Supraclavicular Pedicled Island Flap in Oral and Pharyngeal Reconstruction: Historical Background, Indications, Surgical Technique and Complications

[1] Magdy Bedir Ali, [1] AbdElRaof Said Mohamed, [2] Yehia Zakaria, [1] Said Abdelmonem Mohamed, [1] Alhusin Goda Ali Mohamed

[1] Otorhinolaryngology Department, Faculty of Medicine, Zagazig University, Egypt

[2] Plastic and reconstructive surgery Department, Faculty of Medicine, Zagazig University, Egypt

***Corresponding author:** Alhusin Goda Ali Mohamed

Email: Drhusin90@gmail.com.

Abstract:

Carcinomas of head and neck represent major health problem and they are associated with great mortality and morbidity. Reconstruction of most head and defects remains a great challenge. Since the development of free tissue transfer and microsurgical techniques, large variety of defect dimensions and locations can be reconstructed allowing for larger oncologic resections, improved tissue coverage and lower patient morbidity. The supraclavicular flap (SCF) is a fasciocutaneous flap used to cover head, oral, and neck region defects after tumor resection. Its main vascular supply is the supraclavicular artery and accompanying veins and it can be harvested as a vascularised pedicled flap. The SCF serves as an excellent outer skin cover as well as a good inner mucosal lining after oral cavity and head-neck tumor resections. The flap has a wide arc of rotation and matches the skin colour and texture of the face and neck.

Keywords: Supraclavicular Flaps, Carcinomas, SCF.

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Introduction:

The ventral shoulder slope and the supraclavicular region are among the possible donor sites for flap surgery to cover defects in the face and neck, particularly because the texture, color, softness, and elasticity of the skin are similar to those of the face. However, due to ultimately unclear vascularization conditions and frequent ischemic complications, these flaps have been viewed with extreme caution and skepticism for quite some time **(1)**.

Nowadays, in addition to the lateral trapezius flap, at least 4 other supraclavicular flaps can be distinguished on the basis of localization, vascularization, and size **(Figure 1)**:

- Supraclavicular fasciocutaneous flaps (classic design and island flaps).
- Supraclavicular perforator flaps (SCPF) (topographically different from above).
- Extended supraclavicular island flaps based on the transversa cervicis artery.
- Anterior supraclavicular artery perforator flap (a-SAP-flap) **(2)**

The vascular supply of the first-mentioned supraclavicular flap follows an axial pattern based on the suprascapular artery, a branch of the transversa cervical artery, which in turn arises with greatest frequency from the thyrocervical trunk, and less frequently from the supraclavicular artery. The suprascapular artery is regularly found within a triangle outlined by the posterior border of the sternocleidomastoid muscle, the external jugular vein, and the medial clavicle. Metrically, the suprascapular artery is reported to be located a mean of 3.6 cm above the clavicle, 8.6 cm from the sternoclavicular joint, and 2.1 cm dorsal to the posterior border of the sternocleidomastoid **(3)**.

The origin of the suprascapular artery is 3–4 cm above the origin of the thyrocervical trunk. The vessel diameter is 1.1–1.5 mm. Venous drainage is via 2 vessels, a collateral vein parallel to the supraclavicular artery with an orifice into the transversa cervical vein and a vein divergent from it that drains into the external jugular vein or the subclavian vein **(4)**.

