

Original Research

Efficiency of Pre-Expanded Anterior Supraclavicular Artery Pedicled Skin Flaps: A Meta-Analysis Study

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Abstract

The supraclavicular artery flap presents a promising solution for facial reconstruction challenges since 1997, surpassing limitations of traditional methods like the deltopectoral flap. Its extended pedicle and thin, pliable epidermis offer reliable outcomes with minimal donor site morbidity, making it a preferred choice for head and neck reconstruction. This systematic review evaluates the efficacy of pre-expanded supraclavicular artery flaps based on a comprehensive analysis. In accordance with the Preferred Reporting Items for Meta-Analysis (PRISMA) recommendations, this meta-analysis was carried out. A comprehensive search of electronic databases including PubMed, Google Scholar and Web of Science between 2013-2024. The search strategy utilized the following keywords: ["supraclavicular" AND "flap"]. Searches were limited to English-language articles. We also manually searched reference lists of relevant articles to identify additional studies. The inclusion criteria for the articles were as follows: (1) original research articles discussing the use of Pre-Expanded Anterior Supraclavicular Artery Pedicled Flaps; (2) English language publications; (3) human subject studies; and (4) studies reporting pertinent outcomes like flap viability, complications, or aesthetic results. Free, thoracic, deltoid and pectoral flaps were excluded. Reviews and studies



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written in languages other than English were eliminated. To determine the eligibility of the initial pool of 202 studies that were gathered from different sources, a rigorous screening procedure was carried out. Nine publications were subjected to a thorough full-text evaluation following the exclusion of 193 research studies that did not match the inclusion requirements. After this evaluation, only seven papers were deemed suitable for this meta analysis's inclusion. All studies reported successful outcomes of the flap procedures, indicating the effectiveness of pre-expanded anterior supraclavicular artery pedicled skin flaps in the sample. Wound healing outcomes varied across the studies, with 42.9% reporting excellent wound healing and 57.1% reporting good wound healing. This suggests overall favourable outcomes in terms of wound healing. Expansion in the area of the lifting site increases flap size and allows reconstruction of more extensive facial and neck defects in terms of function and aesthetics. The advantages of the pre-expansion are well reported and include the minor donor site morbidity, flap safety and reliability, and most importantly, its favorable match in color and texture to tissue of the head and neck area in addition to vascularity. Pre-expansion not only increases size and reduces thickness, but also enhances the vascularization process through a well-formed capsule enriched with vessels. Primary closure of the donor site can be achieved with tensionless technique due to the laxity of the skin after expander insertion.

Keywords

Supraclavicular flap; perforator flap; head and neck reconstruction; pre-expansion; maxillofacial reconstruction

1. Introduction

The supraclavicular artery flap has gained recognition as a reputable method for reconstructing defects primarily situated in the head and neck region, which continue to pose a challenge for plastic and reconstructive surgeons ever since its initial description in 1997 [1]. Facial soft tissue defects may arise due to factors such as trauma, congenital nevus, tumor excision, or post-burn hyperpigmentation. These abnormalities give rise to functional, social, and psychological implications. Reconstruction of significant facial defects continues to be a challenge for plastic surgeons, particularly after deep burns or tumor excision.

Facial scars resulting from burns and/or trauma have profound functional and aesthetic implications for the affected individual. A functional and aesthetic outcome should result from the ideal treatment response; flap texture and color are, at all times, crucial components. In order to achieve optimal skin texture matching with the face and neck, the anterior chest has been the site of investigation for numerous flap techniques [2].

The deltopectoral flap, which is frequently employed near the anterior thorax, has been broadly implemented in managing cervicofacial defects [3]. Many deltopectoral flap variations have been documented, such as the regional pedicled flap, pre-expanded flap, tubed flap, and free pre-expanded flap [4-6]. Multiple extensive pioneering research studies were conducted utilizing free or expanded deltopectoral flaps to repair facial wounds [5, 7]. Nevertheless, these flaps have two significant drawbacks: the short pedicle length and the great distance between the pivot point and

the defect. These factors can potentially prolong the operation and cause patient distress due to the requirement for compulsive positioning.

