

VILNIUS UNIVERSITY
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The Final thesis

**Most Popular Breast Reduction Techniques: Impact of Multiple Factors on the Method
Choice, Results and Complications**

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I. A B S T R A C T

Background: The main goals of a breast reduction are the alleviation of symptoms and remodelling the breast to a youthful and aesthetical breast.

Objective: The aim of this work is to analyse the most popular breast reduction techniques

Methods: A narrative review was performed using PubMed database, focusing most studies between 2012-2022. For some research the timeframe was extended to 2005 due to lack of studies.

Results: The most tested and familiar pedicle type with acceptable results remains the inferior pedicle(1). The superomedial and superolateral pedicle are tailored specifically to maximise the full vasculature supply and breast innervation(2)(3). The superomedial and superolateral pedicle experience lower complication rates compared to the inferior pedicle(4)(5). Both techniques experience a better long term satisfactory rate among patients(6)(7).

Conclusion: Every patient needs to be assessed individually and the breast reduction approach should be individually designed to the patient and anatomical examinations of the breast. Pedicles are not solely influencing the results, as resection weight and morbidity of the patients matters. Promising results for breastfeeding and sensory preservation postoperatively were obtained when the column of subareolar parenchyma was preserved. The superomedial and superolateral pedicle remain less adapted as the inferior pedicle due to their novelty. Contradictory, they yield the most satisfactory results with the highest vascular reliability and should be considered as first choice options for most patients(8).

Keywords: “reduction mammoplasty”, “breast reduction”, “superomedial pedicle”, “inferior pedicle”, “superolateral pedicle”, “central pedicle”, “superior pedicle”, “free nipple grafting”, “weight”, “complication”, “nipple necrosis”, “gigantomastia”, “nipple innervation”, “vascular supply”, “ptosis”.

II. I N T R O D U C T I O N

Breast reduction surgery, with 534.294 operations performed in 2018 is the 8th most frequent operation by plastic surgeons globally. Especially adolescent girls have undergone this surgical intervention over the past decade(9). Most patients choose breast reduction surgery to alleviate pain & complaints caused by the heavy burden(10). Quite common symptoms such as neck pain, sub mammary intertrigo, back pain, hurtful bra indentations, breast pain, difficulty in choosing and wearing clothes, headache, shoulder pain, peripheral neuralgias, posture

problems, inability to exercise, difficulty during breathing and sleeping etc. can be experienced with breast hypertrophy(11)(12). Additionally, psychosocial symptoms such as insecurity, poor perception of one's own body image and emotional stress, originating from peer pressure and ridicule can be driving factors for undergoing breast reduction. The surgery can be very important especially for adolescent girls, as this age is crucial for social development and the operation could restore their self-esteem(1). However, the first treatment goal of any breast reduction is to reduce the intensity and frequency of associated health impairments, and the second is to create a more youthful, smaller and aesthetically pleasing breast(13). The surgeon's focus is to identify the anatomy of both the vascular supply and the breasts innervation, to design the appropriate pedicle tailored individually to every patient(14). The surgeon can choose from a majority of patterns when planning the breast reduction(15).

The aim of this research work is to create an overview of the most promising and most applied breast reduction techniques over the past decades. After reading this article one should have achieved a broad overview and understanding of the different pedicles, their operative techniques, complication rates, sensory level impairments, the nature of vasculature supply to the breast and special indications for each pedicle technique. This review will focus on the inferior, superior, superomedial, superolateral and central pedicles as well as the free nipple grafting technique.

III. LITERATURE SEARCH STRATEGY

A PubMed database search was made with inserting the keywords “superior pedicle”, “inferior pedicle”, “superolateral pedicle”, “superomedial pedicle”, “central pedicle”, “free nipple graft” all in combination with “breast reduction” and “reduction mammoplasty” separately. It was attempted to collect most data from in between 2012 - 2022. However, due to important discoveries being published before 2012 an extension of the timeframe was made for 6 of the 59 studies reporting one source on the superomedial and 4 sources on the superolateral pedicle and 1 source mentioning both techniques. Furthermore, due to a lack of studies regarding the free nipple graft & superolateral pedicle some studies were not within the 10 years' timeframe. The oldest publication was released 2001, however 50 of the 59 sources fit in the timeframe. Sorted by best match and within 10 years, the search “breast reduction” in combination with “superolateral pedicle” yielded 6 results, 76 results with “superomedial pedicle”, 123 results

with “inferior pedicle”, 31 results with “central pedicle”, 51 results with “free nipple grafting” and 60 results with “superior pedicle”. The same was done with “reduction mammoplasty”. In total this gave 347 articles to investigate. Many crossmatches were found, which decreased the number of articles significantly. Only abstracts or articles published in English were included. A few studies with promising material could not be reviewed due to limit access on their educational database hence only their abstracts could be reviewed. Additional papers were included that have been linked as references in articles found during the first search attempt and only if they meet the inclusion criteria.

IV. DISCUSSION

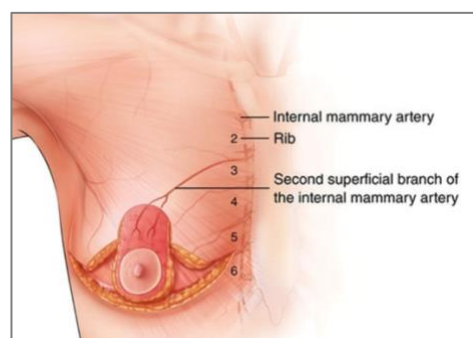
1.1 Introduction and operative technique of the superior pedicle

The superior pedicle has been described, adapted, and modified in many ways since it has been introduced in 1960s by Pitanguy. At that time, it was combined with the wise skin resection pattern, but further advancements in the field of breast reduction and eagerness to reduce scar formation allowed to eliminate the horizontal scar length using the superior pedicle technique in combination with other resection patterns. Especially the publications of Lassus, Marchac and de Olarte, and Lejour et al. are responsible for the improvement of combining the vertical scar incision pattern to the superior pedicle. Hereby the boxy appearance that occurred time to time with the inverted T appeared less frequently(14).