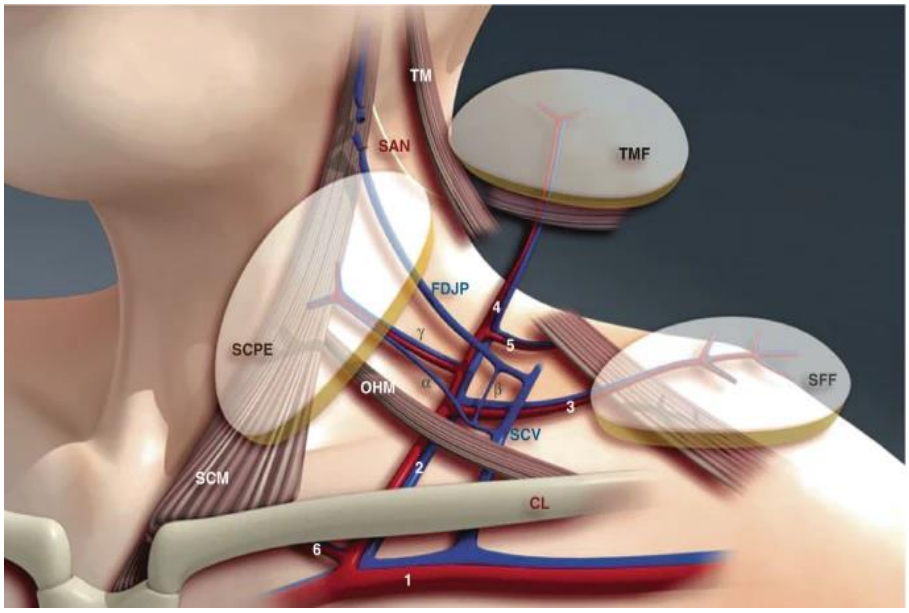

Figure 1: Arterial and venous vascular anatomy in the lateral triangle of the neck and 3 flaps in the supraclavicular region (1)

The vascular territory (angiosome) of the supraclavicular artery has dimensions ranging from 10 × 22 cm to 16 × 30 cm and extends over the supraclavicular region and shoulder

prominence to the ventral surface of the deltoid muscle. Accordingly, the fasciocutaneous flap must be harvested over the ventral surface of the deltoid muscle, the deltoid fossa, and the pars clavicular is of the pectoralis major muscle. Here, to maintain safe limits, the lateral peripheral flap margin should extend at most to the level of the inferolateral deltoid insertion (i.e., approximately 3 cm lateral to the acromion), although the actual size of vascular territories has been reported to be underestimated in in vitro perfusion studies and the flap could potentially extend beyond the deltoid muscle onto the humerus clinically-intraoperatively **(5)**.

The neuro-sensitive innervation of the supraclavicular region originates from the Punctum nervosum (Erb), from where a group of multiple cutaneous branches (cervical plexus C3 and C4) spreads in fan-shaped branches over the clavicle and the shoulder region. The supraclaviculares intermedii and laterales nn, respectively, pass below the platysma over the middle third of the clavicle and over the acromion and deltoid muscle, respectively. Anterocranially of the vascular exit zone, a larger main branch can usually be identified, which branches further anterior to the base of the flap on the one hand and along the longitudinal axis of the flap on the other. Preservation or recoaptation of these branches allows neurotization ("sensate flap") of the supraclavicular flaps **(6)**.

Supraclavicular flaps can be used as transposition flaps with a broad vascular fascia pedicle, island flaps, perforator flaps or also as micro-surgically revascularized free flaps for defect coverage in the anterior neck region or in the cheek-face region. The angle of rotation around the exit point of the vessels can be up to 180 ° in extreme cases when pedicled flaps are rotated to the contralateral side of the neck (cf. propeller flap); when rotated to ipsilateral defects, the values range between 110 ° and 160 ° **(7)**.

It should be noted that the nomenclature of the supraclavicular flaps varies in the literature and that different names may conceal identical flaps or vice versa. Names in circulation include supraclavicular fasciocutaneous flap (SFF), supraclavicular island flap (SIF) or supraclavicular artery island flap (SCAIF). The SIF has recently been addressed as the classic or original SIF and also as the supraclavicular perforator flap (SCPF), a name also used for a much smaller flap limited to the medial region of the supraclavicular fossa **(8)**.

Historical background: flap varieties

The chronology of supraclavicular flaps dates to the mid-nineteenth century with the description of an "immediate mastoid-occiput based shoulder flap" for reconstruction after release of a mento-sternal scar contracture. Other precursors were grafts called shoulder flaps, acromial flaps, or charretera flaps. After initial systematic anatomical studies of the vascular supply and dimensioning of the harvest region, the name was changed to cervico-humeral flap**(9)**.

