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SUBDERMAL PLEXUS FLAPS

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Subdermal plexus flaps are a group of skin flaps used to close acute and chronic wounds. They can be obtained from any location and direction, and their viability depends on the collateral circulation from the remaining skin junction and its vascularisation, the subdermal plexus. Flap survival is conditioned by surgical decision-making, understanding of skin physiology, factors affecting wound healing, and assessment of skin elasticity, mobility, and local lines of tension.

ANATOMY AND PHYSIOLOGY

Flaps based on the subdermal plexus, which include skin and subcutaneous tissue, receive their blood supply from collateral connections to the subcutaneous plexus. The skin has a segmental arterial supply from simple and mixed cutaneous arteries that run between or through the muscles, respectively, and branch into three main plexuses that run parallel to the skin surface. These plexuses include:

- Subcutaneous plexus (deep)
- Cutaneous plexus (middle)
- Subpapillary plexus (superficial)

In the absence of underlying diseases, such as neoplasms or infections, critical factors for rapid healing of a defect covered with a skin flap include preservation of blood supply, closure with minimal tension, and adequate systemic nutritional status.

The delay phenomenon comprises a set of mechanisms by which flap survival is improved through staged development. The flap can be physiologically "trained" to depend on the vascular support of its pedicle by progressively reducing the blood supply from other sources. Tissue expansion is another form of delay. In this type of flap, circulation increases to 120–150% of the baseline value after approximately 3 weeks. The new elevation of a flap after a 3-week delay causes a much smaller decrease in blood flow (up to 90% of the baseline value), thus increasing the survival rate.

The main factors contributing to this phenomenon are: modification of sympathetic tone, dilation of transition vessels ("choke vessels"), vascular reorientation, early and late metabolic changes, and neovascularisation.

Recent research in dogs has shown that local treatment with autologous platelet-rich plasma increases tissue perfusion and improves the survival of subdermal plexus flaps through vasodilation of existing vessels.

PATIENT PREPARATION

To plan and perform a flap to cover the wound in question, the following conditions must be met:

- Optimal general and nutritional status of the patient.
- Healthy wound bed, free of infection, necrotic tissue, or neoplastic disease. In chronic open wounds, margin excision may be necessary to remove thin layers of fragile epithelium that could compromise the aesthetic outcome.
- Extensive shaving to include as much skin as possible within the surgical field.

GUIDE FOR FLAP DESIGN

Subdermal plexus flaps are used when there is vascularised skin in the vicinity of the defect, but their insertions must be strategically divided to allow their displacement from areas with loose skin.

Avoid creating them in highly mobile regions (axillary or inguinal) unless axillary or inguinal skin folds are used as subdermal flaps.

Flaps and relief incisions are most effective when developed adjacent to the skin defect.

As a general rule:

- The base of the flap should be slightly wider than its body to avoid inadvertent narrowing of the pedicle.
- The length should be limited to that necessary to cover the recipient bed without excessive tension. Shortening the length of the flap, when possible, improves its viability.
- For these flaps, a length-to-width ratio of ≤ 1.5 is generally recommended.

Excessive narrowing of the base compromises survival, but widening beyond the optimal diameter does not improve it; it simply increases the likelihood of including a direct cutaneous artery in the base.

Therefore, flaps should be designed with a base slightly wider than the total width of the flap and with sufficient length to cover the defect, while allowing closure of the donor site and maintenance of adequate blood supply to the flap. A guideline based on a "proportional length-to-width ratio" has been proposed in the human surgical literature; however, it is not possible to establish specific recommendations for this ratio, as vascular supply varies between individuals and in different body regions.

A study in dogs showed that flaps of equal length but varying width (based on the same blood supply from the subdermal plexus) had essentially equivalent areas of survival.

During dissection, damage to the subdermal plexus should be avoided. In some cases (e.g., cutaneous muscle of the trunk), the subcutaneous musculature should be included in the flap due to its close association with the skin.

Closure is usually performed in two or three layers: absorbable sutures buried in the subcutaneous tissue and non-absorbable sutures or staples in the skin, concentrating all the tension in the deep sutures to relieve tension on the skin.

TYPES OF FLAPS BASED ON THE SUBDERMAL PLEXUS

Flaps can be classified as local or distant depending on their location relative to the recipient site:

- Local flaps: these are adjacent to the recipient site and can be used in most areas of the body.
- Distant flaps: these are obtained at a distance from the recipient site (used mainly for wound closure in the extremities). They can be subdivided into:

- Direct: transferred directly to the wound.
- Indirect: delayed transfer of a tubular flap.

In this text, we will focus exclusively on local flaps.

ADVANCEMENT FLAPS

These move skin without rotation, taking advantage of the skin's inherent elasticity to cover the defect.