The superior pedicle is stated to be efficient, simple, and easily reproducible.(13) It has been used for resection sizes above 2000g.(16) Although authors differ in their statements with the resection limit for superior pedicle, one mentioning the limit to be at 600g(13). Another had raised the possible limit to 1000g(17). It is stated that the superior pedicle has the most beneficial outcomes for patients with minimal to moderate resection size. Above these limits only patients presenting with extremely ptotic breast are candidates for the superior pedicle technique. The consensus is that it becomes difficult to inset the superior pedicle with increasing resection sizes(17). This method enables surgeons to create medial and superior breast fullness which gives the breast a more youthful and lifted appearance. Alongside the aesthetically pleasing result, most patients have an improved quality of life and decrease of symptoms correlated to mammary hypertrophy, such as neck pain, headaches, tingling in hands etc.(13).

In breast reduction surgeries it is particularly important to understand the vasculature and innervation of the breast to tailor the operation technique individually to the patient. In the case of superior pedicle, the main blood supply reaches the pedicle via the internal mammary and its second superficial branch descending downwards through the 2nd intercostal space. Due to its superficial position, it allows for quick pre- and intraoperative assessment with a pencil doppler probe(14). Therefore, the superior pedicle technique maintains an easily identifiable and reliable blood supply to the nipple-areola complex and involves minimal transposition of the nipple areolar complex(13).

Figure 1



Superior Pedicle Vasculature (2)

The superior pedicle technique benefits from the fact that it is supplied by the most reliable arterial contribution to the nipple areolar complex (NAC). The internal thoracic artery can be found in 81,8% of patients according to a recently published article examining the arterial supply of the nipple areolar complex by the means of angiographic CT imaging(18). Additionally, the 2nd superficial branch of the internal mammary artery, which is the most relied on branch when performing the superior pedicle technique, is most frequent reproducible, according to the research of Manchot, Carr et al., O'Dey et al. and Marcus(19). This makes the superior pedicle a technique suitable for many patients.

1.2 Complications of the superior pedicle

A major disadvantage of the superior pedicle technique is the higher risk for sensory loss at the nipple-areolar complex postoperatively(17). A reduced sensibility was analysed especially in the inferior and lateral part of the areola. This should not be attributed to a higher resection volume as studies have proven there is no association between increased resection weight and higher complication rates with the superior pedicle. After 10 years follow up of 33 patients

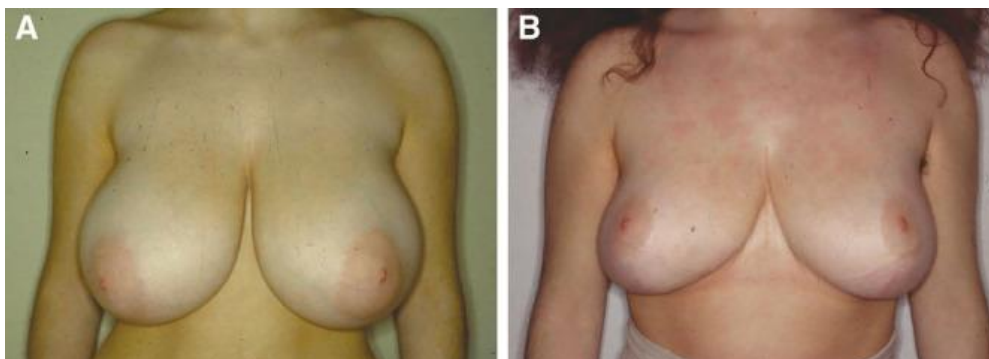
ranging between <500g, 500-1000g and >1000g resection weight “all findings were independent from the resection weight”(20). Furthermore, the same study noted an overall complication rate of 21% with 18% needing corrective revisions(20).

Out of 823 patients, with average age of 48, average operative time of 77 minutes and average resection volume of 860 grams per breast, more than a third (35%) encountered complications. Thirty percent of all operated patients experienced transient areolar hypoesthesia, underlining the substantial risk for sensory loss postoperatively to the superior pedicle technique. However, it was shown that this initial high percentage drastically decreases after 1 year postoperatively, with only 0.72 % of patients reporting permanent hypoesthesia(21). There should be more research and reviews on this topic as other studies have shown that in some trials even up to 70% of women experienced diminished sensation at the NAC 1 year postoperatively. The sensory loss is attributed to the resection at the base of the breast part inevitable in the superior pedicle technique(17). Wound dehiscence occurred in 5 % of all patients, 0.97% of patients experienced infection and 4% suffered from poor scarring. The most devastating complication for patients, nipple areolar complex necrosis arouses partially in 3% and complete in 0.48%(21).

1.3 Results of the superior pedicle

Patients’ satisfaction is the best indicator for a successful treatment. While some studies merely state “97% of the patients were very satisfied or satisfied with the result”(20), others implement a more accurate approach applying the Visual-analogue-scale in their follow up regimen achieving high patient satisfaction presenting a mean VAS score of 8.1(21).

Figure 2



A: Patient before operation. With hypertrophic bilateral breast.

B: 1year post-op using the superior pedicle technique(21).

2.1 Introduction and operative technique of the inferior pedicle

In combination with the Inverted-T resection pattern, the inferior pedicle (IFP) was the most popular used technique the past 40 years(1). Its origin can be traced back between 1975 and 1977. Described by Ribeiro, Robbins and Courtiss and Goldwyn. Many surgeons to date are firstly familiarised with the inferior pedicle technique before advancing to a different pedicle. Additionally, the inferior pedicle approach serves as a benchmark for comparing newly developed techniques(12).

