

ALT Free Flap as a Crucial Tool in Management of Post Burn Neck Contracture

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ABSTRACT

Contractures of the neck following burn injuries result in a restricted range of motion and an unattractive appearance. While various reconstruction techniques have been used to treat this condition, a minimal and unsatisfactory outcome is frequently achieved. Free flaps are an excellent single-stage alternative for neck contracture reconstruction following burns.

Objective: To evaluate the use of free Antero-lateral thigh flaps in management of post burn neck contracture.

Patients and Methods: This study was conducted at the Plastic Surgery Departments, Al-Hussien & Bab Elsheria Hospital, Faculty of Medicine, Al-Azhar University (Cairo) and Plastic Surgery Department, Faculty of Medicine, Beni Sweif University between January 2017 and May 2018, this study evaluated ten patients with postburn neck contractures managed with Antero-lateral thigh flaps in terms of functional, aesthetic Outcome, technical difficulties, and donor site morbidity.

Results: The results indicated that the recipient site improved functional and aesthetic outcomes. Also, the ALT flap has a long vascular pedicle that may reach up to seventeen centimeters in length. Additionally, the ALT flap allows a two-team approach and avoids shifting the patient's location during surgery. Limitations of flap usage are the variable anatomy of its vascular pedicle, the bulkiness of the flap, which necessitates secondary surgery for flap debulking, needs meticulous dissection of the pedicle, and limited width of the flap.

Key Words: *Post-burn contractures of neck – Contractures of the anterior cervical area – Free flaps – ALT flap.*

Conclusion: The ALT flap is a good option for post-burn neck contracture management.

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INTRODUCTION

Neck burn contracture is one of the most devastating deformities aesthetically and functionally. The deformity typically results in different degrees of decreased neck range of motion, shallow and restricted mento-cervical angle, stooped posture,

insomnia, and pain in the neck, especially with movement. Persistent upward gaze, Headache, and secondary vision problems are frequent. Malformations such as the inability to enclose the mouth, pulling the jaw inferiorly, ectropion of the lips, and even micrognathia originate from the surrounding skin being distorted. In advanced severe cases, the surrounding tissue beyond the neck subunits is also burned, which becomes a tremendous reconstructive challenge. These burn patients usually have various degrees of social problems and depression [1].

Recent studies recommend local tissue expansion, advancement, or expanded local perforator flaps as the ideal and straightforward treatment using similartissue [2,3].

In developing countries, burning is one of the causes of morbidity and mortality. According to World Health Organization (WHO), about 95% of fire-related burns worldwide occur in these developing countries [4].

Neck post-burn contracture incidence has been increased because of a decrease in mortality of major burns [5].

Anterior neck contractures have a unique group of complications compared to other areas in the body [6].

Due to the pliability of neck skin and flexibility, the neck is one of the common sites prone to contracture, affecting the function of the lower face and the neck movement [7].

When the basis of management of this challenging surgical post burn neck contracture is well known, good function and good aesthetic Outcomes can be achieved, which is the goal of neck reconstruction [8].

Scar excision and release then covered with a skin graft or flap is the standard technique for neck reconstruction in post-burn cases [9].

Neck contractures can be repaired using various methods, including Z-plasty, full and split-thickness skin grafts, pedicled skin flaps, and free flaps. Neck contracture can be treated in a variety of ways [10].

After contracture release, skin grafts as a cover have limitations as hyperpigmentation and re-contracture. Local flaps such as the transverse cervical artery perforator flap and the deltopectoral flap can be options with good contour and color. Still, they can cause unaesthetic donor site outcomes, so many patients don't accept [11].

After the burn contracture release, significant defects may result in local flaps not being managed except after expansion. But if local tissues are also burned, distant tissue transfer remains the only option for management [12].

ALT free flap has been the workhorse for soft tissue defects reconstructions all over the body since 1984 as it is pliable and thin. Its pedicle is based on perforators from the descending branch of the lateral circumflex femoral artery. Dissection of these perforators is the most challenging portion of raising the ALT flap due to their variability and different locations [13].

ALT flap has many clinical applications in the upper extremity, lower extremity, head & neck, trunk, breast, and abdominal wall reconstructions. Also, in complex reconstruction, the flap benefits from a generous pedicle length and diameter and can be used as a flow-through flap [14].