The supraclavicular artery was first identified in 1979 as the constant vessel responsible for supplying the SIF. In an experimental 3D and 4D CT angiography study on post-mortem human donors, it has now been confirmed with regard to reliability that the arterial perfusion of the entire flap depends on the flow of the supraclavicular artery and is established distally via the "inter perforator flow" between direct linking vessels and a recurrent flow in the subdermal plexus **(Figure 2) (10)**.

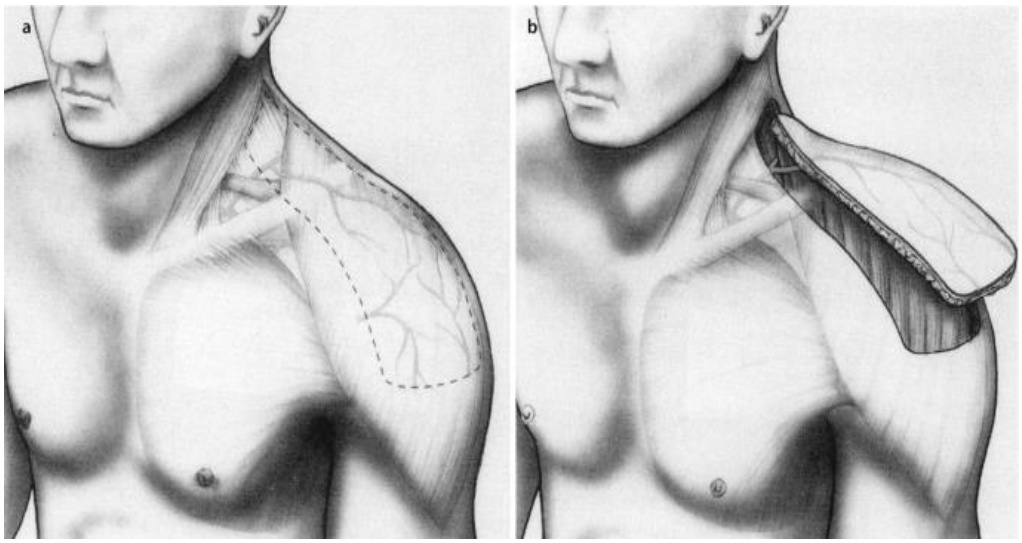

Figure 2: a) Outline and blood supply of the fasciocutaneous supraclavicular insular flap. Distal over deltoid muscle vessels on left with perforators from circumflex humeral artery and deltoid branches from thoracoacromial vascular axis. b) Fasciocutaneous supraclavicular insular flap after elevation (1)

The demarcation line between "axial" and "random pattern flow" moves over the origin of the deltoid muscle at the acromion and lateral clavicular third. It has been shown that direct anastomoses with perforating vessels from the surrounding area occur up to this area, but that a zone with indirect "choke vessels" increasingly forms distal to it and thus, analogous to the upper trapezius flap, the risk of ischemia for the flap tip increases when extending into the distal angiosome **(11)**.

Venous outflow also follows a territorially distinct pattern. Distal to the demarcation line provided by the deltoid, the venous perforator and subdermal vessels drain into the Vv. circumflexae of the humerus and the V. cephalica after passing through the deltoid muscle. Proximal to the line, venous drainage occurs via the accompanying veins of the supraclavicular artery and the superficial cervical vein, from where it continues into the transverse cervical vein and the external jugular vein and subclavian vein, respectively **(12)**.

The cause of this “watershed phenomenon” is the opposite direction of the venous valve system. After intraoperative ligation of the distal drainage connections during flap raising, an increase in pressure with consecutive incompetence of the venous valves and shunting in the venous passageways can be assumed, resulting in an anterograde outflow **(13)**.

The SIF is a flap in sizes up to 4 × 6 cm with vascular pedicle lengths between 3 and 6 cm, intended for use as a microsurgical free flap. The flap is created in an elliptical shape in the supraclavicular fossa parallel to the posterior sternocleidomastoid margin dorsal to the sternoclavicular joint and ventral to the anterior margin of the trapezius. The longitudinal axis of the flap follows the skin folds in the lower neck region **(14)**.