The supraclavicular flap can surmount these constraints due to its elevated fulcrum point and extended pedicle. Since its initial documentation in 1979, the flap has undergone significant development and is presently regarded as a dependable and safe technique for reconstructing the head and neck [8-10]. A supraclavicular flap has been utilized in reconstructive surgery on over 400 patients, establishing it as a well-established procedure [11]. Nevertheless, the dimensions of the shoulder restrict the flap's breadth [12]. According to reports, in order to prevent the requirement for split-thickness skin transplants or bilobed flaps obtained from the dorsal region, the flap width should not exceed 10 cm [1, 13, 14].

1993 marked the debut of the subclavicular incision as documented in China. It utilizes the identical pedicle as the supraclavicular flap and is supplied by the supraclavicular artery. However, distinct branches provide nourishment for the wings [15]. Lamberty initially devised the supraclavicular flap after identifying the deltoid branch, also referred to as the principal vessel of the supraclavicular artery [8]. After Pallua's popularization, this flap is emerging as a multipurpose reconstructive instrument utilized in the orofacial and neck regions [1, 16, 17].

For this objective, the supraclavicular artery-based flap is exceptionally dependable. It provides thin and malleable epidermis, with excellent color fidelity and minimal donor site morbidity. The standard covering fails to enclose the mid and lower facial region adequately. In order to ensure adequate tissue provision for facial resurfacing, pre-expanded supraclavicular flaps would be necessary. The pre-expanded anterior supraclavicular flap is a solid example of prefabrication successfully used to achieve definitive reconstruction (Figure 1). While prelamination describes the pretransfer implantation of anything else, prefabrication refers to the pretransfer implantation of a vascular pedicle.



Figure 1 Flap Mapping with tissue expander insertion in the first stage (Courtesy of Dr. Ziyad Alharbi).

2. Patients and Methods

Following the Preferred Reporting Items for Meta-Analysis (PRISMA) recommendations [18], this meta-analysis was carried out. A comprehensive search of electronic databases, including PubMed, Google Scholar, and Web of Science, between 2013-2024. The search strategy utilized the following keywords: ["supraclavicular" AND "flap"]. Searches were limited to English-language articles. We also manually searched reference lists of relevant articles to identify additional studies.

Written informed consent was obtained according to the Guidelines and Declaration of Helsinki.

2.1 Study Selection Criteria

The inclusion criteria for the articles were as follows: (1) original research articles discussing the use of Pre-Expanded Anterior Supraclavicular Artery Pedicled Flaps; (2) English-language publications; (3) human subject studies; and (4) studies reporting pertinent outcomes like flap viability, complications, or aesthetic results. Free, thoracic, deltoid, and pectoral flaps were excluded. Reviews and studies written in languages other than English were eliminated.

2.2 Data Extraction

Data extraction was conducted using the included studies' standard data extraction form. Study information (author, year of publication, study design), participant characteristics, intervention specifics, outcomes of interest, and any pertinent findings were among the extracted data (Figure 2).

