Plastic Surgery

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***Plastic surgery*** means *formative surgery (reconstruction of form & function)*.

* **structural integrity**, **function**, and **aesthetics** are simultaneous goals - plastic surgeon must be both *artist* and *engineer*.

Tagliacozzi, of Bologna (1545-1599) is modern *father of plastic surgery.*

Three propertiesof skin are essential for reconstruction:

1. **Elasticity** (collagen fibers) keeps skin in constant tension; absence of elasticity → wrinkles.
2. **Extensibility** - skin's ability to stretch.
3. **Resilience** - skin's resistance to infection and puncture.

GENERAL PRINCIPLES

Wound Repair

##### Skin Incisions & Excisions

* place incision in most inconspicuous place possible (e.g. facelift incision is placed at hairline).
* key determinant of scarring is amount of **tension across wound**.
* tension can be minimized by placing incisions parallel to relaxed skin tension lines (RSTL):

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| * incisions should be placed such as to distract viewer's eye from scar – by hiding scar in junction lines of face that exist around ala base, nostril rim, preauricular region, and lower eyelid just below eyelashes (subciliary region): |  | |
| * incisions placed across joint surfaces must be oriented across joint in oblique / transverse manner (scar will not limit range of motion): | |  |

* if excision is made, make certain that incision is placed so adequate amount of skin can be mobilized to allow *closure with minimal tension*.
* make certain that operation can be accomplished through incision, keeping in mind that it should be possible to lengthen incision if necessary.
* body areas that are especially prone to excessive scarring:

1. **Shoulders, triangle over anterior chest** (acromion processes - xiphoid process) - incisions will predictably heal with conspicuous scar (often hypertrophic or keloidal).
2. **Plantar area** - pain with scarring is common problem.

Healing skin wounds contract in three dimensions.

* skin wounds contract up to 20% in **longitudinal direction** (same axis as wound) - can be *functionally incapacitating* (e.g. across flexor surface of joint).
* contraction **across wound** is minimal owing to short distance.

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| * contraction in **plane perpendicular to skin** **surface** can result in *scar depression*.   Scar depression can be prevented by use of *everting sutures* (esp. vertical mattress) + *excision design* (excision is trapezoidal and edges are 3-6 mm undermined): |  |

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| Double lenticular (ellliptical) excision is best excision for removal of basic skin lesions.   * *long axis* should be 2,5-4 times length of *short axis* (if ellipse is too short, excess tissue will form at end and require excision): |  |

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| * orient long axis **along RSTL** (if it is difficult to determine RSTL, circular excision is made, surrounding tissue undermined in all directions - will elongate to elliptical shape with natural skin tension - ellipse can then be extended): |  |

* when elliptical / oval defect is closed, there often is excess tissue at wound end (“***dog ear***”) two methods may be used:

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| 1. hook is placed in wound end and excess tissue is elevated to define exact tissue amount for removal → excess tissue is incised at its base as ellipse or triangle: | 1. extend incision as ellipse and then remove excess tissue: |

##### Open Wounds

* always consider **systemic processes** that impair wound healing (diabetes, malnutrition, anemia, hypoxemia, CHF / CAD, immunosuppression, cancer, genetic factors).
* **regional causes**: peripheral atherosclerosis, venous hypertension, peripheral neuropathy.
* **local causes**: trauma, burns, pressure, infection, radiation, infiltration.

N.B. systemic problem will need to be treated at same time with regional / local cause (e.g. diabetes control, reducing / ceasing smoking).