This study aimed to evaluate the use of free Antero-lateral thigh flaps in terms of functional, aesthetic Outcome, technical difficulties, and donor site morbidity.

PATIENTS AND METHODS

Study design: A prospective clinical trial.

Study site: The study was conducted at the Plastic Surgery Department, Al-Hussien & Bab Elsheria Hospital, Faculty of Medicine, Al-Azhar University (Cairo) and Plastic Surgery Department, Faculty of Medicine, Beni-Suef University.

Study period:

The study was conducted from January 2017 till February 2019.

Study population:

Patients with post-burn contracture of the neck who were seeking treatment in the outpatient plastic surgery clinic in both Al-Hussien & Bab Elsheria Hospital, Al-Azhar University (Cairo) and, Beni Sweif University Hospital.

Study sample:

The study consisted of 10 patients. Patients were entered into the study after giving written informed consent.

Inclusion criteria:

All patients with post-burn neck contracture for more than one year.

Exclusion criteria:

Patients younger than 12 years and older than 60 years, Patients with severe chronic illness as uncontrolled diabetes mellitus, hypertension, chronic renal failure, severe psychological disorders, patients with minor post-burn contracture, and finally, patients unable to complete the follow-up and rehabilitation program.

Pre-operative preparation:

- Proper history taking - Full general and local examination.
- Routine pre-operative investigations.
- Control of patient's medical condition, e.g., D.M. or hypertension.

Pre-operative photography:

Flap perforators were not subjected to routine radiological examinations.

Study procedure:

It was confirmed that the patient was willing to join the study just before entering the operating room (OR) for surgery.

All surgeries were performed or directly supervised by a study investigator. All participants had perioperative antibiotics per standard of care.

Pre-operative marking:

All flaps and sites of neck release were marked while the patient was awake.

1- *Marking of the vascular pedicle (Fig. 1):*

- Marking is done in a supine position.
- Two landmarks were identified; first at ASIS and second at the lateral border of the patella (two points marked by blue X).

- A line (blue dashed line) was drawn between these 2 points.
- This line was measured, and its midpoint was marked. A circle (small blue circle) of 5-6cm diameter was drawn centered around this midpoint. 85-100% of the perforators were found in this circle.

The perforator site was confirmed by handheld Doppler, and the location of the perforator with the highest intensity was marked with a red dot. A line (red line) was drawn from this dot toward a point along the course of the femoral artery (identified by feeling its pulsations) 2 fingers below the inguinal ligament. This line represents the expected course of the vascular pedicle.

2- Marking of the skin paddle:

The apparent defect size was roughly estimated by comparing each patient with another person of similar height and weight. These dimensions were confirmed after the full release of the neck.

Operative steps:

The patient was positioned in a supine position with the neck in hyperextension. Fiberoptic tracheal intubation was done for anesthesia. Vasoconstrictive agent (epinephrine 1:100,000) was infiltrated into the scar. The incision was made from the scar and deepened to the investing layer of the deep cervical fascia. The scar was excised, with the endpoint being a full cervical extension. Dissection of the recipient's vessels was performed (Fig. 2).

- The target arteries for anastomosis were the anterior branches of the external carotid artery, mainly the facial artery, and superior thyroid artery.
- The target vein for anastomosis was a common facial vein.

Two teams worked simultaneously; one team carried out the contracted cervical scar excision, and the other harvested the free flap.

ALT flaps were used from an unburned thigh. An incision was made along the medial border of the skin paddle. A subfascial dissection was done to identify perforators piercing the fascia arising from the lateral circumflex femoral system branches. The descending branch of the lateral circumflex femoral system was easily found after retracting the rectus femoris muscle medially.

Under loupe (4.5 x) magnification, retrograde intramuscular dissection was conducted in the direction of the designated musculocutaneous per-

forators. The motor nerve to the vastus lateralis was preserved to maintain the function of the residual muscle. Primary closure of donor-site was not possible because the width of the harvested flap for all cases was more than 7-8cm (Fig. 3). Split thickness skin grafts were used for coverage for all patients.

Flap debulking:

After harvest, any flap with a thickness of 15mm or more was thinned down to 1cm or less thickness by removing subcutaneous fat.

This was done by marking a circle with a 5cm diameter around the main perforator (No touch area), then the subcutaneous fat outside this circle was removed till reaching the desired thickness (Fig. 4).

Flap inset:

In setting the flap to the defect was done with 3-0 polypropylene vertical mattress sutures (Fig. 5).