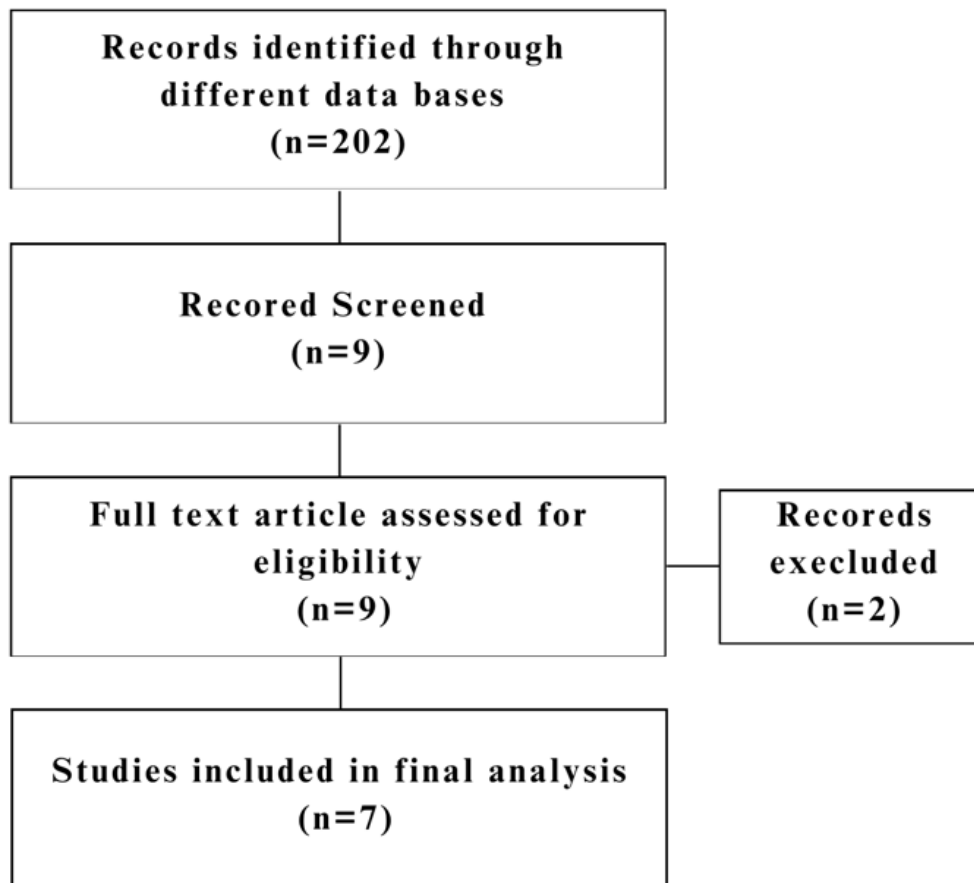


Figure 2 Included Studies in the Meta-Analysis. The inclusion criteria: (1) original research articles discussing the use of Pre-Expanded Anterior Supraclavicular Artery Pedicled Flaps; (2) English-language publications; (3) human subject studies; and (4) studies reporting pertinent outcomes like flap viability, complications, or aesthetic results. Exclusion criteria: Free, thoracic, deltoid and pectoral flaps were excluded Reviews and studies written in languages other than English.

2.3 Reported Methods for Patients

2.3.1 Stage 1: Expander Implantation and Water Inflation

Before surgery, the thoracic branches of the supraclavicular Artery and vein were marked using a Doppler probe. The pedicle and flap were outlined. An incision approximately 5 to 8 cm long was made on either the anterior axillary or parasternal lines and deepened down to the deep fascia. The dissection continued along the surface of the pectoral fascia. At the superior edge of the required flap, the thoracic branch of the supraclavicular vessels could be observed on the surface of the deep fascia, and care was taken to avoid damaging the pedicle. The perforators of the internal mammary artery or the thoracoacromial artery could be ligated to achieve a delay effect if encountered during the dissection procedure. After dissection, the expander was implanted into the interspace horizontally, and the incision was closed. Vacuum drainage could then be applied, followed by water inflation. The period of water inflation ranged from two to 6 months until the expanded flap was

considered sufficient. Our protocol for fluid inflation is 3 weeks post-operative without any port expansion until complete wound healing is achieved. Then, expansion can start once weekly with 10% of the expander volume until full expansion can be achieved.

2.3.2 Stage 2: Expander and Scar Removal and Flap Transfer

The facial defects were removed, and the size of the tissue defect was measured using a plastic sheet. The anterior subclavicular flap was meticulously designed. If the defects reached beyond the flap, the pedicle could be dissected to its origin from the transverse cervical artery or even to the thyrocervical trunk to increase the flap's rotation arc. The flap could then be transferred and placed in the defect (Figure 3). The donor site was closed primarily.



Figure 3 The Pre-Expanded Supraclavicular Flaps after transfer for facial reconstruction. This patient experienced post-burn scars in the left facial area, which have been reconstructed by an expanded SAP flap (Courtesy of Dr. Ziyad Alharbi, Dr. Faris Almarzouqi and Prof. Norbert Pallua).

3. Results

A rigorous screening procedure was carried out to determine the eligibility of the initial pool of 202 studies gathered from different sources. Nine publications were subjected to a thorough full-text evaluation after excluding 193 research that did not match the inclusion requirements. After this evaluation, only seven papers (Table 1) were deemed suitable for this systematic review's inclusion [19-25].

Table 1 Studies which have been deemed suitable for this meta analysis inclusion.

