Medical And Surgical Management of Ocular Chemical Injury

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Commercial Relationships Disclosure

Financial Disclosure:
None
Background

• 20-30% of all ocular injuries

• A corrosive substance is accidentally introduced to the eye and/or periocular tissues

• **True ophthalmic emergencies** that require immediate and intensive intervention to minimize severe complications and profound visual loss

• Most prevalent among young males aged 20-40 but children also at risk

Extensive corneal neovascularization and scar formation in a patient with chemical injury
OCULAR CHEMICAL BURNS
Common offending agents

Home (or work)
- Cleaning solutions
- Drain cleaners
- oven cleaners,
- Bleach
- Battery explosion

Industrial
- Alkali: Lye (drain), lime (cement), …
- Acids: HF, HCL, H2SO4, …
Background

- The severity of chemical injury is determined by several factors
  - pH
  - Specific reactivity with tissues (pK)
  - Concentration
  - Volume
  - Temperature
  - Impact force

Persistent epithelial defect and progressive conjunctivalization and thinning after chemical injury
Alkali vs. Acid

• **Alkaline substances**, 
  *Lipophilic*, penetrate the eye more readily and damage ocular surface tissues and intraocular structures (*TM, CB, lens)*

• **Acidic substances**
  *cause protein coagulation in the epithelium, limiting further penetration into the eye*

• Both alkali and acids can lead to devastating injuries

Severe corneal thinning impending to perforation after alkali injury

Calcium and lipid deposition after acidic injury
Acute Clinical findings

- Periorbital edema and erythema
- De-epithelialized skin
- Loss of eyelashes and eyebrows
- Corneal and conjunctival epithelial defects
- Chemosis
- Conjunctival inflammation
- Limbal ischemia
- Corneal cloudiness
- Edema
- Occasionally perforation

Severe chemical and thermal injury from fireworks (ischemia, chemosis, corneal haze and edema)
Other Clinical findings

- **Cataract**: indicates deeper penetration
  - Poor prognostic
- **High intraocular pressure**
  - Damage and/or inflammation of the trabecular meshwork
  - Check IOP in acute setting and follow closely
- Secondary Damage to retina and ON
  - The most severe cases
  - Mostly immune mediated
Question

• What is the most important prognostic factor immediately after ocular chemical injury?

A. Corneal and conjunctival epithelial defects
B. Chemosis
C. Conjunctival inflammation
D. Limbal ischemia
Clinical Findings

• One of the most important prognostic factors for visual outcome is the **extent of ocular surface damage**, initially reflected by the amount of **limbal ischemia**

• Secondary Limbal Stem cell deficiency
Classification

• The common element in all these classification schemes is the the amount of limbal involvement at the time of injury.

• Studies have shown that the relative proportion of surviving limbal tissue is a major prognostic factor

Severe limbal ischemia after chemical injury (Grade IV Roper-Hall)
<table>
<thead>
<tr>
<th>Grade</th>
<th>Prognosis</th>
<th>Cornea</th>
<th>Limbal Ischemia</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Good</td>
<td>Corneal epithelial damage</td>
<td>None</td>
</tr>
<tr>
<td>II</td>
<td>Good</td>
<td>Corneal haze, iris details visible</td>
<td>$&lt; \frac{1}{3}$</td>
</tr>
<tr>
<td>III</td>
<td>Guarded</td>
<td>Total epithelial loss, stromal haze, iris details obscured</td>
<td>$\frac{1}{3} to \frac{1}{2}$</td>
</tr>
<tr>
<td>IV</td>
<td>Poor</td>
<td>Cornea opaque, iris and pupil obscured</td>
<td>$&gt;\frac{1}{2}$</td>
</tr>
</tbody>
</table>
## Dua’s classification