##### Closure

* goal is to achieve wound closure as soon as safely possible.
* progressive algorithm in choosing reconstructive technique (“**Reconstructive Ladder**”) – sudėtingumo didėjimo tvarka:
  1. **Linear closure** (± adjacent skin undermining) - most desirable choice!
  2. **Skin graft**.
  3. **Skin flap** (**local flap** → **distant flap**) - first choice in:
     1. *pressure sores* (if linear closure is attempted, it will place closure under tension immediately over bony prominence).
     2. *plantar surface* - flaps move suture line away from pressure point (particularly over metatarsal heads).
  4. Muscle flap
  5. Skin/muscle flap
  6. Skin/muscle/bone flap
  7. Skin/muscle free flap
  8. Bond/tendon/nerve free flap
* wound should be closed in layers: muscle/fascia, dermis/epidermis; subcutaneous fat does not hold sutures well and does not require closure.
* skin edges should be perfectly approximated.
* ***dermal sutures*** are used to bear any tension (dermis contributes bulk of wound strength), whereas ***epidermal sutures*** are only for fine alignment.
* needle should enter and exit skin at 90° to surface.
* prefer *reverse cutting needle* except for vascular sutures (tapered needle is preferred).
* surgical tape can be used alone or in conjunction with sutures and glue.

Skin Grafts

* defects that cannot be closed linearly can often be closed by using skin graft.
* transplanted skin is completely detached from donor area and attached to recipient site.

Skin graft types - graft consists of **epidermis sheet** + :

**portion of dermis** – *partial (s. split)-thickness grafts* (A, B, C) - *thin*, *medium*, or *thick*, based on included dermis amount (0.010-0.025 inch).

**entire dermis** (with­out subcutaneous fat) - *full-thickness graft* (D).

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| **Split-thickness grafts** are used to resurface ***large areas*** (e.g. burn wounds).   * ease of harvesting; leftovers may be stored for later use. * **primary contraction** - graft contracts immediately after being harvested (related to elastic fiber recoil in dermis) – 10-20% of original graft volume. * **secondary contraction** - graft shrinks after it has healed at recipient site (related to wound contraction) - cosmetic inferiority. |  |

* not as durable as full-thickness grafts, but they have better chance of survival.
* may develop *abnormal hyperpigmentation* (to minimize this, patients should wear sunscreen for at least 1st year).

**Full-thickness grafts** are used when ***aesthetical results*** are priority (color & texture match, minimal contraction).

N.B. *thicker the graft, the less* **secondary contraction** (e.g. full-thickness skin grafts are used in face to reduce wound contraction).

* large **primary contraction** – up to 40%! (vs. secondary contraction is less in full-thickness grafts)
* maintain *normal pigment* - cosmetic superiority!

Skin grafts develop some **reinnervation** with time - assume local sensory pattern (surrounding regional nerves grow into graft through remaining neurilemmal sheaths) - begins at 1-5 months and is complete by 1-2 years.

Skin grafts also develop limited **sebaceous secretions** and **sweating** (esp. full-thickness grafts and thicker split-thickness grafts).

**Composite grafts** are formed of *multiple tissues* (e.g. fingertip con­taining skin, subcutaneous fat, and bone or ear segment containing skin and car­tilage) - may be effective in young patients or in situations where dis­tal graft portion is < 1 cm from blood supply.

Skin graft sources

1. **auto­graft** - from the same person.
2. **allograft** - from genetically dissimilar individual of same species (usually cadaver).
   * skin allografts are usually rejected, but they have already performed their function (fluid & protein loss prevention).
   * **cultured skin** can be grown from patient epidermal cells in 2-3 weeks; most useful for extensively burned patients; cultured skin tends to be very thin and friable!
3. **xenograft** - from different species (usually pigs).

Grafting procedures

**Split-thickness grafts** - best obtained with *specifically designed instruments*.

1. **knives** (e.g. Humby, Weck) – have adjustable roller / gauge to determine thickness; knife is slowly advanced as cutting pro­ceeds in back-and-forth direction.
2. **drum dermatome** (Reese) - fixes epidermis to drum with glue - allows graft to be cut as drum is rolled back; grafts have uniform thickness.
3. **electrical dermatome** (e.g. Brown, Padgett) - rapidly oscil­lating knife and gauge to adjust depth; long skin strips can be removed.