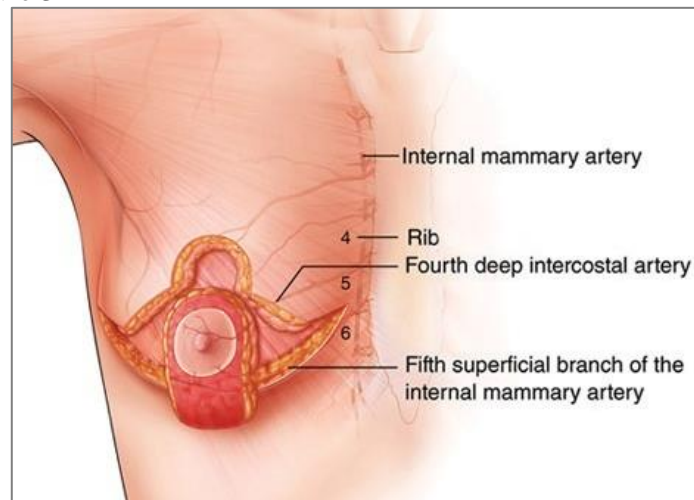
The main benefit of the inverted-T inferior pedicle technique is its range of use and operability. There is theoretically no upper limit as to how much breast volume can be resected. Resulting in a higher number of operations performed with larger resection masses. Furthermore, many surgeons tend to choose the inverted-T inferior pedicle technique in difficult and unclear cases, because of its reliability, proven effectiveness, and familiarity(1). It is to note that the inferior pedicle needs a strong skin brassiere and skin tightness so that the breast is hold in position as superior parenchymal resection is applied.(14)

A promising technique for smaller resection masses but still applying the inferior pedicle is the Short-Scar Periareolar Inferior Pedicle (SPAIR). As much as 1500 g can be resected with this technique. Due to its familiarity with the Inverted-T pattern many surgeons can quickly adapt applying the inferior pedicle with the Short-Scar Periareolar approach(1). Many complications caused by the inverted-T inferior pedicle have been resolved by SPAIR. Firstly, by reducing the heavy scar burden. Secondly, the boxy appearance of the breast sometimes occurring with the inverted-T approach is not seen here. And additionally, any vertical scar complication is not created with the SPAIR technique. Furthermore, no inferior migration of the breast tissue is risked, as the inframammary fold (IMF) is untouched during the operation, resulting in almost no bottoming out. The position and shape the breast is seen as on the operation table is manly the position and shape it will achieve postoperatively. Allowing to make the most accurate inoperative adjustments any pedicle design allows. This adds another reason as to why this pedicle is chosen by novices and experienced surgeons alike(1).

When the inferior pedicle is applied, the tissue resected will be around the upper hemisphere of the pedicle(1). Arteries from the deep system coming up from the fourth and fifth intercostal space supply the pedicle and allow it to reach its immense length(14). Additionally, a transversely positioned internal breast septum located in the inferior base of the breast consisting of many perforators directed to the pedicle is contributing its share of blood supply.

When it is managed to keep the caudal aspect of this septum intact the pedicle can amass even greater length(1). Anterior intercostal arteries are the most necessary for the inferior pedicle. Internal thoracic perforators, lateral thoracic and acromiothoracic arteries less so. Many anatomical descriptions have shown us the most reliant branches from the intercostal arteries to the inferior pedicle. They are originating from the third to fifth intercostal space according to Marcus, fourth and fifth by O'Dey at. al., fourth, fifth and rarely sixth by Würinger, fourth and fifth by Salmon and fifth and sixth intercostal space by Palmer and Taylor(19).

Figure 3



Inferior Pedicle blood supply(14)

2.2 Complications of the inferior pedicle

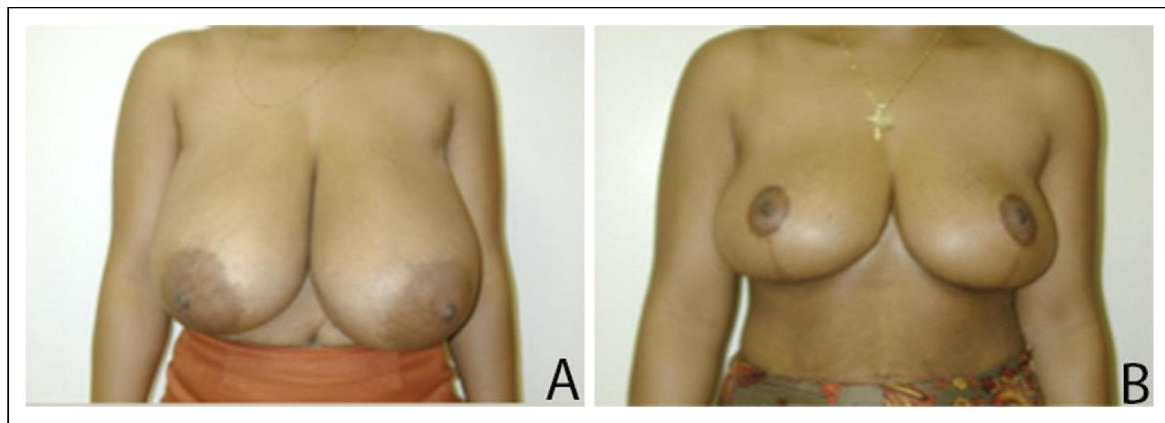
Complications arising with the inferior pedicle are divided as to what resection pattern is applied. Selecting the inverted-T pattern, patients usually suffer from heavy scars along the IMF, making it highly unpopular for younger patients. This scar cannot be compensated for by the skill of the surgeon. Contrariwise the SPAIR technique allows for almost no scar burden, creating a low-scar operative option for any breast with a dominant blood supply suited to the inferior pedicle(1). The rate of breast deviating in their shape postoperatively occurs rather frequently with the inverted-T inferior pedicle design. The so-called bottoming out, presents itself with a descent of tissue to the inferior pole due to the skins inability to act as a brassiere. Now the skin is overstretched and the nipple to IMF distance is increased, leaving the patient with Pseudoptosis(22). Furthermore, medial, and lateral dog ears are experienced on some breasts postoperatively. Although the natural incision line of the inverted-T predisposes patients to this condition, surgeons can counteract by matching the length of the skin flaps to the IMF incision and removing tissue deep to the skin. Seromas will often not heal

spontaneously as seen in other pedicles due to the drainage blockade the IMF scar creates. The inverted-T inferior pedicle technique needs the skin to hold the breast shape, therefore more pressure and skin tightness is required here. Although many studies have revealed that extensive skin pressure and tightness should not be applied to the pedicles as it prevents skin closure and delays wound healing process(14).

