2.12) and if BMI was >40 kg/m^2, RR was 2.05 (95% CI: 1.29–3.26) (6). We have changed our practice according to prior study results a few years ago. We encourage obese patients to lose weight and operate when BMI is under 30 kg/m^2. In our study, 24% of patients were obese (BMI ≥30 kg/m^2), but of these, only a few had BMI over 35 kg/m^2. Previously documented relationship between obesity and complications was not apparent in our data, which might be associated with the small number of patients with BMI >35 kg/m^2 in our study population.

This study has several limitations. There was a great difference in the sample size of three groups, which increases the chance of simple bias. Especially the number of patients operated with SP combined with vertical skin incision was small, which could have influenced the results. The retrospective study may be prone to observer bias, recording bias and selection bias overall. Retrospective study designs may also lead to an inaccurate representation of the study population and an inability to capture emotional responses. We did not have any patient-reported outcomes (PROs), which would have given more information in comparing reduction techniques. However, the purpose of the current study was to analyze the complications of different pedicles. The analysis of aesthetic results of these three techniques is a scope of our further study in which we plan to conduct both preoperative and postoperative surveys. The choice of reduction technique depends on patient characteristics and the preference of the surgeon. This decision-making could not be analyzed properly in retrospective study. At our institution, we strongly favor the use of SMP technique now, but in the beginning of the study period, IP was more commonly used. Neither patients nor the reduction methods were randomized. However, even in a prospective study, the randomization of patients might not be ethically acceptable. Our data are based on one health system's practice. Our results might not be applicable in some settings.

Our study presents that the rate of complication can be predicted by a risk-scoring system. Four variables, including age under 50 years, IP technique, bilateral operation and tissue resection ≥650 g per breast were associated with increased risk of developing complications after breast reduction surgery. The variety of patients undergoing reduction mammoplasty is broad and careful consideration of the best technique and informing the patient about possible complications is important.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://gs.amegroups.com/article/view/10.21037/gs-22-116/rc

Data Sharing Statement: Available at https://gs.amegroups.com/article/view/10.21037/gs-22-116/dss

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://gs.amegroups.com/article/view/10.21037/gs-22-116/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by institutional scientific center ethics board of Tampere University

Hospital (No. R20548). Individual consent for this retrospective analysis was waived.

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