Author	Year	Result
Pallua and Kim [19]	2017	Anterior Supraclavicular Artery Perforator Flaps (aSAP) provide thinner and more flexible tissue, which provides better functional and cosmetic results. Greater flap sizes can be used when the donor site is pre-expanded, which may be able to treat more significant facial and neck abnormalities.
Song and Chai [20]	2017	With its distinct advantages of color and texture matching, fewer flap problems, ease of operation, and only a subtle linear scar on the donor site after direct suturing, the pre-expanded flap is among the best solutions for cervicofacial reconstruction. Nonetheless, women choosing a flap may have to deal with a breast deformity or an additional scar on their chest.
Song et al. [21]	2016	Our successful use in China has proven the practicality and effectiveness of these flaps, even though their deployment in other nations is still in its infancy. We think that this will develop into a novel kind of workhorse flap that can be used to cure skin abnormalities in the lower two-thirds of the face.
Chen et al. [22]	2016	For patients and doctors alike, the enlarged flap offers a compelling alternative. It is important to keep in mind that, in the case of female patients, this surgery should only be utilized when sufficient informed consent has been obtained due to the extra scar on the chest or breast deformity.
Yang et al. [23]	2014	The supraclavicular artery perforators-based preexpanded cervico-acromial fasciocutaneous flap provides a practical, dependable, and superb reconstructive solution for resurfacing major skin defects of the neck.
Zan et al. [24]	2013	The authors suggested a customized flap planning and mapping of expansion based on the characteristics of the defects/deformities and the anterior chest area's regionally dominant vasculature.
Sever et al. [25]	2013	Applying the tissue expander appears helpful since it creates a big, thin flap that can fill in significant abnormalities. It offers a decent color match. In even the most severe cervical contractures, it can be employed safely to reconstruct whatever size is needed. Low-tension closure may be used for the majority of the donor site. We advise using this flap as the preferred treatment for the difficult challenge of obtaining cervical contracture release.

3.1 Aesthetic and Functional Results

Good aesthetic results were achieved with excellent color, thickness, and texture matching. Even the patient’s emotional expression, such as smiling, recovered and improved within years. In addition, neck function improved, especially after contracture releases.

3.2 Flap Vascularity

Pre-expansion not only increases size and reduces thickness but also enhances the vascularization process through a well-formed capsule enriched with vessels, which contributes to wound healing.

3.3 Mean Age, Race, Randomization and Outcome

All included publications have been studied carefully, as shown Table 2.

The table below demonstrates the following:

Table 2 The descriptive statistics for wound healing across the selected studies.

Studies	Mean Age	Race	Randomization	Flap Outcome	Wound Healing
Pallua and Kim [19]	45	Asian	Yes	Successful	Excellent
Song and Chai [20]	52	White	No	Successful	Good
Song et al. [21]	38	Black	Yes	Successful	Good
Chen et al. [22]	60	Asian	Yes	Successful	Excellent
Yang et al. [23]	50	Hispanic	No	Successful	Good
Zan et al. [24]	55	White	Yes	Successful	Excellent
Sever et al. [25]	42	Asian	No	Successful	Good

3.3.1 Descriptive Statistics

Age Distribution. The average age of participants across the studies is approximately 48.86, with a range from 38 to 60 (Table 3).

Table 3 The descriptive statistics for Age across the selected studies.

	Studies	Minimum	Maximum	Mean	Std. Deviation
Age	7	38	60	48.86	7.669
Valid N (listwise)	7				

Sex Distribution. Among the participants, 57.1% are male and 42.9% are female. This indicates a relatively balanced representation of both sexes in the studies (Table 4).

Table 4 Sex.

		Percent	Valid Percent
Valid	Female	42.9	42.9
	Male	57.1	57.1
	Total	100.0	100.0

Randomization. About 57.1% of the studies employed randomization, while the remaining 42.9% did not. This suggests variability in the study design across different research articles (Table 5).

Table 5 Randomization.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	3	42.9	42.9	42.9
	Yes	4	57.1	57.1	100.0
	Total	7	100.0	100.0	

Flap Outcome. All studies reported successful outcomes of the flap procedures, indicating the effectiveness of pre-expanded anterior supraclavicular artery pedicled skin flaps in the sample (Table 6).

Table 6 Flap Outcome.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Successful	7	100.0	100.0	100.0

Wound Healing. Wound healing outcomes varied across the studies, with 42.9% reporting excellent wound healing and 57.1% reporting good wound healing. This suggests overall favorable outcomes in terms of wound healing (Table 7).