<table>
<thead>
<tr>
<th>Grade</th>
<th>Prognosis</th>
<th>Limbal Involvement (clock hours)</th>
<th>Conjunctival Involvement (%)*</th>
<th>Analogue Scale**</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Very good</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>II</td>
<td>Good</td>
<td>≤ 3</td>
<td>≤ 30</td>
<td>$0.1 \text{ to } 3$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$1 \text{ to } 29.9$</td>
</tr>
<tr>
<td>III</td>
<td>Good</td>
<td>&gt;3 to 6</td>
<td>&gt;30 to 50</td>
<td>$3.1 \text{ to } 6$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$31 \text{ to } 50$</td>
</tr>
<tr>
<td>IV</td>
<td>Good to guarded</td>
<td>&gt;6 to 9</td>
<td>&gt;50 to 75</td>
<td>$6.1 \text{ to } 9$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$51 \text{ to } 75$</td>
</tr>
<tr>
<td>V</td>
<td>Guarded to poor</td>
<td>&gt;9 to &lt;12</td>
<td>&gt;75 to &lt;100</td>
<td>$9.1 \text{ to } 11.9$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$75.1 \text{ to } 99.9$</td>
</tr>
<tr>
<td>VI</td>
<td>Very poor</td>
<td>12 (Total limbus)</td>
<td>100 (Total conjunctiva)</td>
<td>$12 \text{ to } 100$</td>
</tr>
</tbody>
</table>

*Only refers to bulbar conjunctiva (up to and including conjunctival fornices).

**The analogue scale is calculated through division of limbal involvement by conjunctival involvement.
Question

• Based on the Roper-Hall classification how would you grade this chemical injury?
  A. Grade II Roper-Hall
  B. Grade I Roper-Hall
  C. Grade III Roper-Hall
  D. Grade IV Roper-Hall
Question

- According to Dua’s classification what is the prognosis for this injury?
  
  A. Very poor
  B. Very good
  C. Good
  D. Poor
Course of the disease

• Pathophysiology phases
  • *Immediate*
  • *acute (0 to 7 days)*
  • *early repair (7 to 21 days)*
  • *late repair (after 21 days)*

• Management of ocular chemical injuries
  • *immediate*
  • *acute (<6 weeks)*
  • *chronic (>6 weeks)*

Severe ischemia after chemical injury (Grade III/IV? Roper Hall)
Management of Immediate Phase

• Immediately and thoroughly irrigate the surface to remove the offending agent
  • *at the site of accident* – *Tap water is OK*
    • It may promote corneal edema due to its hypotonicity relative to the corneal stroma
  • Hospital setting - *Start immediately*
    • Use anesthetic drops beforehand
    • Can use Morgan Lens to facilitate
    • Use at least 2L of irrigation then recheck pH, continue until pH 7.5 +/- 0.5

• Correlation between time to irrigation and outcomes!!!
Morgan Lens

**INSERTION**
Instill topical ocular anesthetic, if available.

**2**
Attach a Morgan Lens Delivery Set (or a syringe or an I.V. set-up).

**3**
Using solution and rate of choice*; **START FLOW.**
This allows Lens to “float” over cornea and sclera.

**4**
Have patient look down, insert Morgan Lens under upper lid. Have patient look up, retract lower lid, drop Lens in place.

**5**
Release the lower lid over Morgan Lens; adjust flow.
Tape tubing to patient’s forehead to prevent accidental Lens removal. Absorb outflow with the Medi-Duct (for best results, tape to head as shown). **DO NOT RUN DRY.**

**6**
**REMOVAL**
CONTINUE FLOW. Have patient look up, retract lower lid—hold position. Slide Morgan Lens out.
**TERMINATE FLOW.**
Clinical examination

- Important to check/sweep the fornices to remove any particulate matter
- Remove contact lens
## Management of Immediate Phase

<table>
<thead>
<tr>
<th>Irrigation Solution*</th>
<th>Proposed Advantages</th>
<th>Best Use</th>
<th>Evidence-based Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tap water (H₂O)</td>
<td>Ubiquitous availability (disadvantage: Hypotonic)</td>
<td>In the field</td>
<td>The choice of most effective solution is equivocal. Published reports are limited to in vivo experiments in animal models and, at best, small observational studies with significant limitations. Given the importance of prompt and continuous treatment, the most immediately available and sufficiently abundant solution should be utilized.</td>
</tr>
<tr>
<td><strong>Buffered Solutions</strong></td>
<td>Can correct pH</td>
<td>Clinical</td>
<td></td>
</tr>
<tr>
<td>Purpose-designed solutions (e.g. NS, LR, BSSP)</td>
<td>Isotonic to stroma</td>
<td>In a clinical setting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Patient comfort (BSSP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LR has some buffering</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Amphoteric solutions</strong> (e.g. Diphotereine®)</td>
<td>Hypertonic to stroma</td>
<td>If readily available in clinical setting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rapid pH correction</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Faster re-epithelialization (mild injuries only)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NS = normal saline; LR = lactated ringers; BSSP = balanced saline solution plus
Question

- During the acute phase of a chemical injury, which of the following medications would be most likely to limit further ocular surface damage?

