

ANTEROLATERAL THIGH FLAP - CLINICAL APPLICATION IN THE CERVICO FACIAL SOFT TISSUE DEFECT RECONSTRUCTION

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ABSTRACT

Anterolateral thigh flap (ALT flap) is first found and used by Song in 1984. Classified in the perforator type flaps, ALT flaps is blood supplied by the perforators of the descending branch of the lateral circumflex thigh artery. The flap is the first of choice in many cases, those need a large soft tissue for reconstruction, especially in the cervico facial area thanks to many advantages of the flap: constants and relievable anatomic structure, large blood supply, flexible in use as well as other advantages. From 9.2016 to 10.2020, 26 ALT flaps are dissected in fresh and Formalin cavades of mature Viet people for the anatomic research and 34 ALT flaps used for patients with soft tissue defects in cervicofacial area. The outcome is considerable with the main following conclusions:

- ALT flap is constant and reliable in anatomy.
- The flap is harvested relatively easy in clinical practice.
- The use of the ALT flap is flexible with good result in reconstruction of soft tissue defects in cervico facial area.

Keyword: *anterolateral thigh flap*

I. INTRODUCTION

Major defect in cervicofacial soft tissue due to many causes (after removal of benign or malignant tumors, burn scars or sequelae of wounds, trauma, etc.) is one of challenges in reconstructive surgery. With the

development of microsurgery techniques and in-depth studies on skin blood supply, finding of suitable materials for cervicofacial area with relatively strict requirements such as large area, similar quality with the cervicofacial skin, leaving little sequelae in flap-donor area, etc leads to development of a variety of skin flaps such as scapular - parascapular flap, radial forearm flap, supraclavicular flap, ect. Each flap has its advantages and disadvantages, and has its own use in each case. In 1984, Song et al. reported for the first time a study of anterolateral thigh flap (ALT flap) anatomy as a fasciocutaneous flap that could be used for microsurgery [1]. In 1988, this flap was applied clinically by Xu [2], and because of its prominent advantages, ALT flap was used so much that many famous surgeons in the field of reconstructive surgery such as Fu Chan Wei and Jeng Feng Seng almost exclusively used it for all soft tissue reconstruction. In 2002, Wei used up to 672 ALT flaps [3], in 2009 Chen reported using more than 1000 ATL flaps [9].

In Vietnam, ALT flap was first used at 108 Central Military Hospital (2004), and then also applied at some medical settings such as Saint Paul Hospital and Viet Duc Hospital. There have been reports on the use of this flap, but there have not been any in-depth studies of its anatomy and clinical applications, especially in cervicofacial reconstruction. Therefore, we conducted this study with following purposes:

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- Description of ALT flap's anatomy in adult Vietnamese.

- Evaluation of its applicability in cervicofacial soft tissue defect reconstruction

II. MATERIALS AND METHODS

2.1. Materials

- Anatomical study: recruitment of 8 fresh cadaver specimens at 108 Central Military Hospital and 20 specimens of formalin-treated cadavers at Ho Chi Minh City University of Medicine and Pharmacy and Pham Ngoc Thach University of Medicine.

- Clinical study: recruitment of 34 patients with cervicofacial soft tissue defects due to different causes, reconstructed by ALT flap at 108 Central Military Hospital from September 2016 to October 2020.

2.2. Method

2.2.1. Anatomical study

- Determination of anatomical landmarks: The superior anterior iliac spine and lateral border of the patella are marked. The line connecting these two points is ALT flap's axis.

- Dissection: In order to find all skin-supplying perforating branches of flap-supplying vascular peduncle, we actively make an incision through the inguinal crease, expose the deep femoral artery and find the lateral femoral circumflex artery. Dissection follows the lateral femoral circumflex artery, lateral branches are ligated and follows the descending branch of this artery. Careful dissection of all branches originating from this descending branch, but we actively ligate branches that are too small or transmuscular other than the rectus femoris and vastus lateralis muscles to save time, because perforating branches supplying the skin of

ALT flap pass through these two muscles or intermuscular septum between them.

The perforating vessels are dissected downstream along their courses (through intermuscular septum or muscles) to deep fascia layer of the thigh and to site the vessels perforating through the fascia. Vascular peduncle's sizes, including diameters and lengths of descending branches and perforating vessels, are measured. Photos are taken and data is recorded according to built-in tables. For fresh cadavers, we also inject methylene blue into descending branches after isolating branches that don't supply blood to skin of the anterolateral thigh and ligate distal descending branches to evaluate skin blood supply area of skin-supplying perforating branches. Skin area soaked methylene blue is measured, photos are taken and data is recorded.