End-to-end microsurgical anastomosis of the vessels was performed using 9-0 nylon under loupe (4.5 x) magnification. A soft rubber drain was placed under the flap and away from the site of anastomosis. Post-operative splinting not done. Patients were followed-up at a plastic surgery facility or ICU.

Anticoagulant protocol:

- 5000 IU of Heparin was given once the anastomosis started, and 1000 IU every hour till the end of surgery.
- Post-operative anticoagulant, Heparin 5000 unit every 4 hours for 24 hours then shifted to enoxaparin sodium therapeutic dose for three days.

Follow-up:

For the 1st 48 hours post-operative, the patients were observed every hour for vital signs, bleeding, and for any signs of flap failure (venous or arterial).

According to their weights, the patients were maintained on I.V fluids to ensure tissue perfusion.

After discharge, patients were followed-up every week for one month, then at 2, 3, and 6 months.

Study investigators and participants were aware of group assignments (open-label).

The patients were asked and examined for any complications or side effects at each visit.

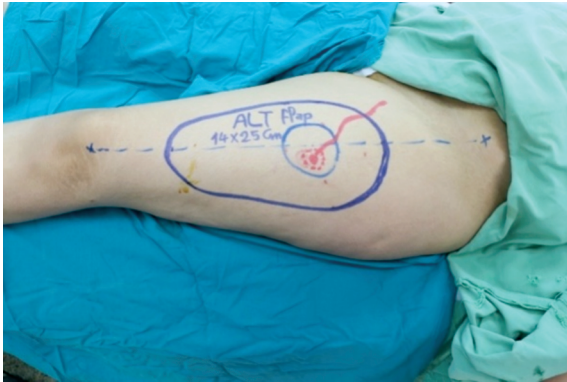


Fig. (1): Marking of ALT flap, a point at ASIS and second at the lateral border of the patella, perforators were found in a circle 5cm around the midpoint the flap measures 14cm width *25cm length.



Fig. (2): After full release of the neck and marking of recipient's vessels.

Fig. (3): ALT free flap after harvesting (14*25 cm in dimensions).

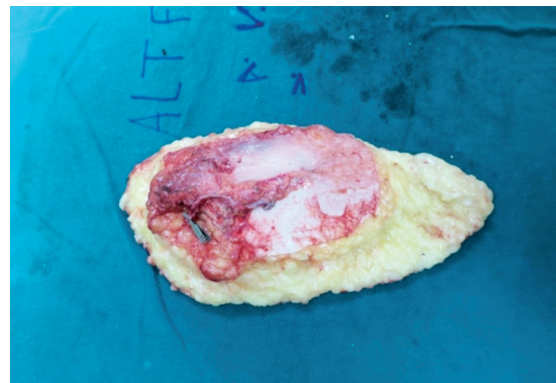
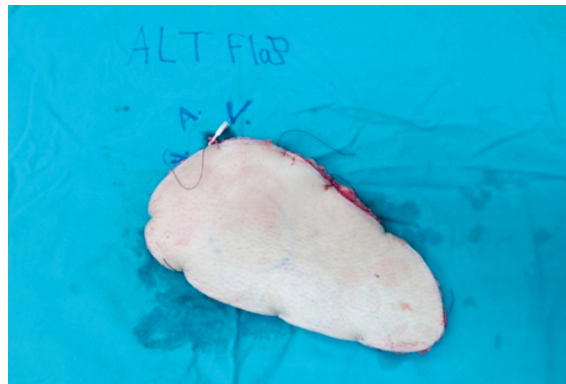


Fig. (4): Shows an ALT flap before, and after debulking, a 5cm diameter around the main perforator (No touch area), then the subcutaneous fat outside this circle was removed till reaching the desired thickness.



Fig. (5): Showing Flap inset.

Evaluation:

1- *Ease of harvesting:*

- Patient positioning.
- Possibility of two teams approach.
- Constancy of perforators.
- Operative time.

The thickness of the flap.

2- *Need for secondary procedures:*

Procedures for flap debulking (surgical or liposuction), 2ry closure for wound dehiscence, and contracture release along flap margin.

3- Donor site morbidity:

Problems of graft and scar issues.

4- Functional assessment:

- Degree of neck extension.
- Measurement of cervicomenal angle was done by using the Goniometer.