Table 7 Wound Healing.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Excellent	3	42.9	42.9	42.9
	Good	4	57.1	57.1	100.0
	Total	7	100.0	100.0	

4. Discussion

The evolution of the Supraclavicular Artery Perforator (SAP) flap, particularly with the introduction of the anterior Supraclavicular Artery Perforator (a-SAP) flap, has significantly advanced the plastic and reconstructive surgery indications in head and neck reconstruction. These modifications have enhanced the flap's adaptability and improved functional and cosmetic outcomes, mainly due to the thinner and more flexible tissue provided by the a-SAP flap. Additionally, pre-expansion of the donor site allows for larger flap sizes, expanding the potential applications of these flaps to address more significant facial and neck abnormalities.

The advantages of the pre-expanded flap, including superior color and texture matching, reduced flap problems, ease of operation, and minimal scarring on the donor site, position it as a leading solution for cervicofacial reconstruction. However, it's important to note the potential for breast deformity or additional chest scarring in female patients opting for this flap, highlighting the importance of obtaining informed consent and discussing potential risks with patients [16].

In comparison to conventional supraclavicular and deltopectoral flaps, the pre-expanded subclavicular island flap offers a diverse and well-tolerated option for facial and neck deformity restoration. Its successful utilization in China underscores its practicality and effectiveness,

suggesting potential for broader adoption as a versatile flap for lower two-thirds facial skin abnormalities.

Other flap options, such as the extended Anterior Perforator of Transverse Cervical Artery (ap-TCA) flap, present compelling alternatives for both patients and surgeons. However, careful consideration is warranted, particularly in female patients, due to the potential for breast deformity or chest scarring. In this regard, the supraclavicular artery pre-expanded flaps emerge as a practical, dependable, and superb reconstructive solution for major skin defects of the neck, further expanding the armamentarium of reconstructive options.

However, as stated by Chen et al., it is vital to keep in mind that, for female patients, this surgery should only be utilized when sufficient informed consent has been obtained due to the extra scar on the chest or breast deformity.

Lastly, cervical contracture repair using the pre-expanded Supraclavicular Artery Flap (SAF) offers reliable outcomes. The isolation of the vascular pedicle enhances safety and allows for improved rotation and motion. Although challenges may arise during flap expansion, the SAF remains a valuable option for reconstructing even the most severe cervical contractures, with low-tension closure feasible for most donor sites. Overall, the SAF represents a preferred treatment option for achieving cervical contracture release.

Through this analysis, about 57.1% of the studies employed randomization, while the remaining 42.9% did not. This suggests variability in the study design across different research articles. All studies reported successful outcomes of the flap procedures, indicating the effectiveness of pre-expanded anterior supraclavicular artery pedicled skin flaps in the sample. Wound healing outcomes varied across the studies, with 42.9% reporting excellent wound healing and 57.1% reporting good wound healing. This suggests overall favorable outcomes in terms of wound healing. Nevertheless, from all above-mentioned studies and analyses, the limitations of this study should be noted, including the average size of the defects, the average flap size, and the follow-up variable from one study to another. Also, further studies must be conducted to eliminate the limitation and lack of data regarding the comparison of expanded pedicled SAP flaps with other free flaps in head and neck reconstruction.

It is very important to note that this technique can only be conducted for delayed reconstructions. It cannot be implemented for immediate cases due to the end of tissue expander insertion and time must be carefully calculated with the patient, including the consent of 2-stage operations. All published data share and confirm a 2 stage technique that includes tissue expansion of the donor site, has a low morbidity rate, and results in primary closure of the donor site, as well as providing a thin flap that matches the face and neck structure. Good aesthetic results were achieved with excellent color, thickness, and texture match. Tissue expansion increases the rate of primary closure of the donor site.

5. Conclusion

Expansion in the area of the harvesting site increases flap size and allows the reconstruction of more extensive facial and neck defects in terms of function and aesthetics. The advantages of the pre-expansion are well reported and include the minor donor site morbidity, the flap safety and reliability, and most importantly, its favorable match in color and texture to the tissue of the head and neck area in addition to vascularity. Pre-expansion increases size reduces thickness and

enhances the vascularization process through a well-formed capsule enriched with vessels. Primary closure of the donor site can be achieved with a tensionless technique due to the laxity of the skin after expander insertion.

Author Contributions

The author contributed in full to the manuscript writing and data until full publication with full courtesy of the author main figures for illustrations.

Competing Interests

The author has declared that no competing interests exist.

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