2.3 Results of the inferior pedicle technique

The inferior pedicle design shows high patient satisfaction rates (86%-97%) in multiple outcome studies(12). Although it is by far the most used pedicle design, it is not superior to others. One comparative study between inferior pedicle and superomedial pedicle has shown that sensation tends to be only reduced with patients of the inferior pedicle group(23). Contradictory another study claims that between 50 inferior pedicle and 50 superomedial pedicle both using the Wise resection pattern no differences in outcomes and complications occurred(24). Additionally new advancements have been made to reduce blood loss intraoperatively in inferior pedicle breast reduction by using a preoperative hydrodissection before incision. This reduced the average blood loss from 226 ml to 112 ml. Followed by a 96% satisfaction rate(12). Another advancement was made by starting to use tumescent infiltrations, which resulted in decreased blood loss, decreased operative time and a shorter hospital stay(25).

Figure 4



36-year-old woman. Inferior Pedicle with wise pattern technique.

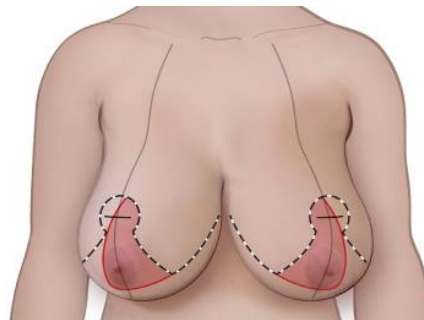
A: postoperatively; B: 6 months after surgery(12).

3.1 Introduction and operative technique of the superomedial pedicle

The superomedial pedicle (SMP) is overshadowed by outdated studies and has been portrayed as a second-class pedicle when it comes to breast reductions. It is not as popular as other pedicles, but has recently experienced more studies describing it, revealing its true potential, and comparing it to its predecessors and even proving its superiority in certain aspects.

Previously the superomedial pedicle technique was critiqued for its incompatibility for breast reductions with larger resection masses(3). But decreased operative time, better aesthetic appearance with a fuller breast and a prominent cleavage as well as less bottoming out over time are features and recent achievements of the superomedial pedicle, which motivates present reconstructive surgeons to relearn their approach on breast reductions(4).

Figure 5



Superomedial Pedicle(4).

The superomedial pedicle was first described by Arie in 1957 and found to be inconsistent in providing nipple viability for long pedicle scenarios. Only when it was refined by Orlando and Guthrie in 1975 the pedicle was designed with adequate NAC vascularity by lifting medial parenchyma into the pedicle. Recent studies have seen resection weights of up to 4700g(4). The superomedial pedicle is combined with the wise skin resection pattern, but it is also involved in more novel approaches such as Hall-Findlay's superomedial vertical scar breast reduction(26). The operation begins as usual: markings in the standing position, sternal notch, chest midline, IMF, and breast meridian. Next the de-epithelialization of the pedicle, followed by incision of the new nipple areolar complex. Following the wise pattern, the tissue is resected above the pectoral fascia. After assessing the breast intraoperatively and seeing satisfactory results it can all be sutured up and drains are placed at the IMF suture. Lastly the new NAC must be incised. From now until wound closure the NAC is controlled regularly to assess for vascular congestion or ischemia(27). Additionally, the NAC can be assessed for its capillary refill time and is supposed to have adequate perfusion if the capillary refill time is 2-3 seconds

(28). To ensure the NAC has sufficient blood supply the resection is constructed in a medial to lateral fashion. This allows a portion of parenchyma to be left adherent to the pectoral fascia. The main blood supply reaches the pedicle from the internal mammary artery perforators and secondarily from the intercostal perforators and thoracoacromial artery supplying the protected breast parenchyma(4). The Superomedial pedicle was designed for maximal blood supply and nipple sensation. It achieves this by incorporating the internal mammary artery and its perforators as the main blood supply, which is dominant in 70% of cases with a reproducibility of 100% according to Palmer and Taylor. Additionally, it preserves the medial and lateral rami of the fourth intercostal nerve(3). The venous drainage occurs via the subdermal plexus, and often large veins show just beneath the skin(27).

3.2 Complications of the superomedial pedicle

The complication rates associated with the SMP technique differ with every author and surgeon. Therefore, it is necessary to review multiple articles discussing their respective complication rates. From 17 articles discussing complications, the mean complication rate was 16.9% and they ranged from 1.6% to 43%(4). This massive difference in complication frequency although using the same pedicle method shows the need for more organized studies and perhaps a further subdivision of patient groups, as some risk factors increase the rate of complications when applying the SMP(29).

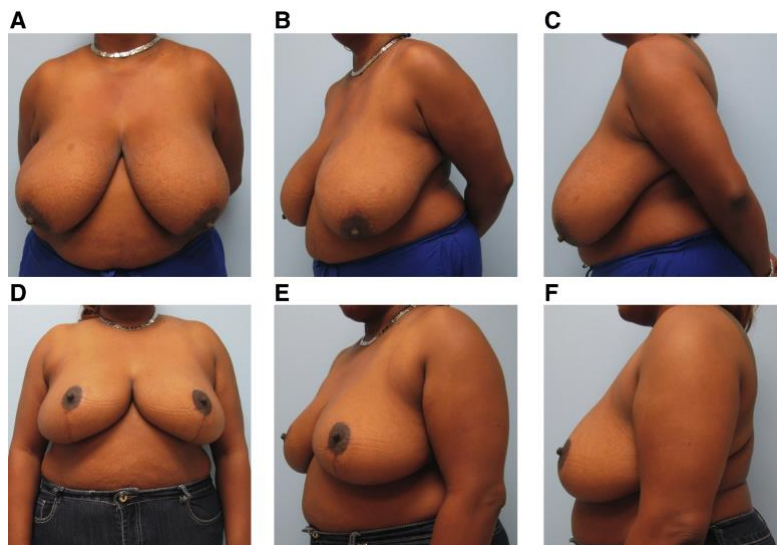
For instance, much contradictory evidence is scattered throughout the databases. Some authors claim that with increased resection weight no increased complications rates appear(30). Contradictory, others have found a correlation between increasing resection weight and an increase in complication rates(31)(32)(33)(29). According to the latter articles, an increase in complication rates can be noted in patients with an BMI above 30, ptosis grade of 3, breast reduction weight above 831g and a nipple to sternal notch distance above 35.5 cm(4). In this study the population group with a sternal notch to nipple (SNN) distance higher than 35.5 cm made up only 17 % of the study population, yet they were responsible for 40% of all complications(4). This is backed by other studies with one summarizing, that only patients with a mean SNN of 37.4 cm developed major NAC congestion or necrosis(3). And a second one agreeing that increased resection weight and increased nipple to fold distance is a risk factor for developing more complications(32).