5- Aesthetic outcome:

- The patients themselves used a self-made, non-standardized questionnaire to assess the subjective satisfaction with the aesthetic results. According to the German school marking system, results were rated on a scale from 1 to 6 (1 excellent, 2 good, 3 fair/satisfactory, 4 sufficient/pass, 5 deficient/bare pass, and 6 poor/fail).
- These questionnaires were applied for both the donor site and the reconstructed neck.

6- Complications.

Photography:

- Each patient was photographed in 3 views: Anterior and bilateral views.
- Each view in 2 positions resting position and maximum extension of the neck.
- Photography was done preoperatively and repeated at every follow-up visit post-operatively.

Ethical consideration:

Approval by the institutional ethical committee was taken.

Time was spent with the patient and his family, explaining the procedure in detail utilizing photographs and video imaging.

All Inquiries from the parent regarding possible complications, Duration of hospital stay, time to return to regular activity, and any other inquiry were discussed in detail with each patient.

Individual consent process:

Informed consent was taken after informing the study objectives and the procedures to potential participants. Participation was voluntary, and we told the participants that the decision they took would not affect the quality of care they would receive.

RESULTS

This study was conducted at the Plastic Surgery Department, Al-Hussien & Bab Elsheria Hospital,

Faculty of Medicine, Al-Azhar University (Cairo), and Plastic Surgery Department, Faculty of Medicine, Beni-Suef University.

The study included 10 patients with post-burn contracture of the neck.

Informed consent was obtained.

Our research included the following parameters:

1- The baseline characteristics:

- Age.
- Gender.
- BMI.
- Co-morbidities, e.g., hypertension and D.M.
- Smoking.
- Analytical data:

All the patients had been subjected to follow-up for 6 months. The following results were reported:

- 1- Operative time.
- 2- Hospital stay.
- 3- Flap dimension, thickness.
- 4- Pedicle length, the diameter of artery and vein.
- 5- Complications: Early and late.
- 6- Need for secondary procedures.
- 7- Functional Outcome:
 - Degree of neck extension.
 - Cervico-mental angle.
- 8- Aesthetic Outcome:
 - Donor site.
 - Recipient site (reconstructed neck).

According to the German school marking system, results were rated on a scale from 1 to 6 (1 excellent, 2 good, 3 fair/satisfactory, 4 sufficient/pass, 5 deficient/bare pass, and 6 poor/fail).

The analyzed data were collected and tabulated, and the following results were obtained.

1- Baseline characteristics.

2- Co-morbidities:

There was one patient (10%) who had diabetes mellitus, two (20%) had hypertension, and two (20%) patients were smokers.

4- Intra-operative and post-operative parameters.

1- Operative time:

The mean operative Time was 386.5 ± 32.7 min.

2- Hospital Stay:

Mean hospital stay 12.1 ± 1.8 days.

3- Flap Parameters

Flap thickness: The mean flap thickness was 15.8mm (ranging from 8 to 23mm).

Arterial pedicle diameter: The mean arterial pedicle diameter was 2.9mm (ranging from 2.5 to 3.9mm).

Venous pedicle diameter: The mean venous pedicle diameter was 3.3mm (ranging from 2.8 to 4.3mm).

Pedicle Length: The mean of the vascular pedicle length f was 12.56cm (ranging from 10.7 to 14.cm).

4- Constancy of perforators:

Eight ALT flaps had an intramuscular perforator (80%) with only two flaps (20%) with septocutaneous perforators.

5- Patient positioning and Possibility of two teams approach:

All cases did not require a change position of the patient, with two teams operating simultaneously. Team for neck contracture release and preparation of recipient vessels and the other team to harvest the ALT flap.

6- Recipient's vessels.

7- Donor site closure:

In all patients, the donor site is closed by a split-thickness graft.

8- Functional Outcome

Average Improvement in Cervico-Mandibular Angle:

- ALT = $114.5 - 53.5 = 61$ degrees.

Average Improvement in Neck Extension:

- ALT = $46 - 17 = 29$ degrees.

9- Aesthetic Outcome

The donor site of ALT flap.

10- Secondary Procedures.

11- Complications

Early Complications:

Table (1): Summarizes the relevant patients' baseline characteristics of the patients.

Variables	Mean (S.D.) or Frequency (%)
Age	33.1 (8.69)
<i>Gender:</i>	
Male	3 (30%)
Female	7 (70%)
BMI	29.9 (2.9)
Duration since burn (months)	13.6 (4.22)

Table (2): Associated co-morbidities.