The flap is supplied by an average of 4 perforators, mainly originating from the R. superficialis of the transversa cervicis artery. These perforators are independent of the supraclavicular artery, which accompanies the clavicle in its course to the shoulder. The special venous outflow conditions of the SCPF should be emphasized, which must be taken into account during free preparation and for harvesting a suitable vascular pedicle. There are always 1 or 2 commissural veins of the transverse cervical artery including its branches and a superficial cervical vein **(15)**.

The superficial cervical vein extends from the lateral third of the anterior margin of the trapezius along the clavicle and joins the external jugular vein. Venous drainage is consistent via the accompanying venous vessels of the perforators to this superficial cervical vein and variable (60%) to the commissural veins of the transverse cervical artery. At the same time, the accompanying venous vessels opening into the superficial cervical vein always have a connecting branch to the external jugular vein **(16)**.

Based on vascularization by the A. transversa colli and its branches, pedicled laterally extended supraclavicular flaps extending to the shoulder have also been documented in addition to the SIF. A further development of the classic SIF is the a-SAP-flap **(Figure 3)**, which can be applied pedicled or free. Compared to the SIF, the donor site undergoes “forward moving” so that the skin island of the a-SAP-flap is essentially located over the deltoideopectoral fossa and consequently anterior or ventral to the clavicle. The a-SAP-flap is even thinner, and the skin color is said to match the facial skin even better than the SIF **(2)**.

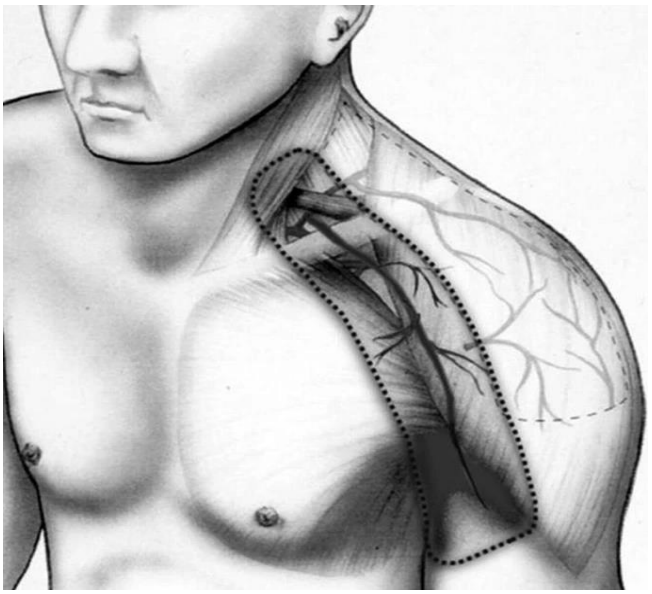

Figure 3: Design of the a-SAP-flap over the deltoideopectoral fossa (1)

The vascular basis of the a-SAP-flap is provided by the so-called anterior supraclavicular perforator pedicle, which branches off as a separate vessel from the transversa cervicis artery. This anterior vascular pedicle is said to be characterized by the same constant occurrence as the supraclavicular artery. The vascular pedicle emerges to the surface just above the clavicle immediately lateral to the lateral sternocleidomastoid head, breaches the platysma, and crosses the middle clavicular third, then continues toward the deltoideopectoral fossa. The design of the a-SAP-flap corresponds in principle with the classic SIF, but the flap is narrower with the same length (17).

Indications

The clinical applications of the supraclavicular flaps cover a wide spectrum. SIF and a-SAP-flap are considered almost ideal reconstructive options for cutaneous defects in the neck and facial region. Prime examples are extensive scar contractures after burns in the anterior neck region with the goal of restoring mobility and mentocervical angle by resolving the contractures and replacing the scar plates with healthy skin (18).