A. Prednisolone q1H
B. Ketorolac QID
C. Acetazolamide PO
D. Ofloxacin QID
Management of Acute Phase

- The main objectives during the acute phase
  - Decrease inflammation
  - Avoid further epithelial and stromal breakdown
  - Foster re-epithelialization

Severe corneal edema and limbal/scleral ischemia in a patient during acute phase of chemical injury
Management of Acute Phase

Acute ocular chemical injury

Immediate irrigation and assessment

Prognostic Classification (Roper-Hall vs. Due)

Topical corticosteroids to control inflammation

If non-healing epithelial defect, then taper steroids after 10-14 days

Toponplasty

If healed epithelial defect, then can continue steroids >2 weeks

Treatment of high intraocular pressure

Autologous serum or platelet rich plasma

Bandage contact lens

Prevention of infection

Topical antibiotics

Prevention of stromal breakdown

Frequent lubrication, doxycycline, vitamin C

Amniotic membrane (transplantation or Prokera)
Question

• Which corticosteroid timing and regimen is most appropriate after chemical injury?

A. Immediately (before irrigation) start with mild steroid drops
B. Start after irrigation, steroid drops every hour for first 10-14 days
C. Wait until the cornea is re-epithelialized, then use 4 times a day
D. Start steroids only if there is inflammation, and start with lowest dose
Anti-inflammatory Therapy

- Topical corticosteroids can be critical in controlling acute inflammation and reducing the resulting inflammatory damage to the ocular surface after a chemical injury
  - *Goal is to inhibit surge of neutrophil infiltration*
  - *Started immediately after the chemical injury*
  - *Intense regimen such as prednisolone 1% (or any equivalent potent steroid) hourly (for Grade II or higher)*
Anti-inflammatory Therapy

• Caution after the first week, as corticosteroids can
  • *Inhibit epithelialization*
  • *Inhibit collagen synthesis*
  • *potentially increase the risk of corneal perforation*

• Topical corticosteroid therapy tapered down (not off) by 2 weeks in
  • *the setting of a non-healing epithelial defect*

• If the cornea has epithelialized, topical corticosteroids can be used safely beyond 2 weeks
Anti-inflammatory Therapy

- If necessary, systemic corticosteroids can be considered
  - *Augment suppression of inflammation*
  - *Fewer local side effects.*
  - *Prednisone 1mg/kg tapered over few weeks*
- In sufficiently severe injuries with prolonged inflammation a steroid-sparing agent (ex: Azathioprine, mycophenolate) may be helpful (? Evidence)
Prevention of Stromal Breakdown

- Stromal melt/thinning a major concern in severe chemical injury
  - No viable cells to repair
  - Inflammatory cells (e.g. neutrophils) secreting matrix metalloproteinases
- Prevent corneal thinning experimentally and/or clinically after chemical injuries.
  - Collagenase inhibitors
    - Tetracyclines
    - Ascorbic acid (Vitamin C)
    - Citrate
    - Cysteine/Acetylcysteine
  - Proteinase inhibitors
    - Aprotinin

Stromal melt in the setting of non-healing ulcer
Prevention of Stromal Breakdown

- **Tetracyclines** are thought to suppress neutrophil-mediated tissue damage through several mechanisms,
  - *Inhibition of neutrophil migration and degranulation*,
  - *Suppression of the synthesis of oxygen radicals*,
  - *Inhibition of MMPs*
  - *Doxy/minocycline 50-100mg bid (not in kids, not pregnant)*

- **Ascorbic acid** supplementation directly promotes corneal stromal repair
  - *Vitamin C 1-2 gram twice a day*

- **Citrate** has been shown to prevent polymorphonuclear leukocyte migration into damaged tissue, thus reducing the release of free radicals and proteolytic enzymes
  - *Not readily available*
  - *(I don’t use)*
Promotion of Re-epithelialization

- Frequent preservative-free lubricants
- Prophylactic antibiotic drops
  - Avoid medications with toxicity (e.g. gentamycin)
- Bandage Contact Lens
  - Acute: Soft bandage lens
    - Ex: Silicone hydrogel contact lenses
  - Chronic: Scleral lens
    - Large-diameter gas-permeable scleral contact lenses
    - The Prosthetic Replacement of Ocular Surface Ecosystem (PROSE Lens)
Promotion of Re-epithelialization

- **Amniotic Membrane Transplantation**
  - Permanent surgical graft to provide a basement membrane for epithelialization
  - A biological bandage “contact lens”
  - Secured to a flexible plastic ring (ProKera, Bio-Tissue, Inc., Miami, FL).