	Count	%
<i>Diabetic (type 2) (Yes/No):</i>		
Yes	1	10
No	9	90
<i>Hypertension:</i>		
Yes	2	20
No	8	80
<i>Smoking:</i>		
Yes	2	20
No	8	80

Table (3): Operative time.

	(ALT) Mean (S.D.)
Operative time (minutes)	386.5 (32.7)

Table (4): Hospital stay.

	ALT Mean (S.D.)
Hospital stay (days)	12.1 (1.8)

Table (5): Flap parameters.

	(ALT) Mean (SD)
Flap Size (cm)	12.6 (1.35) * 23 (1.76)
Flap thickness (mm)	15.8 (4.7)
Arterial pedicle diameter (mm)	2.9 (0.35)
Venous pedicle diameter (mm)	3.3 (0.55)
Pedicle Length (cm)	12.56 (1.1)

Table (6): Recipient's vessels.

Recipient's vessels	No.	%
Rt Facial artery	5	50
Lt facial artery	2	20
Rt superior thyroid artery	1	10
Lt superior thyroid artery	2	20

Table (7): Functional assessment.

	Mean (SD)
Preoperative Cervicomentral angle	53.5 (14.35)
Postoperative Cervicomentral angle	114.5 (7.25)
Degree of neck extension (from the normal horizontal plane) (pre-operative)	17 (5.37)
Degree of neck extension (from the normal horizontal plane) (post-operative)	46 (7.75)

Table (8): The distribution of patients by aesthetic outcome.

	No	%
<i>Donor site:</i>		
Excellent	0	–
Good	1	10
Fair	2	20
Sufficient/pass	2	–
Deficient	2	20
Poor/Fail	3	30
<i>Recipient site (Reconstructed neck):</i>		
Excellent	1	10
Good	2	20
Fair	3	30
Sufficient/pass	4	40
Deficient	0	–
Poor/Fail	0	–

Table (9): 2ry procedures required.

	No	%
Immediate Debulking	7	70
Delayed Debulking (Liposuction)	6	60
Z Plasty along flap margin	2	20
Donor Site (Regraft-2ry closure)	3	30



Fig. (6): Donor site of the graft (on the left) and Donor site ALT (on the right).

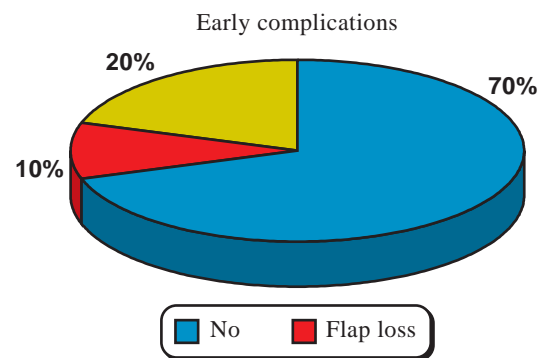


Fig. (7): Early complications.

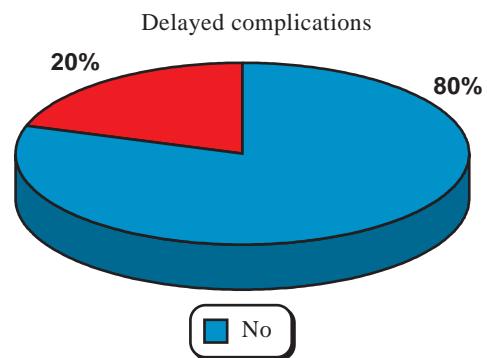
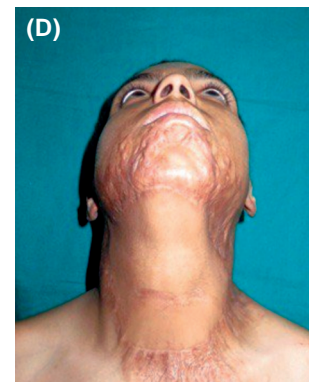