3.3 Results of the superomedial pedicle

Modifications to the SMP technique aim to further improve its outcomes, increase the aesthetic and youthful appearance. With modifications such as adding a horizontal scar, layered pillar approximation and restoration of the fold, revision rates small as 3% are possible(32). The SMP technique can deliver decreased operating time, less bottoming out. Furthermore, the patients enjoy a superior positioned, youthful breast appearance compared to the IFP(4).

Combining the SMP with the wise pattern takes benefits from each technique. Upper pole fullness is restored, and the resection pattern is standardized and easily taught(27). Blood supply to the pedicle is one of its key features as the SMP was specifically designed to take profit from being supplied by the most reproducible and most frequently dominant perforator vessels of the internal thoracic artery(3). Studies comparing IFP with SMP have concluded that the SMP has an overall higher satisfactory rate combined with a higher scar acceptance of the patients. Furthermore, the superomedial pedicle causes lesser ptosis, has a stronger contour and better long-term results than the inferior pedicle(6).

Figure 6



Superomedial pedicle with Wise pattern. (A-C) Pre- vs. (D-F) post-operatively(4).

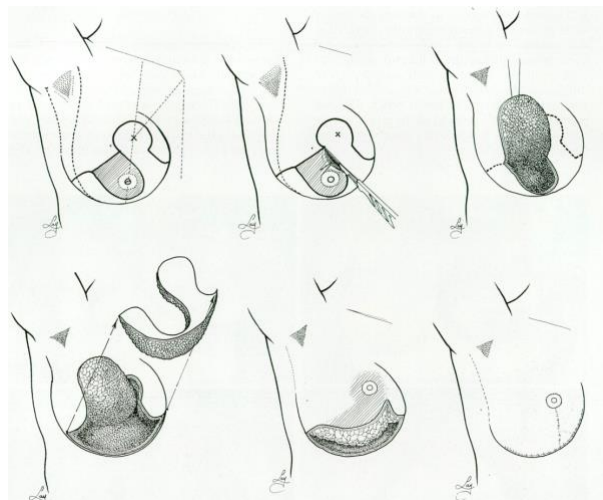
4.1 Introduction and operative technique of the superolateral pedicle

The superolateral pedicle technique has been perfected over many years by different pioneers implementing multiple features found in previous pedicle techniques. Its first description took place in 1960 by Strombeck who utilized a horizontal bipedicle dermoparenchymal flap for reduction mammoplasty(34). Later in 1970 Skoog designed a lateral pedicle, based on Strombecks description but managed to elevate the NAC solely with the lateral pedicle. His

pedicle was based on anatomic studies conducted by Cooper in 1840 and later confirmed by Marcus in 1934(2). Skoogs initial design consisted of a very thin dermal pedicle not including any glandular tissue, his consumption was, that in case of vascular compromise the whole breast structure and shape would suffer, leaving the breast deformed. Further contributions to the superolateral pedicle development were made by Strauch, Blomqvist, Cárdenas-Camarena and Blondeel(7).

A study analysing the long-term sensory recovery of nipple areola complex following superolateral pedicle reduction mammoplasty described a NAC pressure threshold of 0.66 preoperatively and 3.23 postoperatively(35), statistically proving the fact which Skoog already assumed years before, that his initial operation technique resulted in a decreased nipple sensitivity postoperatively, for most of his patients. This incentivized Cárdenas-Camarena to conduct further research and subsequently develop a full thickness superolateral pedicle, and contrary to Skoogs technique, involving a glandular component(7).

Figure 7



Design of superolateral dermoglandular pedicle by Cárdenas-Camarena(34).

The surgical steps of the most recent approach for the superolateral pedicle are described by Cárdenas-Camarena in a 15-year retrospective analysis of 702 breasts in 356 patients. After completing all markings, the pedicle is deepithelialized in a 4 cm diameter. Secondly, all tissue around the pedicle inside the design is resected without any undermining to the pedicle itself, thus retaining the vascular supply. When all tissue is resected, the Pedicle is tilted towards the new NAC position and is fixated with sutures to the medial portion of the pectoral muscle. This step allows for a good shaping of the breast without using the skin as a brassiere(2), which can

lead to increase rates of wound dehiscence as seen in the inferior pedicle technique(1). The only indication for this surgery was that patients required a minimum migration of the NAC of 5 cm. Furthermore, Cárdenas-Camarena stated that migration of less than 5 cm with this technique can produce torsion of the pedicle and compromise the vascular supply. The resection weight was between 300-1380g(2). Other studies showed similar resection weights(36)(7), with some ranging close to 2000g, testing this pedicle's limit regarding NAC sensation (35)(37). Liposuction of the axillary fat can further enhance the breast shape(7).

The superolateral pedicle claims to take full advantage of the vascular supply to the breast. Undoubtedly the lateral thoracic artery is relied on heavily in this pedicle(2). Second choice arteries are the anterior intercostals, internal thoracic perforators and acromiothoracic arteries(19). According to O'Dey et al. the lateral thoracic artery was found in 100% of cadaver dissections and its subcutaneous course runs deep rather than superficial(8). Highlighting the importance of knowing, that in case of superolateral pedicle a deep tissue dermoglandular pedicle is the method of choice, preserving many deep perforators. The nerves innervating the pedicle are mainly the lateral cutaneous branch of the 4th intercostal, with 93% reproducibility, plus the 3rd and 5th cutaneous branches, with 57 % reproducibility. Once more, the importance of a deep tissue pedicle is highlighted as it is stated by many studies that apart from the vasculature, also the innervation to the pedicle runs deeply with 93% of branches coursing deep(2).