2.2.2. Clinical study

Patients are fully examined for lesions and performed necessary tests for endotracheal anesthesia.

Recruited patients meet following criteria:

- Diagnosis of cervicofacial soft tissue defect (due to removal of pathological masses, scars, etc.)

- General conditions and laboratory tests allow endotracheal anesthesia.

- The expected ALT flap-donor area has no lesions.

- Patients agree to receive surgery and participate to the study.

Surgical procedure are usually divided into 2 surgical teams:

- Team 1 removes the lesion and exposes recipient vessels: the lesion is removed as expected, if related to bones such as the

mandible and the maxilla which needs immediate reconstruction, bone flaps, usually fibula flap, can be used for combination. Recipient vessels are dissected before the lesion is removed, because this is more active, protects these vessels better, and avoids accidentally damaging these vessels while removal of the lesion, especially in lesions which are complex and near donor vessels, or have active bleeding. Arteries such as the facial and the superior thyroid arteries, and the facial vein or other branches of the external jugular vein usually are found.

- Team 2 dissects ALT flap: The target line connecting the anterior superior iliac spine and lateral border of the ipsilateral patella is determined. Midpoint is marked, a circle with 6cm-diameter whose center is the midpoint is determined, perforating branches of the ALT flap mainly concentrated in the area of this circle. The flap's area is drawn according to the needs of use. First, anteromedial border of the flap is incised, usually following superficial fascia layer of the thigh from inside to outside to near the central circle region, then went down below the fascia to find perforating vessels, perforating vessels can be also found first and then fascia is incised down, depending on each case whether it is necessary to preserve flap or use many components of the thigh fascia in the flap or not. The flap is dissected by countercurrent technique, perforating vessels are found first and then following them to reach descending vessels of the lateral circumflex thigh artery, length of the flap peduncle is taken according to position and length of previously exposed recipient vessels.

The flap is transferred, vessels are connected and ALT flap is used according to reconstruction requirements. Incision is closed and thin skin is grafted for flap-donor area if necessary.

2.2.3. Evaluation of clinical outcomes

- Short-term outcome (postoperative evaluation):

+ Good outcome: The flap is fully alive, incision heals in the first phase, appearance and aesthetic is recovered well, flap-donor area's function is not affected.

+ Fair outcome: The flap is fully alive or only small part is poorly supplied, reconstruction purpose is still ensured, or flap-donor area heals slowly and needs additional treatment.

+ Poor outcome: The flap is fully or largely necrotic, reconstruction purpose isn't reached, or flap-donor area's function is severely affected (infection, femoral muscle necrosis, severe muscle hernia, etc.)

- Long-term outcome (evaluation after 6 months):

+ Good outcome: The flap is fully alive, good appearance and aesthetic is ensured, flap-donor area's function is normal.

+ Fair outcome: The flap's reconstruction purpose is ensured, additional repair may be necessary, flap-donor area's function is mildly affected (walking is still difficult, mild muscle hernia).

+ Poor outcome: The flap becomes fibrous, reconstruction purpose isn't ensured and repeat surgery is necessary. Or flap-donor area's function is severely affected (severe hernia requiring surgical repair, function loss of the anterior thigh muscle group, etc.)

III. RESULTS AND DISCUSSION

3.1. Anatomy of anterolateral thigh flap

Table 1. Amount of perforating vessels

Amount of perforating vessels	1	2	3	4	5
Amount of specimens	1	4	15	7	1
Percentage (%)	3.57	14.29	53.57	25.0	3.57

Results of above table show that there is 1 specimen with only 1 perforating vessel, accounting for 3.57%. Percentage of specimen with 3 or 4 perforating vessels is the highest (78.57%), we don't find any specimens with 6 perforating vessels or more. According to the report of Tansatis et al. [6], there are an average of 3.8 - 4 penetrating vessels on 60 specimens, so our results are quite suitable, but according to these authors, the most amount of penetrating vessels is 11 while ours is 5. This difference may result from determination of size of penetrating vessels with actually clinical significance, we only dissect perforating vessels with root diameters from 0.5 to 1mm, because according to many authors such as Wei, Kimatra and Chen [7, 8, 9], perforating

vessels with too small root diameters will not be clinically usefull when dissecting the flap, these vessels will be injured and their lengths (especially transmucular vessel) will cause them to constrict, making them unable to supply enough blood to the skin flap. According to some statistics, percentage of specimen without found perforating vessels of ALT flap is very different. When studying 74 ALT flaps, Kimata et al. report that up to 5.4% of total specimens doesn't find any perforating vessels, but according to Hung Chi Chen et al., only 2% of total specimens has no found perforating vessels. We don't find any cases without perforating vessels, clinical reality is also siutable with the anatomical study.