Examples of advancement flaps:

- **Single pedicle advancement flap (U-shaped) Fig. 1:** formed by two skin incisions of equivalent length to the defect.
  - For these flaps, a length-to-width ratio of ≤ 1.5 is generally recommended.
  - These incisions start at each end of the wound bed, the margin of which forms the third side of the flap.
  - Divergent incisions towards the base are recommended to avoid compromising the blood supply.
  - Two single-pedicle flaps can be used simultaneously bilaterally (H-plasty) to reduce the length of each flap and preserve irrigation.

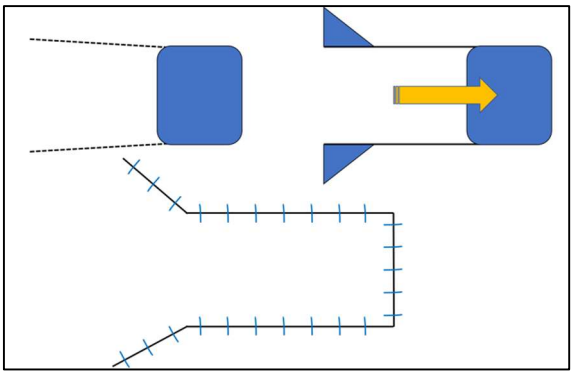

Fig. 1 Single pedicle advancement flap

- **Double pedicle (bipedicle) advancement flap:** this is created by a single relief incision, parallel to the length of the wound, leaving two vascular pedicles (in the form of a bridge).
  - The width of the flap should approximate the width of the defect.
  - The total length should not exceed twice the width of the base.
  - It is mainly used for quadrangular wounds on the trunk, face, and forehead.

- **Full-thickness advancement flap (upper and lower):** a composite flap of total thickness that includes skin, subcutaneous tissue, and oral mucosa.
  - It is based on the upper and lower labial arteries (facial, *angularis oris*, etc.), partially classifiable as axial flaps.
  - Commonly used in full-thickness rostral lip defects.
  - The mucosal incision (3-5 mm from the gingival junction) should extend to the last molar if maximum length is required.
  - Due to excellent orofacial vascularisation, these flaps can tolerate ratios of up to 3:1 (length:width). Closure is performed in three planes: mucosa, subcutaneous tissue and skin.

ROTATION FLAPS (Fig. 2)

Semicircular flaps that rotate towards the adjacent recipient bed. They are versatile and capable of covering large areas.

In triangular wounds, the curved incision begins at the shorter side, so that the anterior edge of the flap shares a border with the longer side.

In rectangular wounds, bilateral rotation flaps can be developed.

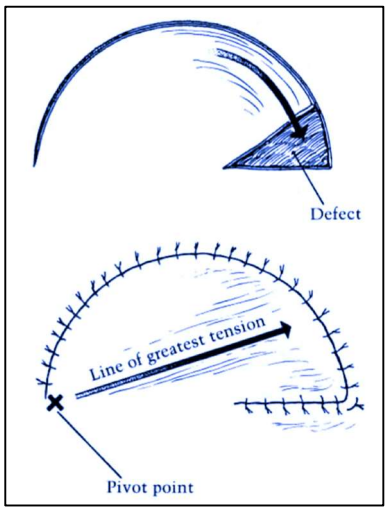

Fig. 2 Rotation flap

TRANSPOSITION FLAPS (Fig. 3)

Rectangular pedicle flaps developed at less than 90° to the longitudinal axis of the defect, with one edge adjacent to the recipient bed.

- The width should match that of the defect.
- The length is equivalent to the distance between the pivot point and the furthest point of the defect.

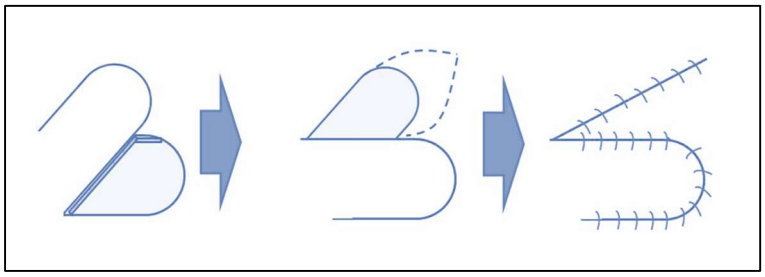

Fig. 3 Transposition flaps

INTERPOLATION FLAPS (Fig. 4)

These are basically transposition flaps that do not share an edge with the defect and must cross healthy skin via a bridge incision.

Long pedicles can be made in the form of a tube in the segment that crosses intact skin; after integration into the bed, the excess skin is removed once healed, about two weeks later, requiring a second surgery.

An example of an interpolation flap is the lip-to-lid flap, which uses the junction between the caudal skin of the upper lip and the labial mucosa to replace the lower (or laterodorsal) eyelid. They generally have a high success rate and good ophthalmological results in dogs and cats.

Although classified as a subdermal plexus mucocutaneous flap, its high success rate is probably due to the vascular contributions of the *angularis oris* artery.