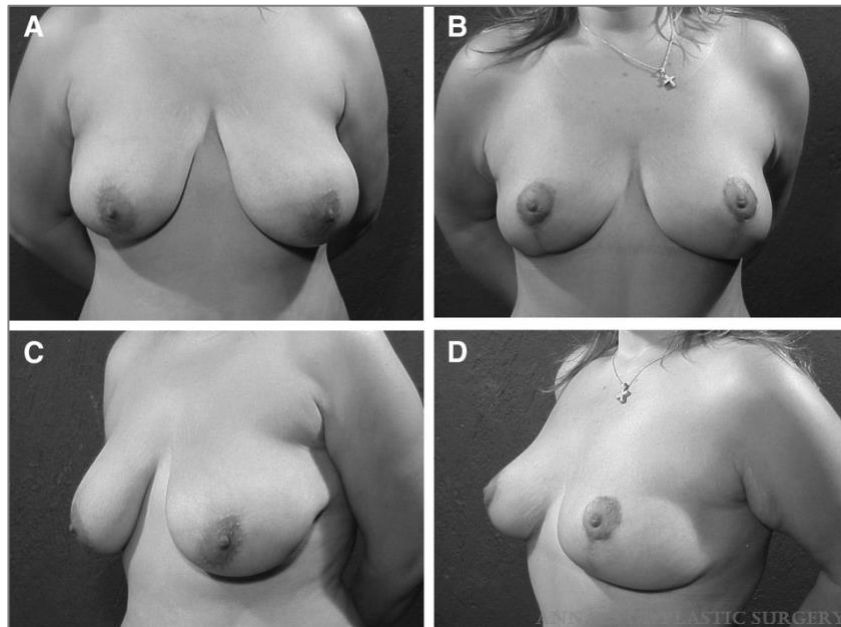
4.2 Complications of the superolateral pedicle

The most prominent minor complications were “wound dehiscence (5.9%), scar hyperpigmentation (3.9%), fat necrosis (3.8%), hypertrophic scarring (3.1%), alterations in sensitivity (2.27%), and keloid scarring (0.5%)”(2). Major complications included “9 cases of necrosis of the NAC (1.28%), of which 7 were partial (0.99%) and 2 were total (0.28%)”(2). Partial NAC necrosis occurred solely in patients with resection weight above 800g and more than 10 cm NAC migration. Total NAC necrosis occurred in patients of resection weight above 1000g(2). Another study confirmed the percentage of nipple-areolar complex loss with 0.2% and wound dehiscence of 8%(5). Only 7% of patients experienced breast feeding problems during their lactation period(2).

4.3 Results of the superolateral pedicle

This pedicle technique seems to be superior to most of its contestants. The technique is easily reproducible and safe. In the case of the superolateral pedicle, the foundation pillars of a good breast reduction: vascularity, sensitivity and functionality are all protected by design. As the technique protects the deeper tissue and glandular component, it allows for the maximum preservation of the major nerves to the nipple(38). And additionally, vessels supplying the newly shaped breast. As well as the sparing the galactophorous ducts, which enables patients to breastfeed in the future, if they wish so. Which is not the case in other pedicle techniques. Satisfaction rates are as high as 94% and in other studies 96%(5). Furthermore, almost no cases of bottoming out appear with this method due to the absence of a heavy inferior pedicle. It is proven that patients up to 15 years later still have a good breast shape and projection. The technique is versatile as it can be applied to the wise skin resection pattern and vertical pattern(5). The most breast resected with this technique should be classified as medium to large(7). Needing a migration of the NAC of more than 5cm(2). The most outstanding success is the ability of lactation postoperatively by preserving dermoglandular tissue whilst not compromising the initial goal of the operation: a youthful, rounded breast with a nice projection and superior fullness(7).

Figure 8



Before and 8 months post-op. 31 years old. NAC migration of 7cm and 8 cm. Tissue resected 425g from right and 575g from left breast(2).

5.1 Introduction and operative technique of the free nipple graft

The free-nipple-graft (FNG) has been deployed since its description by Thorek in 1921(39). The main complications that the FNG receives critique on, is an unaesthetically wideness and flatness to the breast(39), nipple necrosis, nipple areolar hypopigmentation(40) and sensation impairment(41). Furthermore, the inability to breastfeed postoperatively, which is the most devastating complication for the patient. Only 4% (median value) of patients undergoing FNG technique, or any other technique not preserving a column of parenchyma from the NAC to the chest wall during the reduction mammoplasty, retained the ability to breastfeed compared to 75% with partial and 100% with full preservation of the column(41). The unaesthetically and insufficient breast projection results from a lack of central breast tissue that otherwise would form the anatomic projection(42).

The FNG is considered a last resort option for breast reduction. If the patient presents with extremely severe gigantomastia or high-grade ptosis and every other pedicle creation would be of lesser viability and at risk of congestion, the FNG technique must be considered(43). Physicians and patients want to avoid using the FNG technique as it is “essentially an amputation”(44). But as previously mentioned in some cases it is the last treatment option. In some exceptionally large and ptotic breasts it becomes nearly impossible to create a pedicle with sufficient vascular supply due to its immense length. The risk of unilateral or bilateral nipple necrosis increases when long pedicles are applied and rotated into position(40). Since only few studies to date tried to distinguish patients, breasts and procedural elements that can indicate the use for choosing the FNG technique and have not found clear evidence, the decision remains multifactorial(43).