Table 2. Diameter of vascular peduncle (calculated at origin of the descending branch, measurements on formalin-treated cadavers are multiplied by a normalization factor of 1.18 to correspond to sizes of fresh cadavers)

Diameter	Maximum	Minimum	Average
Artery	2.7 mm	1,9 mm	2,33 mm
Vein 1	3.5 mm	2,1 mm	2,91 mm
Vein 2	2.9 mm	2,0 mm	2,51 mm

Table 2 shows that at origin of the descending branch, diameters of the vessels are quite large, making it easy to perform the microsurgery suture technique. We don't observe any case with only 1 accompanying vein, while Manhotra [10] reports that there are about 2% of cases without any accompanying veins. It is possible that our

study's sample size is small, so there isn't any cases of vascular abnormality. For 2 accompanying veins, we also have similar results with other studies, 1 larger and 1 smaller accompanying veins, but even small veins are good for microsurgery sutures. We find that diameters of arteries and veins in the descending branch don't change

significantly from the origin to the site giving the first skin-supplying branch, so if having no need to use a flap with a maximum-length pedicle, surgeons can remove any part of vascular pedicle, but still ensures the diameter is large enough for vascular

connection without maximum length dissection, which significantly reduces surgery duration and more importantly, avoids too long vascular pedicle, causing folding and twisting, which is easy to block the vessel.

Table 3. Lengths of vascular pedicle and perforating vessels

Diameter	Maximum	Minimum	Average
Vascular pedicle	14 cm	3.1 cm	6.84 cm
Perforating vessel 1	11 cm	2.3 cm	5.74 cm
Perforating vessel 2	8.7 cm	5.2 cm	5.53 cm
Perforating vessel 3	10.3 cm	4.2 cm	6.4 cm
Perforating vessel 4	8.3 cm	4.2 cm	6.08 cm
Perforating vessel 5			8.1 cm

We regulate that the first skin-supplying perforating vessel of the descending branch is perforating vessel 1, followed by perforating vessels 2, 3, 4, 5; length of vascular pedicle is measured from the origin to the site giving the first perforating vessel, and length of the perforating vessel is measured from the site giving the perforating vessel of the descending branch to cutaneous exit point. The average length of vascular peduncle is 6.84cm, according to Manhotra, this length is from 7.5 to 8cm [5], so our study also has some difference, possibly due to ethnicity factor, Europeans are generally taller than Asians. Length of the shortest pedicle is also 3.1 cm, excluding length of transmuscular vessel, which can be used for microsurgery connection to vessels in flap-donor area near the lesion, it's not taking into

account the possibility to use only perforating vessels 2 to 5 (excluding perforating vessel 1) to lengthen the pedicle if necessary. Sometimes, length of perforating vessel (especially transmuscular one) is difficult to use due to potential of folding, twisting or constriction. In our study, perforating vessel 1 (central end) is the most constant, presenting in all cases (there is one case with only one perforating vessel so this vessel is neither central nor peripheral), the last perforating vessel at peripheral end is also quite constant (presenting in 27/28 cases), while middle perforating vessels have a lower occurrence rate, because we choose perforating vessels flexibly and suitably depending on the need to use long or short flap peduncles, or flap area is large or small.

Table 4. Size of flap's blood supply area

Size	Maximum	Minimum	Average
Length	24 cm	22 cm	23.5 cm
Width	16 cm	12 cm	14.5 cm

We have only 4 fresh cadaver specimens that can be injected methylene blue to evaluate blood supply area of the descending branch artery. After injecting methylene blue at a rate of about 1ml/min, we wait for 30

minutes, when color-soaked region does not increase anymore, we measure its area. The average soaked length is 23.5cm and the average soaked width is 14.5cm. Because of small amount of specimens, there isn't

enough amount for comparison and discussion, we only make a preliminary comment that chemical-soaked region first appears in the center (circle with 6cm-diameter) after methylene blue injection, then

soak spreads quite quickly to surrounding region whose size is about 10x15cm, the remaining chemical-soaked region appears gradually after about 10 minutes and stabilizes in size after about 30 minutes.