On the face, the rotational arc of the SIF extends to the cheek at the junction with the temporal region. Accordingly, the flaps can be used to restore the skin of aesthetic units in the chin, lips, and cheek region or after de-epithelialization to fill volume after parotidectomy or even in Romberg's disease and hemifacial microsomia. Furthermore, the infratemporal fossa and lateral skull base can be reached. With folded or folded over supraclavicular flaps continuous defects in the perioral region can be closed, for example after noma or oncosurgical orocutaneous fistulas (19).

With the aid of pre-expansion, very large-area, ultra-thin SIF plastics, which can also be re-sensitized if necessary. For this purpose, a tissue expander is implanted subfascially into the angiosome of the supraclavicular artery and successively filled over weeks and months until the reconstruction can be performed in a second step. As long as the thyrocervical trunk and its branches in level IV and V of the neck are intact, ipsilateral supraclavicular flaps can be used after limited neck dissection to cover defects in tumor ablations in the lower oral cavity and oropharyngeal region (mucosal defects in the floor of the mouth, tongue/basal tongue region, tonsil region). Especially in tumor patients with comorbidities and/or in recurrence treatment and after radiotherapy, they sometimes represent proven alternatives to free tissue transfer as well as to extensive pectorocervicofacial advancement flaps **(20)**.

The flaps can be used for partial or circumferential pharyngoesophageal reconstructions, in conjunction with a bone chip from the clavicle, the tracheal cartilage framework can be stabilized or defects of the nose involving the nasal skeleton can be treated. Applications for soft tissue coverage after interventions in the craniovertebral junction have been described. Another indication is obliteration in deep sternal infections and osteomyelitis after cardiac surgery **(15)**.

As free grafts, a-SAP-flaps and SIF can in principle be transferred to all regions of the body surface. Thus, a-SAP-flaps have been used in the extremities, SIF in the face and for intraoral lining. The advantages of supraclavicular flaps are their low thickness and high flexibility, extensive correspondence to the color and texture of the receiving regions in the neck and facial area, generally simple and time-efficient elevation, and minimal donor site morbidity. On the downside, there are rare anatomical variants and certainly the potential risk of necrosis of extended distal flap portions with random pattern flow, which, however, can be prevented with the delay method **(12)**.

Not only the circumcision of the flap borders, but also the implantation of tissue expanders causes a delay effect and improves vascularization. The expander is placed in a subfascial layer through a limited access after undermining the flap and is filled step by step after wound healing. The delay effect is enhanced by depositing perforators from the internal mammary artery or thoracoacromial artery during expander implantation. The maximum filling of the expander depends not only on its volume specifications but also to a large extent on the cooperation of the patient. The flap increases in width and length and develops a resilient basal boundary layer. As a result, the vascular pedicle elongates, increasing the arc of rotation. Often, expansion also facilitates direct closure of the harvest area **(15)**.

Although the elevation of pedicled supraclavicular flaps does not require microsurgical expertise, the preparation of the base of the flap or the pedicle region requires a meticulous procedure, especially if an ipsilateral neck dissection in level V and a detailed vascular imaging are performed simultaneously. After irradiation or pre-operation, it may be preferable to switch to the contralateral side of the neck; the base of the flap can be temporarily sutured in the form of a round

pedicle flap. For the SIF, previous irradiation and a previous neck dissection are indicated as contraindications (21).

In the preoperative planning phase, 3D CT angiography is recommended to detect the thyrocervical trunk, the transverse cervical artery and the spread of the supraclavicular artery. A Doppler examination of the vessels is performed to localize and map the course of the vessel stalk and the perforators on the skin ideally with the power Doppler and for further confirmation with the Doppler probe at the start of surgery (22).

Surgical technique

- **Supraclavicular island flap (SIF)**

The patient is positioned in the supine position with a shoulder pillow on the donor site. The head, neck, anterior shoulder area including the upper arm to the elbow and the upper chest area are prepared as a surgical field and sterilely draped, and the forearm and hand are wrapped with a stockinette. The posterior border of the sternocleidomastoid muscle, the contours of the external jugular vein, and the medial clavicular border are drawn in as topographical references to aid in locating the vascular pedicle. The length of the flap or the positioning of the skin island can be determined by starting from the fulcrum of the intended base of the flap and measuring the necessary radius to the defect with a thread or an extended compress. The size and shape of the terminal flap portion or skin island is formatted according to the extent of the defect **(Figure** 424**)** (23).