However, one study reveals that from a total 323 patients undergoing breast reduction at their facility, 15 had to receive an FNG. Comparing both groups, it was discovered that the FNG group had a significant higher BMI (37.6 kg/m² vs 29.5 kg/m²), higher proportion of obesity (78.6% vs 46%) and additionally a resection weight of above 1500 grams(43). One other study concluded that all patients meeting the criteria of having gigantomastia of more than 1000 grams each side, grade 4 ptosis, a sternal notch to nipple distance of more than 45 cm and a nipple-IMF distance of no less than 16 cm are indicated to receive a FNG reduction mammoplasty(42). A study which was published recently in March 2022 had 24 patients receive a FNG technique. The mean BMI was 32.9 kg/m², the average tissue removed was 1267,5 grams(40). Lastly, one more study experienced patient with a mean BMI of 35.8 kg/m², an increased sternal-notch to nipple distance with a mean value of 38.8 cm, a mean resection weight 1815 grams and additionally an nipple-IMF distance of mean 17.9 cm(44). An

additional study claims that “the main primary indication for free-nipple breast reduction is more than 1000g of predicted gland resection”(45). In poor-risk elderly patients and those with severe systemic diseases, the shorter operation time associated with the FNG technique becomes a variable that needs to be considered for selecting the method of choice(46). Nevertheless, it can be summarized that patients who have a higher BMI, higher SNN distance, higher resection volume, higher nipple-IMF distance are more likely to receive a free-nipple graft breast reduction rather than a pedicle-based technique. Although it should be noted that many more studies are required in this field as some limitations occur. The lack of clear definitions generates an obstacle for creating guidelines when and when not to perform the FNG technique. An example: the first two studies both mentioned gigantomastia as an indication, yet one study measured breast from 1500g(43) as gigantomastic breasts and the other from 1000g(42).

It is possible to have the NAC completely lifted off the skin and later re-inserted as a graft, but one can also combine the FNG technique with a pedicle. In that case the NAC is harvested and placed on the pedicle’s apex at the end of the reshaping process. In both scenarios the NAC is grafted onto the breast. Vazquez et al. described this operation technique for the FNG with the novel approach to resect breast tissue without using a vertical scar. According to Vazquez et al. this technique performs very well comparatively to the classical free-nipple grafting. First, the skin is marked, and the NAC is harvested. Then the breast tissue is resected and sutured back in shape, already creating an aesthetically pleasing projecting breast. The new NAC position is deepithelialized and the graft can be sutured into position. Keeping the graft covered with dressings after re-suturing to the skin decreases graft rejection cases(40).

Figure 9



Key Operational Steps of the free-nipple graft technique(40).

5.2 Complications of the free nipple graft

The main complications of the free nipple graft technique consist of reduced or complete loss of nipple sensation, high possibility of a lifelong inability to breastfeed, nipple necrosis, nipple areolar hypopigmentation or patchy pigmentation, poor nipple projection, flattened and wide breast, partial and complete loss of nipple graft(39)(40)(42)(43)(44)(45)(46)(47)(48). Guven et al reviewed 24 patients who took the free nipple graft reduction mammoplasty over a 4-year period. He was able to report, that 8% of the patients experienced partial nipple-areolar complex loss and hypopigmentation occurred in 20.8% of the group(46). Basaran et al reviewed partial nipple graft failure in 4% and nipple areolar hypopigmentation in 12% of his patients(44). A review by McGregor yielded equivalent results, with complete loss of the nipple areolar complex in 4,5% of patients and partial loss in 18% patients. Nipple projection was only satisfactory for half the patients and loss of nipple sensation occurred in 70%(46).

5.3 Results of the free nipple graft

The FNG technique cannot be replaced in the current stage of breast reductions. Attempts to substitute the FNG with another technique have been deployed in the past, but significantly more beneficial results have not yet been achieved by any other technique in gigantomastia and multi-morbid patients. Some authors still believe the inferior pedicle to be superior, but the increased appearance of complications such as decreased wound healing, bottoming out and poor long-term projection in such patients gives reasons for doubt(44). The free nipple graft does have more complications than most other pedicle techniques(43). Additionally, even the most devastating complications nipple necrosis/loss and the inability to breast feed are more frequent with free-nipple grafting. But some patients have no better treatment option available(49). The FNG can be applied very well in cases of breast cancer, as it offers a good resection ability to the surgeon with focusing primarily on the cancer yet still retaining the NAC and therefore allowing for a good reconstruction of the breast simultaneously(50). Since the FNG technique is frequently applied in obese patients, it is erroneously to blame the operational technique for all complications as the patients' state is already unfavourable and poses great risks for postoperative complications after any type of surgery(51). After all considerations, the FNG technique remains the last resort option for extremely hypertrophied breasts, and it is heavily burdened with severe complications like the lifelong denial of

breastfeeding. But even for some patients, suffering from gigantomastia or multiple chronic diseases affecting wound healing, achieving an aesthetic satisfactory result is the primary treatment goal(44).

Figure 10



Preoperative 43-year-old patient (left) and the same patient 15 months postoperatively (right).

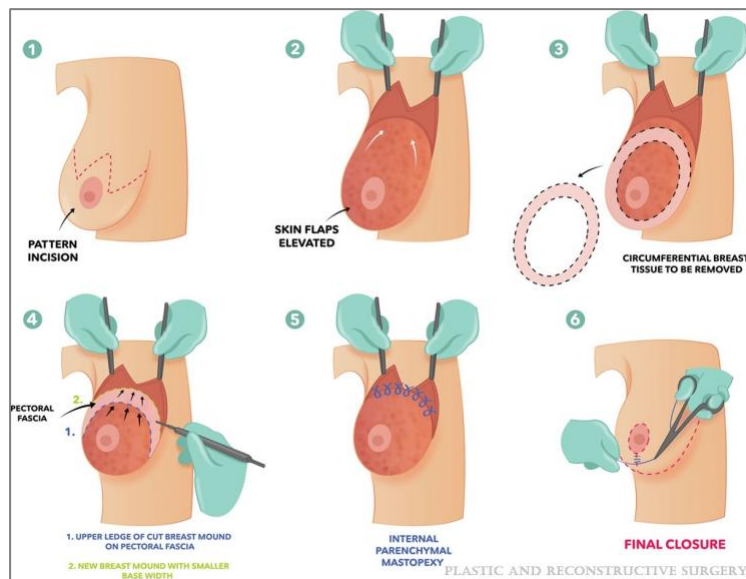
The patient presented with right breast stage 0 carcinoma(40).