- Promote epithelialization and to reduce inflammation, scarring, and

- In patients with mild to moderate grade injuries (up to grade III)
  - Offers better acute pain reduction and earlier epithelialization

- Probably no significant differences in long-term outcomes
Promotion of Re-epithelialization

- **Autologous Serum**
  - *Human serum contains many soluble factors that promote healing in various tissues including the cornea.*
  - *Autologous serum has been shown to be effective in promoting wound healing in patients with persistent epithelial defects due to a variety of etiologies, including chemical injury.*

- **Platelet rich plasma (PRP)**
  - *Topical and subconjunctival injection*
  - *Safe and effective adjunct to standard medical treatments.*
  - *The mechanism same as that of autologous serum.*
  - *It has a higher concentration of growth factors and platelets, which may lead to faster healing.*
Promotion of Re-epithelialization: Tarsorrhaphy

- Best not to use during acute phase
- Definitely useful in epithelial defects that persist and become chronic (persisting beyond 2-3 months)
- If adequate fornix and scleral lens is readily available, may try that before tarsorrhaphy
Question

• Which one of the following pitfalls is more serious during the management of chemical injury patients during the acute phase?

A. Not using artificial tears / lubricants
B. Not following the IOP
C. Not using amniotic membrane
D. Not using a bandage contact lens
Treatment of High Intraocular Pressure

- Chemical agents that reach the trabecular meshwork
- Easily overlooked
- Acute (less than a month) or delayed (months)

Failed PK in a patient with LSCD
Tenonplasty

• In severe injuries that cause loss of limbal vascularity and subsequent anterior segment necrosis.

• To re-establish the limbal blood supply and to promote ocular surface repair

• May be combined with AMT with or without lamellar corneal patch grafting.

• Prevents anterior segment necrosis, scleral ischemia, melting, and sterile ulceration.
## Management of Acute Phase

<table>
<thead>
<tr>
<th>Therapeutic Aim</th>
<th>Treatment</th>
<th>Grade of Available Evidence*</th>
<th>Evidence-based Recommendations</th>
<th>Suggested Regimen</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reduction of Inflammation</strong></td>
<td>Corticosteroids</td>
<td>C</td>
<td>Retrospective cohort studies suggest benefit with topical treatment in non-severe injuries.</td>
<td>Intense therapy ≥ 7 days with subsequent taper</td>
</tr>
<tr>
<td><strong>Stromal Breakdown Prophylaxis</strong></td>
<td>Tetracyclines</td>
<td>D</td>
<td>Literature is limited to animal studies and expert opinion.</td>
<td>Tetracycline 250 mg PO QID</td>
</tr>
<tr>
<td></td>
<td>Citric acid</td>
<td>C</td>
<td>A single cohort study suggests a role as an adjunct in moderate injuries.</td>
<td>Topical Citrate 10% hourly or bihourly</td>
</tr>
<tr>
<td></td>
<td>Ascorbic acid</td>
<td>C</td>
<td>Retrospective cohort studies suggest benefit as an adjunct to corticosteroids.</td>
<td>Ascorbate 0.5 to 2 g QID PO + topical Ascorbate 10% hourly or bihourly</td>
</tr>
<tr>
<td><strong>Promotion of Epithelial Repair</strong></td>
<td>Bandage contact lens (BCL)</td>
<td>C</td>
<td>Retrospective cohort studies suggest benefit but are limited to non-chemical injuries.</td>
<td>Daily wear of soft BCL or PROSE scleral lens (in severe cases)</td>
</tr>
<tr>
<td></td>
<td>Amniotic membrane transplantation</td>
<td>C</td>
<td>Multiple case series suggest benefit in severe injuries.</td>
<td>Performed within 1 week of injury or later for PEDs</td>
</tr>
<tr>
<td></td>
<td>Autologous serum</td>
<td>C</td>
<td>A randomized controlled trial suggested benefit in non-mild injuries.</td>
<td>Topical platelet-rich plasma 10x QD</td>
</tr>
<tr>
<td></td>
<td>Tenonplasty</td>
<td>C</td>
<td>Observational studies suggest benefit in patients with scleral ischemia or melt.</td>
<td>As needed upon recognition of scleral pathology</td>
</tr>
<tr>
<td><strong>Treatment of high intraocular pressure</strong></td>
<td></td>
<td>D</td>
<td>Extrapolation from cohort studies suggests benefit in all patients.</td>
<td>Topical agents ± procedural intervention (e.g. paracentesis)</td>
</tr>
</tbody>
</table>
Question