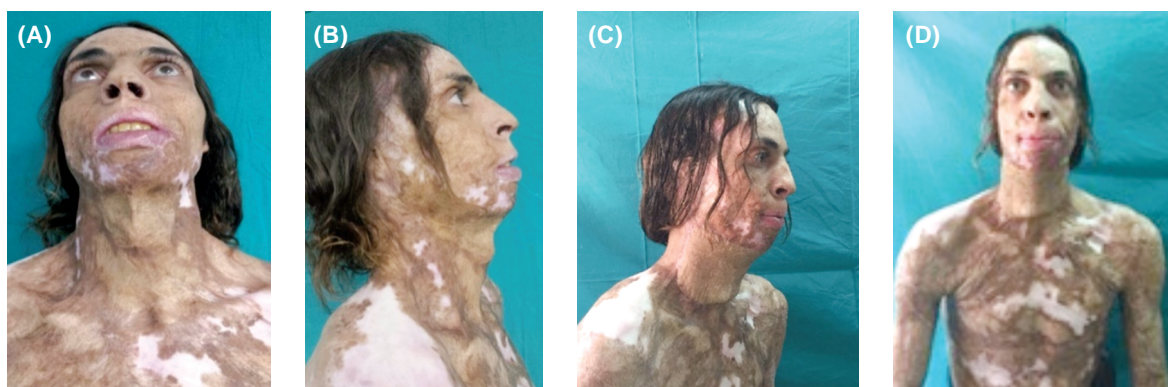
Fig. (8): Delayed complications.



Case (1): 9 years old with post flame burn neck contracture (A) Pre-operative photo lateral view, (B) Pre-operative photo anterior view, (C) Post-operative photo lateral view and (D) Post-operative photo anterior view.



Case (2): 29 years old female patient with post flame burn neck contracture 5 years ago (A) Pre-operative photo anterior view, (B) Pre-operative photo lateral view, (C) Post-operative photo anterior view and (D) Post-operative photo lateral view.



Case (3): 25 years old male patient with post burn neck contracture 4 years ago (A) Pre-operative photo anterior view, (B) Pre-operative photo lateral view, (C) Post-operative photo lateral view and (D) Post-operative photo anterior view.

DISCUSSION

The decreased rate in mortality of extensive burn cases leads to an increase in the incidence of post-burn neck contracture). Deformities and well-being following a contracted neckburn are commonly prevalent and stressful, impacting patients' quality of life [5].

Akita [12] classified neck contractures into mild to moderate, severe, and fusion in which chin fused with manubrium. In contrast, Onah classified it according to shape and extent of contracture [13].

Defects can't be repaired with local flaps when a broad contracture area is released. Local tissue expansion can be a solution in these situations. However, when local tissues are burned as well, distant tissue transfer is the only alternative [14].

Zhang [15] defined the neck for the sake of reconstruction as the area between superiorly, the oral commissure, inferiorly the sternal notch and the clavicles, and laterally the midaxial plane. And then subdivided into 3 subunits: Lower lip/chin subunit, submental subunit, and anterior neck subunit. This is the basis for the currently presented treatment strategy [15].

Hence, we conducted a prospective clinical trial that included 10 patients with post-burn neck contracture to assess free ALT flap considering ease of harvesting, need for secondary procedures, functional and aesthetic Outcomes. They were followed up regularly for 6 months, and the data was analyzed.

ALT flap is known as a workhorse flap providing a large skin paddle that can cover large defects, which is why choosing this flap.

Regarding Duration since burn, the mean duration was 13.6 ± 4.22 .

Although Sarkar et al. [16] similarly reported a mean duration since burn of 12.27 months; they included some patients with only 6 months since burn. This was unlike our study as we excluded any patient with less than one year of Duration since burn to ensure full maturation of the scar.

Regarding operative Time, the mean operative time was 386 ± 32.7 min.

Similarly, Sarkar et al. [16] reported an average operative time for postburn neck contracture release with free ALT was 6.5 hours.

Regarding hospital stay: The mean hospital stay was 12.1 ± 1.8 days.

Sarkar et al. [16] reported 16.36 days as an average hospital stay for postburn neck contracture release with free ALT, which is longer than our study.

Regarding flap parameters:

Flap size:

The mean flap size was $12.6 (1.35) \times 23 (1.76)$.

Flap width is more critical than flap length as it is the factor that determines whether the flap donor site can be closed primarily or not. The mean width was 12.6 ± 1.35 , which is more than 8cm; so, all donor sites were closed by a split-thickness graft or closed primarily.

Flap thickness:

The mean flap thickness was 15.8 ± 4.7 mm.