* donor sites - thighs, buttocks, abdominal wall.
* graft leaves part of dermis in donor site - ***epidermis regenerates*** from skin appendages (in 10-21 days donor site may be reused!).
* recipient site care:cessation of capillary oozing → controlled hydration dressings (polyurethane, hydrocolloid, hydrogel):
  1. ***meshed nonadherent gauze*** - scab is incorporated into dressing; in 2 days, dressing is dry; falls from wound in 2 weeks.
  2. ***semipermeable membranes*** trap leukocyte-rich fluid to form artificial blis­ter, which hastens epithelialization.

After graft has taken, patient must stay out of sun until skin has matured (to prevent hyperpigmentation).

**Full-thickness grafts** are "harvested" with *freehand tech­nique* using No. 10 or No. 15 knife blade (portion of subcutaneous fat is also harvested and must be carefully excised before grafting!).

* donor sites – postauricular and upper eyelid areas (grafts to face), supraclavicular region, antecubital crease or groin crease (grafts to extremity).
* graft does not leave any skin appendages - donor site must be ***closed in linear fashion***!!! (split-thickness grafts may be necessary in some cases).
* recipient site careis similar to split-thickness skin grafts.

Causes of graft failure

1. **Loss of blood supply** - to survive in recipient bed, grafts are revascularized in three phases:

***Imbibition*** - absorption of plasma nutrients into graft - feed graft for first 24-48 hours; fibrin holds graft in place.

***Inosculation*** - donor and recipient capillaries become aligned, graft becomes adhered by fibrous deposition.

***Revascularization*** - differentiation of connecting vessels into arterioles and venules.

* thicker the graft, more tenuous blood supply in initial phases - thicker grafts demand better *vascularized recipient beds*.

N.B. bone denuded of periosteum, cartilage denuded of perichondrium, denuded tendon, nerve do not support skin grafts - require flap procedure!

* graft must be in *contact with recipient bed*;

if graft becomes separated from recipient bed by fluid (hematoma, seroma), it will not take - most common cause of graft failure!

* + - prophylaxis - **graft** **meshing** (creating multiple incisions in graft - drainage is allowed, and graft becomes expandable, allowing it to cover larger defect – up to ratio 1:9), but creates not aesthetically acceptable "pebbled" appearance when healed (this can be minimized with pressure garment [e.g. Ace bandage, Jobst garment] in first few months).
* inadequately excised necrotic eschar (in case of burns) also prevents graft take.

1. **Infection** - second most common cause of graft failure; graft is covered with topical a/b during procedure.

Infected wounds do not support skin grafts! (critical bacterial concentration is > 105 organisms per gram of tissue).

1. **Graft movement** (prevents fibrous adherence and revascularization):

* meticulous **hemostasis** is absolutely necessary.

1. use **tie-over compression dressing:** graft is first secured with interrupted sutures, leaving tied ends long; nonadherent dressing (tailored to graft size), is secured by tying suture ends over it.
2. **open method** (graft is left ex­posed) is useful for large surface areas in burn patients.

Flaps

**Flap** - tissue segment (at least skin + subcutaneous tissue) with its ***own blood supply*** (vs. *graft* - does not carry its own blood supply) – better healing chances!

* nutrient artery and accompanying veins are referred to as *pedicle*.
* donor site must be closed primarily or skin grafted.
* flap must have significant margin of safety; although there are many pharmacologic measures to improve flap circulation, flap success / failure hinges on design, dissecting, anastomosing, and closing technique.
* discoveries of musculocutaneous flaps and free flaps in 1970s have greatly advanced reconstructive surgery - it is possible to design soft and hard tissue reconstruction for almost any defect with acceptable functional and aesthetic result.

flap classification

Flaps are classified by:

1. movement method (i.e. local, distant)
2. blood supply (i.e. random, axial, fasciocutaneous, musculocutaneous)
3. composition.

###### Classification by Movement Method

**Local skin flaps** - are in close proximity to defect:

1. **Rotation, transposition flaps** – flap rotates about pivot point into defect to be closed:

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| Rotational flap: | | Transpositional flap: |
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| 1. **Advancement flaps** - movement of skin and subcutaneous tissue in forward direction for defect closure: |  | |

1. **Interpolation (s. island) flaps** - rotates about pivot point into defect close to but not adjacent to flap (pedicle must pass over or under intervening tissue):

**Distant (s. free) flaps** are moved from one body part to another:

1. by bringing defect to flap (e.g. groin flap for hand wounds).
2. by raising flap, which can be easily moved to fill defect with blood vessels anastomosed to recipient vessels (usually with microscopic technique);

examples: transverse rectus abdominis musculocutaneous [TRAM] flap, free-tissue transfers.