3.2. Clinical study

Table 5. Cause and size of the lesion

Cause / size	Amount	Maximum. Length/width	Minimum. Length/width	Average. Length/width
Removal of benign tumors (pigmented tumor, hemangioma, neurofibromas, etc.)	13	10x21 cm	6x12 cm	7.8x19 cm
Removal of cancerous lesions (primary skin cancer, connective tissue cancer invading skin and soft tissues) or radionecrosis	13	10x23 cm	6x10 cm	8.3x17.6 cm
Removal of scar lesions or sequelae of traumatic wounds	8	16x25 cm	6x18 cm	8.9x21 cm

We find that lesion causes are quite diverse with many different forms, including simple skin lesions and skin lesions combined with soft tissue or bone lesions. Percentage of patients with skin cancer invading skin and soft tissues and patients with soft tissue radionecrosis is quite high (38.2%). Lesions of these patients usually are complex and easy to relapse, or have poor outcomes. Lesion with the largest size reconstructed is observed in patient with cervicofacial burn scars, the flap is taken for grafting with almost maximum size (16x25cm), the flap's minimum size is

6x10cm. This shows the flexibility of ALT flap, unlike some types of axial pattern flap, such as scapular - parascapular flap which is difficult to take if its size is too small, authors such as Koshima and Wei also have similar comments. Fu Chen Wei uses the smallest ALT flap with size of 3x3cm for instep defect reconstruction [3]. The average flap size used is 8.33x19.2cm, which is also similar to foreign author's results. The flap's size used mainly depends on lesion's size and ability to directly close incision of flap-donor area.

Table 6. Short-term outcomes (n=34)

Outcome	Good	Fair	Poor
Patient amount	30	2	2
Percentage (%)	88.2	5.9	5.9

Through 34 clinical cases, evaluated until they are discharged from the hospital, we find that good outcome has a very high percentage, 32/34 cases, accounting for 94.1%. Compared with other authors such as Hung Chi Chen (success percentage is 98%) [4], we also gain similar result. Partly due to our surgeons are well experienced and have quite stable technique to use free flaps and, partly due to ALT flaps are only used for reconstruction purpose (covering or grafting)

so they are easy to success than free flaps for rehabilitation. We observe 2 failed cases, one patient has a history of lupus erythematosus, after vascular connection, the artery constrictes and supplies blood poorly, the flap is removed, another patient is used too long vascular pedicle in mobile neck region, so the pedicle is folded after surgery. The flap is removed and remaining femoral ALT flap is used. Postoperative outcome of second flap is good.

Table 7. Long-term outcomes (n=25)

Outcome	Good	Fair	Poor
Amount	21	4	0
Percentage (%)	84	16	0

After 6 months, percentage of good outcome reaches 84%. We find that ALT flaps thin very quickly after surgery, most of them is soft, their colors are less changed, however, in order to reconstruct delicate skin areas such as the cervicofacial skin, they still have some factors not completely suitable such as color, hair status of the flap, or facial expression ability due to flap-grated skin doesn't have the skin-attached muscle system. We don't observe any case with complications at flap-donor areas such as femoral hernia or decreased motor function of anterior thigh muscle groups. Postoperatively, all patients recover working ability well.

IV. CONCLUSION

Through anatomical analysis of 8 fresh cadavers, 20 formalin-treated cadavers and clinical application to 34 patients, we find that:

- ALT flap has a very constant anatomical structure. All specimens has skin-supplying perforating vessels, 53.57% of total specimens has 3 perforating vessels. Vascular peduncle is long (average is 6.1cm), diameters of 1 artery and 2 veins are regular, which are very suitable for microsurgery suture in cervicofacial area.

- ALT flap can be used very flexibly, shown in used method, used site, good vitality, wide size range, the size up to 16x25cm still ensures good blood supply, on the other hand, it's possible to take a flap with small size that still contains enough skin-supplying perforating vessels, there are many perforating vessels, so it is possible to separate many flaps with vascular peduncles.

- 84% of total patients grafted ALT flap for cervicofacial soft tissue defect reconstruction has good long-term outcomes. Flap-donor areas don't suffer from any major complications.

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