However, we made 15mm thickness as a limit above it, we did immediate debulking, and below it, no immediate debulking was done. According to this, 7 of 10 ALT flaps needed immediate debulking.

Busnardo et al. [17] reported 9.30 ± 3.54 mm flap thickness for the ALT flap, which is lower than ours. It is essential to mention that flap thickness varies according to sex, body weight, and race. Only males with BMI between 20 and 24.9 kg m^2 were selected.

Arterial pedicle diameter:

Using the correlation established by the arterial pedicle average, the overall mean arterial diameter was 2.9 ± 0.35 mm.

Sarkar et al. [16] reported a 2.2mm average diameter of the arterial pedicle of the ALT flap.

Venous pedicle diameter:

The mean of the venous pedicle diameter was 3.3 ± 0.55 mm.

Busnardo et al. [17] reported a 3.87 ± 0.70 mm arterial pedicle diameter of ALT flap.

Also, Sarkar et al. [16] said 2.5mm average diameter the venous pedicle of ALT flap of the artery 2.2mm.

Pedicle length:

The mean length of the vascular pedicle was 12.56 ± 1.1 cm.

Busnardo et al. [17] reported a 13.43 ± 3.92 mm pedicle length of ALT flap.

Wei et al. [18] observed a difference in the length of the vascular pedicle of the ALT flap from 8 to 16cm in 672 free transplants. Shieh et al., 2000 listed an average measurement of 12.01cm, and Yu et al., 2004 said it to have varied between 9.7cm and 13.2cm.

Regarding the recipient's vessels:

The recipient artery for flap anastomosis was the facial artery in 7 cases and the superior thyroid artery in 3 patients.

The recipient's vein was a common facial vein in all our study cases.

Parwaz et al. [19] similarly reported that the recipient artery used mainly was the facial artery and the recipient's vein was one of the internal jugular vein tributaries.

Regarding functional outcomes: The average improvement in the Cervico-Mandibular Angle was 61 degrees measured by the Goniometer.

The average improvement in Neck Extension was 29 degrees.

This was found to agree with Sarkar et al. [16], who reported an Average Improvement in Cervico-Mandibular Angle with 64.28 degrees and an Average Improvement in Neck Extension with 35.09 degrees after treatment of postburn neck contracture with free ALT flap.

Regarding secondary procedures: Immediate debulking was done in 7 cases (70%) with p -value 0.001.

Other 2ry procedures (Delayed debulking (liposuction), Z-plasty, and donor site problems).

Regarding complications:

Early complications:

In our study, early post-operative complications were reported in 3 cases; one case (10%) in the form of total flap loss, which was managed by debridement and split-thickness graft followed by neck splint for two months, and two cases (20%) of post-operative hemorrhage which managed by transferring the patient back to the operative theater and control of bleeding under general anesthesia.

Sarkar et al. [16] reported the following early complications: 2 cases of epidermal loss and 2 cases of distal flap necrosis in a study that included 11 patients of post-burn neck reconstruction with free ALT flap.

Delayed complications:

Our study reported the following delayed complications; 2 cases of contracture along flap border, which were managed by Z-plasty.

Conclusion:

Free flaps are techniques used to reconstruct a post-burn neck contracture, and they involve extensive, time-consuming management with the potential for future revisions. They boost post-burn neck contracture's aesthetics, functional result, and resurfacing by providing full-thickness skin and subcutaneous tissue.

The free anterolateral thigh flap is a reliable alternative for post-burn neck contracture reconstruction. It offers an extensive, high-quality skin flap that can cover the defect after the contracture has been released.

One of the key benefits of the ALT flap is that two teams can approach it without requiring the patient to change positions during surgery. Another potential benefit is the significantly longer vascular pedicle.

In all the current study cases, the donor site was closed with a split-thickness graft from the other thigh.

The ALT flap perforator has a variable course requiring a tedious dissection, particularly for its intramuscular portion.

Limitations of the study:

- A small number of cases.
- Short follow-up period.
- No functional assessment was done for donor site morbidity.