###### Classification by Blood Supply

Blood supply to skin & subcutaneous tissue is through:

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| 1. ***musculocutaneous arteries*** - supply muscle as well as fascia, skin, ad subcutaneous tissue 2. ***direct septocutaneous perforators*** - supply fascia, skin, subcutaneous tissue. |  |
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| **Random cutaneous flaps** (skin, subcutaneous tissue) are perfused by dermal-subdermal plexus of multiple vessels, but they ***do not incorporate specific cutaneous perforator*** (i.e. lack anatomically recognized arterial & venous system) – such flaps are limited in size (esp. length-to-width dimensions).  **Axial/arterial flaps** (skin, subcutaneous tissue) – have direct cutaneous artery and vein (***specific cutaneous perforator***); size and mobility are limited only by length and territory supplied by underlying vessel.  **Fasciocutaneous flaps** (skin, subcutaneous tissue, underlying deep fascia) - ***fascia has its own vessels*** that send branches to overlying subdermal-dermal plexus - flap vascularity is greatly improved! |  | |
| **Musculocutaneous flaps** (skin, subcutaneous tissue, underlying muscle) - blood supply is dependent on underlying muscle and ***musculocutaneous perforators***;   * often, more than one segmental vessel supplies muscle. * muscle *without overlying cutaneous paddle* can be transferred alone - well-vascularized tissue for covering exposed bone, filling in dead space, reconstructing breast (i.e. TRAM flap). | |  |

***Free flaps (free tissue transfer)*** - native blood supply is com­pletely severed, with flap transplantation to separate body area; feeding vessels are reanastomosed using microsurgery.

* they can be axial, fasciocutaneous, muscle, myocutaneous flaps.

Absolute indications for flaps:

1. Exposed bone, radiated vessels, brain, open joint (exposed cartilage), nonbiological implant materials – they do not take grafts.
2. Pressure sores with bony prominence exposed (flaps provide padding).
3. Facial reconstructions

special kinds of flaps

Z-plasty

- kind of rotational / transpositional flap with random blood supply.

* two new incisional limbs are created at original incision ends (optimally at 60° angle to original incision) forming two triangles; two triangles are then transposed – result is:

1. *changing direction* of original incision - used to change scar so that it falls along RSTLs
2. *lengthening* original incision - useful in treatment of scar contractures.

Microsurgery

- surgical procedure requiring **magnification**.

* human eye can see objects down to ≈ 100 μm (or optical angle of ≈ 1 minute).
* very relevant to *vascular surgery*.
* ***standard operating microscope*** - two-headed, epi-illuminating with approximately 200-mm focal length and magnification range from 6 to 40× with foot-operated focus, zoom, and position.
* ***microsutures*** - from 8-0 to 11-0.
* ***needle*** diameters 75-135 μm.

Body Contouring

- removal of fat and/or skin.

* removal of *fat only* (fewer scars and faster recovery) is usually performed in younger patient - skin is elastic enough to drape normally;

in older patient, after massive weight loss and pregnancy, *skin excision* needs to be performed in conjunction with fat removal.

* in thighs

suction lipectomies - for minor deformities

crescent-shaped excision - for intermediate deformities

T-shaped or circular skin excision - for major deformities.

* *compression garments* are important in postoperative period.

**Liposuction (s. suction-assisted lipectomy)**

* most frequently performed aesthetic procedure in USA.
* not substitute for weight loss!
* indications:

1. patients who are close to ideal body weight but have pockets of fat excess.
2. gynecomastia
3. removing lipomas
4. contouring and debulking flaps.