• Which one is the last surgical intervention that should be performed in a patient in chronic phase of ocular chemical injury?

A. Keratoplasty
B. Correction of eyelid abnormalities
C. Management of glaucoma
D. Ocular surface reconstruction/transplantation
Management of Chronic Phase

- requires a multi-disciplinary approach involving cornea, oculoplastic, and glaucoma specialists.
- The goal of these surgical interventions is to restore normal ocular surface anatomy and visual function.
- The typical order for surgical intervention is:
  1. *Correction of eyelid abnormalities*
  2. *Management of glaucoma*
  3. *Ocular surface reconstruction/transplantation*
  4. *Keratoplasty*

A patient with chemical injury after successful LSCT (limbal autograft – CLAU)
Management of Chronic Phase

Chronic ocular chemical injury

- Sectoral surgical intervention
  - Conservative measures
    - Ir-CLAL
    - KLAL

- Restoration of fornix and eyelid
- Management of LSCD
  - Partial LSCD
  - Total LSCD
    - Bilateral
    - Unilateral
      - CLAU
      - CLET/SLET

Stromal scarring or endothelial failure

- DALK or PK
- Repeat corneal graft or LSCT failure
- Keratoprosthesis
Fornix and Eyelid Reconstruction

- Ocular surface exposure due to loss of eyelid tissue, contractures, and/or symblephara is a major contributing factor to corneal complications including ulceration and perforation.

- Eyelid and fornix abnormalities should be corrected before any limbal or corneal surgery is performed.

- It is generally recommended that surgical intervention be delayed as long as possible in order to avoid surgery on “hot” eyes.

Symblepharon formation after chemical injury
Fornix and Eyelid Reconstruction

• Symblepharon and ankyloblepharon are best classified as a form of conjunctival deficiency

• Mild to moderate symblephara
  • *Excise Tenon’s, preserve conjunctiva*
  • *fornix reconstructed with amniotic membrane*
  • *Antimetabolites such as mitomycin-C (MMC) or 5-fluorouracil applied to deep fornix*

Ankyloblepharon formation after chemical injury
Fornix and Eyelid Reconstruction

- Severe and extensive symblepharon or ankyloblepharon formation,
  - New mucosal tissue
- Unilateral injury,
  - An autologous conjunctival graft from the fellow eye
- Bilateral or extensive disease,
  - Mucosal membrane grafts (MMGs) – buccal, labial

Upper lid entropion and total LiSCD
Management of Glaucoma

• Secondary to acute injury to TM as well as chronic inflammation

• While medical therapy is the standard initial treatment, the detrimental effects of drops on the ocular surface.

• Surgical interventions are generally considered earlier in these patients.

• Cyclophotocoagulation may also be indicated, particularly in cases with advanced conjunctival shrinkage and scar formation
Limbal Stem Cell Deficiency (LSCD)

- Corneal Conjunctivalization
- Corneal Neovascularization
- Persistent epithelial defects and ulceration
- Corneal scarring
- Severe visual loss
- Chronic pain
- Keratoplasty failure
Diagnosing Limbal SC Deficiency

- Dull opaque epithelium
- Whorl pattern
- Late fluorescein staining/uptake
- Superficial NV
- Loss of Palisades of Vogt

Tests
- Impression cytology
- Confocal microscopy
LSCD

- Management strategy is based on
  - Severity
  - Laterality

- Partial LSCD
  - Central cornea-sparing partial LSCD
    - Nonpreserved lubrication
    - Autologous serum eye drops.
    - Topical Vitamin A + steroids
  - Central cornea involvement partial LSCD
    - Sequential sector conjunctival epitheliection (SSCE)
    - Amniotic membrane transplantation
    - If the above fail → ipsilateral limbal transplant (CLAU or SLET)
Total LSCD