SIF are elevated from distal to proximal or lateral to medial. The skin incision starts with the incision over the ventral deltoid muscle, the distal part of the flap is quickly detached with the monopolar electrocautery at the level of the muscle fascia. Anteriorly, the incision and dissection is continued below the clavicle, and posteriorly it is extended to the external jugular vein. On the underside of the middle third of the flap, the suprascapular vascular bundle can be visualized by transillumination of the skin. Flow can be confirmed with a sterile Doppler probe. In the wound bed, the hypogastrium of the omohyoid muscle comes into view (24).

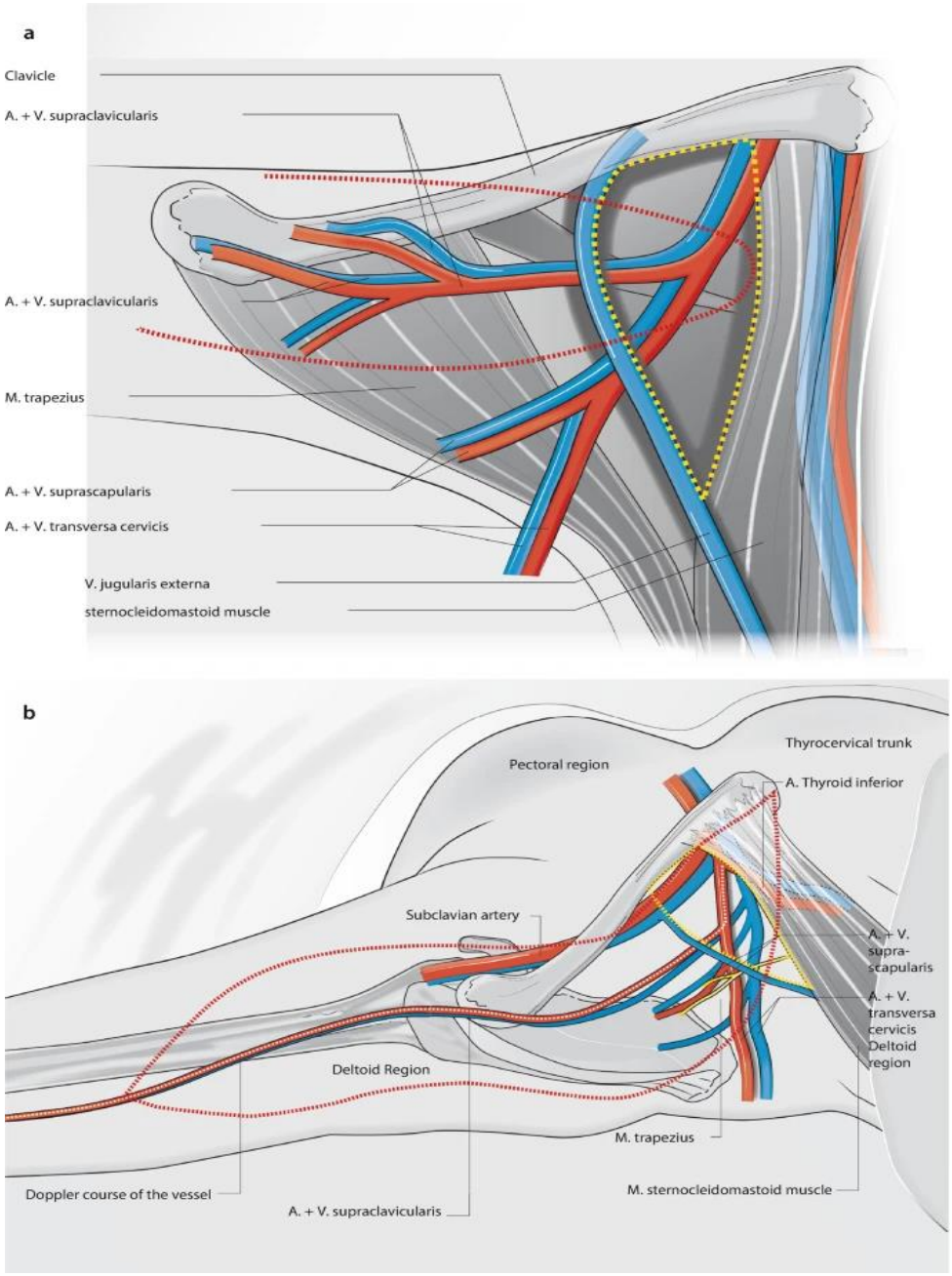

Figure 42: As of outline/design outline and blood supply of the SIF from intraoperative view from cranio-laterally (1)

The proximal part of the flap remains fixed to the base via the periosteal connections to the clavicle until the medial circumference of the flap has been superficially incised in order to protect the vascular pedicle. Then the flap is lifted from caudally in the medial region of the supraclavicular fossa and mobilized. For this purpose, the periosteum must be incised along the clavicle and entered cranially into the soft tissue still adherent to the depth. Further dissection is blunt and releases radiating fascial cords and the fatty tissue caudal to the vascular pedicle (25).