* local or general anesthesia.
* series of small incisions through which small blunt-tip cannulas can be inserted.
* excess fat is removed under ***vacuum suction***.
* **tumescent technique**: preoperatively skin is infiltrated with solution (1000 ml Ringer lactate + 300 mg lidocaine + 1 mg epinephrine) - reduced bleeding and early postoperative pain.
* postoperatively wear compressive garments for 2-4 weeks.
* patient should maintain proper diet to prevent fat reaccumulation.
* complications:
  1. sensory loss and associated paresthesia (may persist for 3-6 months).
  2. contour irregularities, hypertrophic or hyperpigmented scars.
  3. frank skin slough.
  4. fat emboli.

AESTHETIC / RECONSTRUCTIVE SURGERY

Face

##### Cleft Lip and Palate

* seen in 1 in 1000 births.
* timing of repair varies;

**cleft lip** ≈ 3 months ["rule of tens": 10 Ib, 10 weeks of age, and 10 g of hemoglobin] - techniques described by Millard or modifications;

many prefer lip adhesion 1-2 months before definitive lip repair

**cleft palate** ≈ 6 months (before 2 years - to aid in normal speech devel­opment) - bipedicle or V-to-Y advancement flaps.

**bone grafting** of deficient alveolar bone at ≈ 9 years (before permanent teeth erupt if maxillary discontinuity exists);

N.B. ***hard palate repair negatively influences midfacial growth*** – do early repair of soft palate and late repair of hard palate (if necessary, obturator is used in hard palate until repaired to facilitate speech).

##### Craniofacial Surgery

* cranium or facial skeleton is widely undermined, selective osteotomies are performed, part of cranial or facial skeleton is moved, and bone graft / alloplastic material is interposed; skeleton is then fixed in place (with screws and plates, lately of absorbable type).
* so-called ***bicoronal incision*** is frequently used: extends from front of one ear across frontoparietal scalp to area in front of opposite ear → skin, scalp, and periosteum can be elevated from bone, allowing wide exposure of craniofacial skeleton.

##### Aging Face (RHYTIDECTOMY - face rejuvenation surgery)

* most important part of ***esthetic surgery***.
* *progressive face wrinkling* is caused by **aging** (skin elas­ticity↓ + loss of subcutaneous fat), **actinic damage**, **genetic disorders**.
* preoperatively it is important to obtain photographs and discuss with patient realistic expectations.
* stop aspirin & smoking.

1. Incision - from hair-bearing area of temporal scalp along anterior ear margin around lobe and along posterior ear sulcus, terminating in hair-bearing scalp.
2. Undermining, **skin**; skin flaps are extended to nasolabial fold, onto neck and submental area.
3. Tightening underlying **fascia & muscles** (facelift); thin fascial layer overlying facial musculature (superficial muscular aponeurotic system - SMAS) is dissected and suture-plicated to fascia anterior to ear and over mastoid.

* new techniques:
  + 1. deep facelift - dissection in ***subperiosteal plane*** (easier malar and cheek fat repositioning at expense of higher incidence of nerve injuries and bleeding).
    2. ***endoscopic*** technique.

1. Selectively removing / repositioning **fat** (fat is removed from neck [either as direct excision or with suction cannulas] and repositioned in face); plication of **platysma** in neck.
2. Excising redundant **skin**.

* optional adjuncts to rhytidectomy:
  1. **brow-lift** (endoscopic technique allows minimal incisions) - corrects ptosis, or droop.
  2. **blepharoplasty** - used to treat *baggy eyelids***;** may be functional in up­per lids because redundant skin may obscure lateral gaze fields.
  3. **rhinoplasty** (controlled nasal fracture with excision of bone and cartilage).
  4. **collagen injections** (effect of collagen lasts 3-6 months, necessitat­ing subsequent injections).
  5. **fat autotransplantation** (somewhat experimen­tal - amount of viable fat harvested by liposuction cannot be easily assessed clinically).
* **compression head dressing** is left in place for 24 hours.
* *facial edema* is generally present for 3-4 weeks.
* complications:
  1. facial hematoma under skin flaps (H: drainage).
  2. facial nerve injury (<1-2%).
  3. partial flap necrosis (more prevalent in tobacco smokers).
* for left **wrinkles** (esp. perioral wrinkles - not corrected by facelift itself):
  + 1. ***laser treatment***
    2. ***dermabrasion***
    3. ***chemical face peel*** (phenol, trichloroacetic acid, glycolic acid) – induction of mild chemical burn to superficial skin.