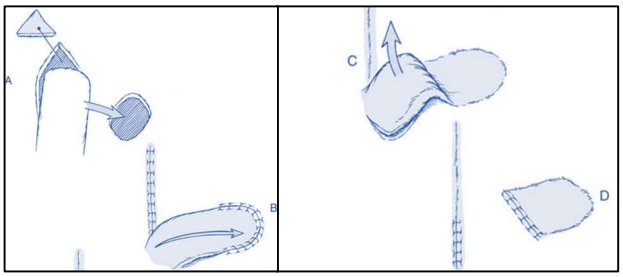

Fig. 4 – Interpolation flap

PLASTY

Procedures designed to modify the shape of tissue. Z, V-Y and H. These are different types of advancement and rotation flaps.

- Z-plasty and V-Y plasty: the long axis of a skin wound is rotated up to 90 degrees, transferring tension and reducing elastic recoil at the far edge of the wound, which is particularly useful near the eyelids.

- H-plasty: bilateral advancement flaps with a single pedicle and a wider base-to-length ratio than unilateral single-pedicle flaps, which improves blood supply and survival.

COMPOSITE FLAPS

Flaps that incorporate underlying structures along with the skin:

- Axial pattern myocutaneous flaps (latissimus dorsi flap).
- Subdermal plexus mucocutaneous flaps, based on the lips and labial mucosa:
    - Labial advancement flap.
    - Lip-to-eyelid flap.

SOME SPECIFIC SUBDERMAL FLAPS

1. Skin fold flaps:

These triangular folds of axillary and inguinal skin are areas with a large amount of useful skin, with two layers of skin (lateral and medial) folded and attached to each other by loose connective tissue, which can be used to close large adjacent skin defects.

The folds have four insertions in the animal: lateral and medial to the thoracic limb, and dorsal and ventral to the trunk.

If the flap is resected and unfolded by sharp dissection, a robust U-shaped piece of skin is obtained. Preservation of any of the four insertions provides sufficient blood supply to ensure flap survival in most animals.

Although they are considered subdermal plexus flaps, the lateral thoracic artery is close to the elbow/axillary fold, and the deep iliac circumflex artery is close to the flank/groin fold. Therefore, when these arteries are included, they function as axial pattern flaps.

Skin fold flaps have been used successfully to close defects in the inguinal and pectoral regions, the lateral thorax and flank, the lateral and medial thigh, the knee, and the medial region of the thoracic limb and elbow.

2. Scrotal flap:

After castrating the patient, an incision can be made at the base of the scrotum adjacent to the defect, and the scrotum (after incising the tunica dartos and preserving a pedicle on the side opposite the defect) is transformed into an advancement flap to close perineal and inguinal defects.

3. Perivulvar flap:

The vulvar fold, perineal skin dorsal to the vulva, can be mobilised by incising its insertion to the dorsal perineum and vulva, but leaving it attached on one side. It is useful for closing dorsal or cranial-ventral perineal defects to the vulva.

4. Phalangeal or digital flap:

This flap is very useful and is probably used much more than is described in the literature. Its creation involves amputating one or more toes while preserving the skin and pad of that toe or toes. Defects involving portions of the metacarpal or metatarsal pad can be closed using a composite skin and pad flap, in which the digital pad is preserved.

5. Labial flaps:

Covered in the section "Advance flaps".

6. Lip-to-eyelid flap:

Covered in the section "Interpolation flaps".

COMPLICATIONS OF SUBDERMAL FLAPS

The main complications of subdermal flaps are:

- Infection: Use proper sterile technique to ensure that the wound bed remains clean and healthy. Some wounds with chronic infection should be treated with open management until conditions for healing improve.

- Seroma formation: Use active suction drainage in areas with loose skin and dead space, or apply a gentle compression dressing. Restriction of activity is also essential for optimal healing.

- Skin edge dehiscence: The main causes of dehiscence are infection, tension, surgical trauma, flap

necrosis, incomplete resection margins and persistence of tumour cells at the edges, patients with systemic problems (renal failure, liver failure, hyperadrenocorticism, hypothyroidism), administration of corticosteroids or chemotherapeutic agents, and local treatment with radiotherapy. The morbidity associated with flap procedures before or after radiotherapy is high, with dehiscence reported in 62%, flap necrosis in 35%, and infection in 27%. The risk of complications is higher when radiotherapy is performed before flap procedures due to damage to local fibroblasts and blood vessels.

- Necrosis: Flap necrosis occurs when the metabolic requirements of the skin exceed the perfusion capacity of the subdermal plexus: insufficient number of vessels due to a narrow pedicle, damage to the subdermal plexus during flap creation, thrombosis of the subdermal plexus, decreased perfusion or peripheral oxygenation due to haemodynamic or respiratory compromise, self-trauma, and bandaging. Hyperbaric oxygen therapy has been recommended as a treatment for flaps with marginal vascularisation. An increase in blood flow (but not vascularisation) and improved flap survival have also been observed following local injection of autologous platelet-rich plasma, presumably due to vasodilation of existing vessels.

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