Mediocranially, the platysma and individual muscle fibers coming from the anterior margin of the trapezius are cut. When deepening the dissection, the external jugular vein and the accessorius nerve must be observed and spared at all costs. Of the sensory skin branches (supraclaviculares mediales and laterales nn.) which also descend below the platysma, a selection may be preserved if necessary. On the lateral side of the flap there is a fascia-like covering layer which surrounds the fat body together with the vascular pedicle; this is carefully weakened and stretched **(Figure** 535) **(16)**.

If possible, the underlying fat tissue is left as a broad-based embedding together with the vascular pedicle to protect against twisting and kinking of the vessel axis during flap insertion. The vessels are skeletonized in detail only if it is necessary to widen the arc of rotation for insertion of the flap. Before deciding to detach individual vascular branches in the pedicle region, the external jugular vein cranially, or even the transversa cervicis vascular bundle dorsal to the junction of the supraclavicular artery, an Acland clamp should be temporarily applied and the effects on the vascularization of the flap observed and checked with the Doppler probe **(26)**.

To establish a connection into the defect region, the intermediate skin bridge is either tunneled, transected and opened to form a corridor, or temporarily covered with the medial portion of the flap after round pedicle formation. Already during flap circumcision and formation of the skin island, the proximal flap base can be de-epithelialized for passage through a skin tunnel **(26)**.

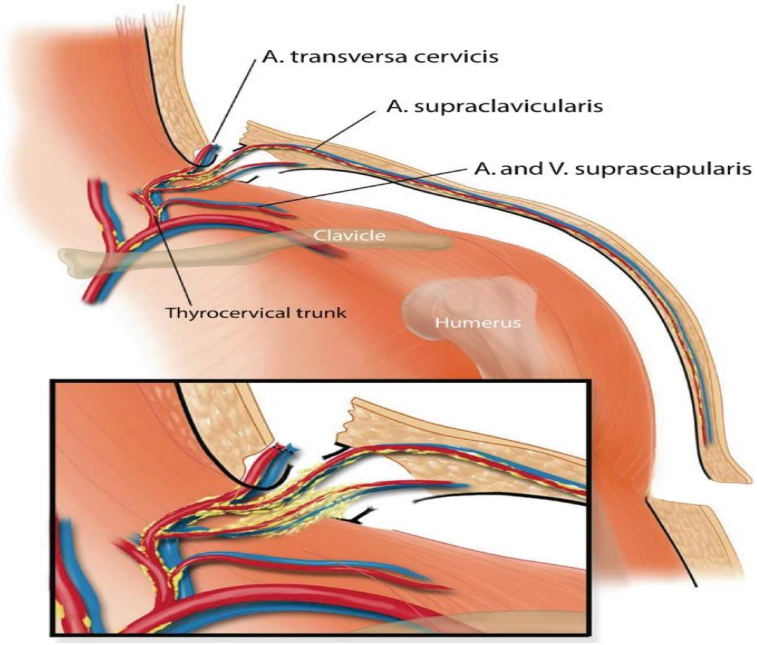

Figure 53: Frontal cross-section through the anterior shoulder region and a supraclavicular flap. Separation of fascia around the vascular bundle to increase flap reach (1)