Nose

##### Reconstruction

1. nasal breathing
2. aesthetic appearance.

* lost components are best reconstructed with similar tissue; however, mucosa can be reconstructed with skin and cartilage can be reconstructed with bone.
* *alloplastic* materials can be used to reconstruct nonmobile nose part skeleton, but in mobile portion *autogenous* material must be used.
* missing bony skeleton is best replaced with bone grafts from cranium, ilium, rib.
* missing cartilage is best replaced with nasal septal cartilage or conchal cartilage.
* workhorse for skin cover in major nasal reconstructions is ***forehead flap***.
* if patient is not able or willing to undergo autogenous nasal reconstruction, *osseointegrated prosthetic reconstruction* is more practical than conventional prosthetics.

##### Aesthetic Rhinoplasty

* internal or external approach.
* nasal skin is elevated from dorsum - direct visualization of entire nasal skeleton.
* frequently, nasal osteotomies are necessary to move nasal bones into desired position.

Eyelid

##### Reconstruction

* whenever possible, *lacrimal system* is also reconstructed (microscopic magnification and silicone stent).
* *orbicularis muscle* is not reconstructed.
* repair *tarsal plate* with absorbable sutures with knot tied away from globe.
* *skin sutures* at or within 3 mm of margin are cut long and either sutured or taped away from eye.
* when eyelid resection involves tarsal plate, we use rectangular design; when defect ranges from 10-12 mm to almost entire eyelid, we use ***tarsoconjunctival flap*** in lower eyelid reconstruction and ***Cutler-Beard type*** for upper eyelid.
* ice packs and head elevation are very important for first 24-48 hours postoperatively.

Ear

##### Reconstruction

* for *total ear reconstruction*:
  1. **autogenous reconstruction** in pediatric patient - framework is sculpted from costal cartilage and covered with expanded retroauricular skin.
  2. **prosthetic osseointegrated reconstruction** in adult: two implants are placed in mastoid bone and buried under skin for 3 months; prosthetic silicone ear is then either clipped or held in place by magnets.

##### Otoplasty

- correction of prominent ears.

Hair Restoration

* average scalp contains 90,000 to 140,000 terminal hairs.
  1. **scalp expansion technique** - present hairs are spread out over larger surface area.
  2. **scalp flaps** - hair can be transposed.
  3. **hair grafting** - single hair follicles can be grafted (*micrografting*).

Acute Soft Tissue Defects in Extremities

1. **Tumor ablations** (usually sarcomas) are elective - reconstruction involves planned and precisely tailored ***free musculocutaneous flap***; sometimes, it is possible to harvest flaps from amputated part.
2. **Posttraumatic defects** are much more complex:
3. trauma is usually not limited to area of soft tissue defect.
4. entire wound is usually heavily contaminated (incl. vital structures such as nerves, blood vessels, and fracture segments).

* *external fixation* of fractures should be used.

Trunk

**Anterior chest defects** (infected sternotomy wounds, chest wounds after mastectomy and radiation, thoracotomy wounds) - local / regional flaps: pectoralis major, latissimus dorsi, rectus abdominis muscles, omentum.

* if there is need for chest stabilization, *methyl-methacrylate plate* can be used.

**Abdominal defects** (large hernias, infections, tumor, trauma).

1. proline mesh
2. fascia lata (preferred if there is contamination).
3. rectus abdominis flaps
4. tensor fascia lata or rectus femoris flaps (in lower abdomen).

**Back defects** (meningomyelocele, spine operations)

1. bipedicle fasciocutaneous or musculofasciocutaneous flaps
2. latissimus dorsi musculocutaneous flaps.

*Panaudota literatūra*:

Sabiston Textbook of Surgery 2001

NMS Surgery