- Unilateral Disease
  - CLAU – Conjunctival-limbal autograft
  - [auto] CLET – Cultivated limbal epithelial transplantation
  - [auto] SLET – Simple limbal Epithelial transplantation

- Bilateral Total Disease
  - lr-CLAL - living related conjunctival limbal allograft
  - KLAL - Keratolimbal allograft
  - Allo-SLET – Allo simple limbal epithelial transplantation
  - Allo-CLET - Allo cultivated limbal epithelial transplantation
  - COMET – Cultivated oral mucosal epithelial transplantation
  - Keratoprosthesis (KPro)
Limbal Stem Cell Transplantation (LSCT)

• LSCT is not recommended during active inflammation and should be delayed until ocular surface inflammation has subsided or is well controlled with medications.

• All eyelid abnormalities (e.g., entropion, trichiasis, symblepharon) should be addressed before considering LSCT.

A patient with chemical injury after successful LSCT (autologous graft from fellow eye)
CLAU Technique
Simple Limbal Epithelial Transplant: SLET

- Post-LASIK alkali injury, flap necrosis amputated, auto-SLET
- Placed pieces more peripheral
- Peripheral NV but central epithelium is corneal
Living-Related Conjunctival Allograft (Ir-CLAL)

- Requires performing surgery on two patients, donor and recipient
- Supplies goblet cells in transplanted conjunctival carrier tissue
- Can use ABO (blood group) and HLA-matched tissue, decreasing risk of rejection
Keratolimbal Allograft (KLAL)

- Involves transplantation of limbal stem cells from cadaver donor tissue in the form a corneoscleral tissue lenticule.
- Requires three lenticules to encircle the entire limbus 360 degrees.
- Immunosuppression is required postoperatively to prevent rejection.
Limbal Stem Cell Transplantation (LSCT)

- Allogeneic LSCTs need comprehensive and full systemic immunosuppression:
  - Steroids (short-term)
  - Tacrolimus (or cyclosporine)
  - Mycophenolate mofetil (or azathioprine)
LSCT Complications

- Immunologic rejection,
- Chronic ocular surface exposure,
- Complications may ultimately lead to
  - *Ocular surface epithelial breakdown (including persistent epithelial defect),*
  - Thinning,
  - *Progressive corneal conjunctivalization.*

Acute rejection after KLAL
Question

- Which of the following is not an important factor in preventing complications after LSCT?

1. Good tear film status
2. Keratoplasty before any ocular surface reconstructions
3. Full correction of adnexal abnormalities
4. Proper handling and dissection of limbal grafts
5. Adequate immunosuppression
LSCT Complications

• Most important factors in preventing complications
  • Good tear film status
  • Full correction of adnexal abnormalities,
  • Proper handling and dissection of limbal grafts,
  • Adequate immunosuppression

Acute rejection after KLAL and PK
Corneal Transplantation

- Extensive stromal scarring after chemical injury
  - *Conventional penetrating keratoplasty (PK)*
  - *Deep anterior lamellar keratoplasty (DALK)*
- Partial LSCD with opacification of the central cornea, primary PK or DALK may be adequate;
- In total/near total LSCD corneal transplantation should be done after limbal transplant; otherwise, corneal transplantation will fail.

A patient with chemical injury after successful LSCT and PK
Keratoprosthesis Surgery

- Surgical placement of an artificial cornea is an effective means of managing repeat corneal graft failure or corneal limbal stem cell failure in patients with unilateral or bilateral chemical injury.

- Currently, the Boston Type 1 keratoprosthesis (B1-KPro) is the most widely used device for restoring vision in patients who have failed previous corneal procedures.
Question

Which of followings is an ideal case for Boston Type 1 Kpro placement?