The SIF can also be prepared and lifted with a stronger focus on the perforator vessels or with separate extensions in a modified form, which expands its range of applications and is sometimes given a separate name in the nomenclature. Primary closure of the donor site is possible without problems in most cases after mobilization of the wound edges, occasionally split or full thickness skin grafts are indicated to cover the surface of the deltoid muscle (23).

- **Supraclavicular perforator flap (SCPF)**

Lifting of the SCPF is more difficult than with the above-mentioned supraclavicular flaps and requires the inclusion of previously Doppler sonographically marked perforating vessels. The elliptical skin island of the SCPF with its longitudinal axis is placed along a skin fold in the lower neck region. First, the skin, platysma and superficial cervical fascia are incised along the laterocaudal margin of the flap and, after blunt dissection, the omohyoideus muscle is identified (18).

For subsequent visualization of the transverse cervical artery with the perforating vessels, this muscle is retracted caudolaterally or even resected. The superficial cervical vein is located dorsolaterally and is approached at the anterior border of the trapezius muscle and then traced to its junction with the external jugular vein. It can then be elevated to expose the transversa cervicis artery to the trapezius muscle, paying careful attention to the perforators pulling into the undersurface of the flap. The R. profundus and R. superficialis of the transversa cervicis artery are exposed at the anterior margin of the trapezius after the accessorius nerve has been identified and displaced (27).

The transversa cervicis artery, now exposed from the lateral side, assumes an “inverted T” configuration with one of the branching main perforator vessels. The transverse segment from the transversa cervical artery offers the alternatives of harvesting an anteromedial or posterolateral (with retrograde flow) flap pedicle, and it can also be used in a “flow through” configuration. The superficial cervical vein with its tributaries must be released with the flap after posterior and anterior transection. Finally, the flap is transected anterocranially and mobilized (18).

- **Extended supraclavicular island flap based on the transversa cervical artery**

The elevation of the Extended Supraclavicular Flap combines elements already known from the SFP or SIF and SPF. The flap is developed from lateral to medial. The arterial vessels are then visualized starting from the superomedial edge of the flap to the anterior margin of the trapezius and onto the deep cervical fascia or cervical plexus. In the inferior lateral triangle of the neck, the superficial cervical vein is dissected free. The pivot points for the flap are the transverse cervical artery and the medially running segment of the superficial cervical vein. Accordingly, these vessels are transected at the anterior margin of the trapezius for mobilization of the flap pedicle (28).

- **Anterior supraclavicular artery perforator flap (A-SAP-Flap)**

The anterior supraclavicular perforator pedicle of the a-SAP-flap is identified preoperatively by Doppler. The intended flap is drawn and completely circumcised. The vascular pedicle is dissected free coming from the caudal to the A. transversa cervicis, which is visualized posteriorly and set down; anteriorly, it is traced until a caliber sufficient for microsurgical re-anastomosis is achieved. The external jugular vein serves as the venous drainage vessel; its feeding veins, e.g., the superficial cervical vein, must accordingly remain intact **(29)**.

Complications, donor site morbidity

Typical complications are venous congestion and ischemia in distal parts of the flap. The cause of these perfusion deficits is not only a flap raising that extends laterally far beyond the middle of the deltoid, but also a transfer and insertion into the defect area under too high a tensile load or tissue tension. In the area of the donor site, hematomas, minor wound healing disturbances and the subsequent development of wide scar lines are not uncommon. Long-term functional morbidity after fasciocutaneous flap harvesting is considered low **(30)**.

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