6.1 Introduction and operative technique of the central pedicle

The central pedicle technique was invented by Balch in 1981 and brought to recognition by Hester in 1985. Further important authors of the central pedicle technique are Moufarrege (1985), Levet (1990), Würinger (1998), White (1996), Grant (2001), Byung (2008), Yang et al. (2012), and Bayramiçli M. in the year 2012(52). It was Hester who first described the beneficial anatomical advantage the central pedicle offers. It encompasses the vascular contributors from the lateral thoracic artery, intercostal perforators, internal mammary perforators and thoracoacromial artery(52). Later it was Würinger et al. who made a significant discovery by describing a horizontal septum which runs from the pectoralis major fascia to the nipple. This septum harbours the main supplying nerve to the NAC. “The cranial vascular sheet is supplied by the thoracoacromial artery and a branch of the lateral thoracic artery, whereas the caudal sheet is supplied by perforating branches from anastomoses of intercostal arteries”(52). The central pedicle technique as described by DeLong et al. is termed as highly reproducible. The patient is marked preoperatively, and the new NAC is marked. Skin incisions are based on the wise pattern. The skin at the inferior base of the breast and around the areola is lifted and discarded. Superiorly 2 flaps are created for later closure and projection of the breast. Parenchymal reduction is performed in a circumferentially doughnut-like pattern around the central pedicle to modulate a cone shaped breast. Now the superior edge of the newly shaped breast is sutured to the superiorly positioned ridge creating an internal

mastopexy(53).

Figure 11



Schematic depicting the central mound reduction technique(53)

6.2 Complications of the central pedicle

There are lesser rates of NAC necrosis with this technique as it utilises the maximal vascular supply as compared to other pedicle types(52). Minor complication occurs in the same rate as with other pedicle techniques. Major complications however occur less frequently. Multiple individual authors experienced no NAC necrosis when applying the central pedicle technique for breast reduction. Datta et al. experienced no NAC necrosis within 91 patients, resecting between 210 - 1720g. Some nipple sensory loss occurred but no additional major complications. As well as Byung et al., who also had no cases of NAC necrosis in his study of 41 patients with a mean resection weight of 389g(52). Comparable results are obtained by Yang et al. who experienced no NAC necrosis nor hematomas in his patients and a good NAC sensibility postoperatively after 2 years(54). Bayramiçli et al. operated 67 patients, with a resection volume of 440 - 1935 g and again no NAC necrosis occurred with the central pedicle technique(55). Additionally, one study claims to have identified minor complications in 17,9% of patients but no cases of major wound complications like NAC necrosis or partial loss of NAC(56).

6.3 Results of the central pedicle

The central pedicle offers forward projection to the breast combined with a good contour, good aesthetic result and additionally a maximal vascular supply to the breast(52). With this

technique lower complication rates are observed than previously described in other pedicles. The initial symptoms patients with macromastia suffer from (back pain, neck pain, shoulder pain, etc.) are alleviated fully or partially postoperatively making the central pedicle a proven breast reduction approach(53). Additionally, this pedicle makes full use of Würingers horizontal septum, which holds the breast tissue in place bringing good projection if preserved and furthermore it is encompassing maximal vascular supply and innervation to the NAC(52).

Figure 12



Removal of 833 g from the right and 814 g from the left with central pedicle.

Preoperatively (left), 6 weeks postoperatively (center), and 1 year postoperatively (right).

The patient lost weight between week 6 and 1 year postoperatively(53)

V. CONCLUSION

Multiple pedicle techniques and variations by different authors have been put forward with only some standing the test of time and others yet to immature to be evaluated properly but promising great potential. However, limitations arise when attempting to grade pedicles within this article, as literature that is available on this topic mainly consists of case series and case reports and only seldomly a systematic review. Only three systematic reviews(41)(51)(15), acceptable within the literature research strategy and timeframe, were found and incorporated

in this review. Any pedicle can be the perfect match to one specific patient but might not be applicable in 1000 other patients.

1. Superior pedicle: The superior pedicle technique has similar features to the superolateral and superomedial features, as all 3 techniques originate superiorly. However, since arterial supply comes from the internal thoracic artery and the lateral thoracic artery, the superior pedicle is less reliably supplied than the superomedial and superolateral pedicles which harness most arterial supply options(19).

2. Inferior Pedicle: The inferior pedicle technique is the most performed technique by American surgeons, as it is still believed to be the best option. Although multiple reviews have stated, other pedicles to be superior in most aspects. Shorter operative time & higher satisfaction rates occurs with the superomedial pedicle compared to inferior pedicle(57). The inferior pedicle technique seems outdated.

3. Superomedial Pedicle: This pedicle was designed for maximal blood supply and nipple sensation(3). Additionally, it allows the patient the ability to breastfeed by preserving the column of subareolar parenchyma within the pedicle(41). It can be applied with all resection weights and has no limits, making it highly versatile(4).

4. Superolateral Pedicle: The superolateral pedicle, according to O'Dey et. al. offers high vascular reliability(8). Furthermore, this pedicle techniques allows the patients to be able to breastfeed by preserving the column of subareolar parenchyma within the pedicle, similar to the superomedial pedicle(2). However, the superolateral pedicle requires a minimum nipple areolar complex transposition of 5 cm, making it more prone to medium to large resections(2)(7).

5. Free nipple graft: The free nipple graft remains a last resort option and must be evaluated as such. If the operation is not going as expected or the patient presents with multiple chronic diseases or overly large ptotic breast a free nipple graft can be the only method of choice to achieve an aesthetically pleasing result. Even at the cost nipple areolar complex necrosis and the almost guarantee to be unable to breastfeed(49).

6. Central pedicle: The central pedicle has a pleasing forward projection combined with a good contour, good aesthetic result and additionally a maximal vascular supply to the breast. A new discovery, the Würingers horizontal septum is perfectly preserved in the central pedicle and offers new stability, vascular reliability to this breast reduction technique(52).

The pedicles discovered as superior in this article, represent pedicle types deemed to be safer,

with more preserved vasculature supply and innervation to the nipple areolar complex, lesser complication results and highest reliability. The two pedicle techniques that achieve best results, are the superolateral and the superomedial pedicle technique. Closely followed by the central pedicle. The superomedial and superolateral pedicles have the advantageous benefit of supplying the nipple areolar complex with multiple different arteries and therefore become very forgiving and offer the surgeons multiple options intraoperatively. Additionally, both pedicles are designed to preserve the innervation to the nipple areolar complex by default (23)(35). Both pedicles have the breasts vascularity, sensitivity and functionality protected by design and hence have earned their position as the most favorable pedicle techniques for the broader population.

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