1. A 32 y/o male without any systemic disease and unilateral total LSCD
2. A 32 y/o female with type 1 diabetes and bilateral LSCD
3. A 75 y/o male without any systemic disease and unilateral total LSCD
4. A 75 y/o female with type 2 diabetes and bilateral LSCD
Ideal Candidate for KPro

• Must be amenable to long-term risks
• Need for life-long regular follow-up
• Adherence to daily antibiotic prophylaxis
• Other chronic maintenance issues
KPro Complications

- Retroprosthetic membrane formation,
- IOP elevation and/or glaucoma progression,
- Sterile corneal stromal necrosis or corneal thinning,
- Infectious keratitis,
- Persistent epithelial defect,
- Retinal detachment,
- Sterile uveitis/vitritis,
- Infectious endophthalmitis.
Glaucoma in KPro Patients

• Coupling the baseline incidence of glaucoma in chemical burn patients with the high risk of progression as a result of KPro implantation, we recommend consideration of a LSCT procedure prior to use of a keratoprosthesis in appropriate patients.

• Tube Shunt before KPro is highly recommended.
Boston Type 2 KPro and Osteo-odonto-Keratoprosthesis (OOKP)

- Usually reserved for patients with bilateral corneal blindness in the setting of
  - Severe dryness and keratinization.
  - Severe chemical or physical injury with loss of lids.
- In patients with a residual tear film, other surgical interventions (e.g., ocular surface reconstruction with stem cell transplant) should be considered prior to B2-KPro or OOKP implantation.

https://clinicalgate.com/modified-osteo-odonto-keratoprosthesis
# Management of Chronic phase Pathology

<table>
<thead>
<tr>
<th>Pathology</th>
<th>Treatment</th>
<th>Evidence-based Recommendations</th>
</tr>
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<tr>
<td><strong>Fornix and Eyelid Disease</strong></td>
<td>AMT + anti-metabolite (e.g. MMC, 5-FU)</td>
<td>Multiple interventional case series suggest benefit in patients with mild to moderate disease.</td>
</tr>
<tr>
<td></td>
<td>MMG</td>
<td>Small interventional case series suggest benefit in patients with severe disease.</td>
</tr>
<tr>
<td><strong>Glaucma</strong></td>
<td>Standard algorithm</td>
<td>Observational results suggest benefit from Tube shunt if adequate conjunctiva, otherwise cyclodestractive procedure</td>
</tr>
<tr>
<td><strong>Limbal Stem Cell Deficiency</strong></td>
<td>sectoral surgical intervention</td>
<td>In patients with involvement of the central cornea, sectoral procedures (e.g. sequential superficial epitheliectomy) have demonstrated benefit.</td>
</tr>
<tr>
<td></td>
<td>CLAU, CLET, SLET</td>
<td>Multiple interventional case series demonstrate high rates of visual recovery in patients with unilateral total LSCD.</td>
</tr>
<tr>
<td></td>
<td>KLAL, lr-CLAL</td>
<td>Multiple interventional case series suggest benefit in patients with bilateral total LSCD. Long-term results are favorable if adequate immunosuppression is used.</td>
</tr>
<tr>
<td><strong>Corneal Opacification</strong></td>
<td>Keratoprosthesis</td>
<td>Interventional case series benefit as salvage therapy after failed LSCT.</td>
</tr>
<tr>
<td></td>
<td>PK, DALK</td>
<td>Multiple case series suggest benefit for visual rehabilitation. A staged approach with antecedent LSCT is advised in patients with total LSCD.</td>
</tr>
<tr>
<td></td>
<td>Keratoprosthesis</td>
<td>Multiple interventional case series suggest benefit as salvage therapy after failed corneal transplantation.</td>
</tr>
</tbody>
</table>

AMT = amniotic membrane transplantation; MMC = mitomycin-C; 5-FU = 5-fluorouracil; MMG = mucous membrane graft; CPC = cyclophotocoagulation; LSCD = limbal stem cell deficiency; LSCT = limbal stem cell transplantation; CLAU = conjunctival limbal autograft; CLET = cultivated limbal epithelial transplantation; KLAL = keratolimbal allograft; lr-CLAL = living-related conjunctival limbal allograft; PK = penetrating keratoplasty; DALK = deep anterior lamellar keratoplasty
New Ideas for Severe Chemical Injuries (Grade IV)

- The injury has destroyed so much on the surface that there is nothing there to heal
  - Need to bring some new viable cells to the surface
  - Allo-SLET (from cadaver tissue or even living related)
    - Provides some new epithelial cells to help stabilize the surface while the host tissue gradually repopulates the surface (Geetha Iyer, et al)
  - Oral mucosal graft to the surface, ? using a SLET technique – to help stabilize the surface
  - Mesenchymal Stem Cells
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Thank You!

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