REFERENCES

- 1- Tahsin O ğuz Acartürk* and Fuat Barış Bengür: Reconstruction of burn contractures of the anterior neck with pre-expanded free anterolateral thigh flaps. *Injury*, 5 (13): 35, 2020.
- 2- Gao Y., Li H., Gu B., Xie F., Zhu H., Wang Z., et al.: Postburn neck contracture: Principles of reconstruction and a treatment algorithm. *J. Reconstr. Microsurg.*, 34 (7): 514-21. doi: 10.1055/s- 0038- 1641724, 2018.
- 3- Li H., Wang Z., Gu B., Gao Y., Xie F., Zhu H., et al.: Postburn neck reconstruction with preexpanded upper back perforator flaps: Free-Style design and an up-date of treatment strategies. *Ann. Plast. Surg.*, 81 (1): 45-9. doi: 10.1097/SAP.00000000000001491, 2018.
- 4- Sinha I., Zhu D., Ojomo K. Gfrerer L., Sawh-Martinez R., Patel A., Chan R.K. and Watkins J.F.: Functional and subjective assessment of burn contracture release in a mission setting. *Burns*, 42: 466-470, 2016.
- 5- Devi S.R., Kalita H., Baishya J., Boruah P., et al.: Functional and esthetic considerations in reconstruction of post-burn contracture of the neck. *Indian J. Burn.*, 21: 58, 2013.
- 6- Margulis A., Agam K., Icekson M., Dotan L., Yanko-Arzi R. and Neuman R.: The expanded supraclavicular flap, prefabricated with thoracoacromial vessels, for reconstruction of postburn anterior cervical contractures. *Plast. Reconstr. Surg. Jun.*, 119 (7): 2072-7, 2007.
- 7- Khan N.U., Amin M.M., El-Muttaqi A., Tayyaba F.U., Sajid M., Javed L. and Ayesha: Supraclavicular artery island flap reconstruction for post burn neck contractures. *Pak. J. Surg.*, 28 (1): 76-80, 2012.
- 8- Sharma R.K., et al.: Post-burn neck contracture: Should the skin graft be banished. *Indian J. Burn*, 21: 48, 2013.
- 9- Goel A. and Shrivastava P.: Post-burn scars and scar contractures. *Indian J. Plast. Surg. Sep.*, 43 (Suppl): S63-S71, 2010.
- 10- Albarah A., Kishk T., Megahed M., Elsakka D. and Ghareeb F.: Pre-expanded extended island parascapular flap for reconstruction of post-burn neck contracture. *Ann. of burns and fire disasters Mar.*, 31; 23 (1): 28-32, 2010.
- 11- Song B., Xiao B., Liu C., He L., Li Y., Sun F., et al.: Neck burn reconstruction with pre-expanded scapular free flaps. *Burns*, 41: 624-630, 2015.
- 12- Akita S., Hayashida K., Takaki S., Kawakami Y., et al.: The neck burn scar contracture: A concept of effective treatment. *Burns & Trauma*, 5: 22, 2017.
- 13- Prakash S. and Mullick P.: Airway management in patients with burn contractures of the neck burns, 41: 1627-1635, 2015.
- 14- Acartürk T.O.: Aesthetic Reconstruction of the Postburn Neck Contracture With a Preexpanded Anterolateral Thigh Free Flap. *J. Craniofac. Surg.*, 25: e23-e26, 2014.
- 15- Zhang Y.X., Wang D., Follmar K.E., Yang J., et al.: A Treatment Strategy for Postburn Neck Reconstruction Emphasizing the Functional and Aesthetic Importance of the Cervicomentale Angle. *Ann. Plast. Surg.*, 65: 528-534, 2010.
- 16- Sarkar A., Raghavendra S., Jeelani Naiyer M.G., Bhattacharya D., et al.: Free thin anterolateral thigh flap for post-burn neck contractures - a functional and aesthetic solution. *Annals of Burns and Fire Disasters. Dec.*, 31; 27 (4): 209, 2014.
- 17- Busnardo F.F., Coltro P.S., Oliván M.V., Faes J.C., et al.: Anatomical comparison among the anterolateral thigh, the parascapular and the lateral arm flaps. *Microsurgery*, Jul., 35 (5): 387-92, 2015.
- 18- Wei F.C., Jain V., Celik N., Chen H.C., Chuang D.C., et al.: Have we found an ideal soft-tissue flap? An experience with 672 anterolateral thigh flap. *Plast. Reconstr. Surg. Jun.*, 109 (7): 2219-26, 2002.
- 19- Parwaz M.A., Dalal R., Chakravarty B. and Malik A.: Free parascapular flap reconstruction of post burn neck contracture. *Indian Journal of Burns. Dec.*, 22 (1): 67-71, 2014.