Introduction

- Trauma - ½ of all deaths amongst children
  - 15,000 deaths/year
- Pediatric facial fractures
  - Rare
Epidemiology

- 5% of all facial fractures (pediatric and adult)
- Rare in children < 5
  - 10% of pediatric facial fractures
- As age increases
  - Increased incidence
  - Increased severity
- Males more common than females
  - 1.5:1 ratio
  - Interpersonal violence and sports injuries - males
Etiology

Varies with Age

< 5 – less causes
- more supervision
- less independence

> 5 – more causes; increase with age
- More independence
- Involved in more activities
- More interpersonal violence
Etiology by Age

- < 3 – falls
- 3-5 – motor vehicle accidents and falls are equal
- > 5 - motor vehicle accidents account for majority
  - Causes that increase significantly with age
    - Interpersonal violence
    - Recreational activities
- Child abuse – any age group
Facial Growth and Development

- Cranium to facial ratio
  - 8:1 at birth
  - 4:1 at 5 years
  - 2:1 by adolescence (13+)
    - adult ratio

- Facial growth
  - Displacement
    - Movement of bone in relation to facial skeleton
  - Remodeling
    - New bone at one end and resorption at the other
Growth By Site

- **Nasomaxillary complex**
  - Septum – coordinates midfacial growth
    - Study of primates
      - Septum removed in infancy -> midface hypoplasia
  - Grows inferior and anterior
  - Nasal cavity
    - Widens
    - Floor descends with permanent tooth eruption

- **Mandible**
  - Condyle growth center = main coordinator
  - Grows anterior and lateral
  - Last bone to complete growth
Sinus Development

- Born with maxillary and ethmoid sinuses - not usually visible

- **Maxillary**
  - Significant growth around 3 years
  - Inferior growth around 7-8 (permanent teeth erupt)
  - Complete growth by 16

- **Ethmoid**
  - Significant growth around 3-7 years
  - Complete growth by 12-14

- **Frontal**
  - Not present at birth
  - Growth occurs around 3 years
    - Not visible until 6 years
  - Complete growth (related to puberty)
    - 12-14 in females
    - 16-18 in males
Tooth Development

- **Deciduous teeth**
  - Begin to erupt - 6 months
  - Fully erupted - 2 years
  - Remain stable until 6 years

- **Permanent teeth**
  - Begin to erupt - 6-7 years
    - 1st molars and central incisors first
  - 2nd molars erupt – 12 years
Pediatric Bony Skeleton

- More cartilage
- Less mineralized bone -> more elastic
- Increased cancellous:cortical bone
- Medullocortical junction indistinct

Results in:
  - More greenstick fractures
  - More irregular fractures
Initial Management

- ABCs - Focus on Airway
  - Airway
    - Always assume c-spine injury
    - Anatomy
      - Smaller airway
        - Modest edema -> significant airway compromise
      - Larger tongues
      - Floppy epiglottis
    - Place supine with head in neutral position
    - Jaw thrust -> open airway
    - Suction oral cavity of all blood and debris
Endotracheal Intubation

- Helpful positioning
  - age < 2
    - place small towel under shoulders
  - age > 2
    - place small towel under head

- Endotracheal tube
  - Proper size = \((\text{age} + 16) / 4\)
  - Proper depth = \(3 \times \text{endotracheal tube size}\)
  - Fiberoptic intubation is an option
Surgical Airway

- **Age < 12**
  - Avoid cricothyrotomy
    - Landmarks very difficult in younger children
    - Higher incidence of airway stenosis later
  - Tracheotomy preferred (controlled)
  - Needle cricothyrotomy
    - Buys more time (10-30 minutes)

- **Age > 12** – Similar to adult
Secondary Assessment

- Difficult -> children less cooperative
- Asses entire face and head
  - Visual examine and palpation
  - Test sensation
  - Ophthalmologic examination – very important
    - visual acuity
    - extraocellar muscle function
Secondary Assessment

- **Nasal cavity**
  - High risk of septal injuries (hematomas)
- **Oral exam**
  - Missing teeth, lacerations/open fractures
  - Occlusion
    - Difficult to assess in children
      - Teeth are variable
      - Wear facets less apparent
- **Midface stability**
- **Orbital Injury = Formal ophthalmologic evaluation**
Imaging

- **Computed Tomography (CT) scans**
  - Largely replaced plain films in evaluation of facial fractures
    - Readably available
    - Better visualization
  - Axial and coronal scans

- **Panorex**
  - Mandible fractures
  - Second view helps visualization (condyles)
    - Towne’s view (occipitofrontal view)
Fracture Types - Overview

- Nasal fractures
  - Most common
  - 45% of cases

- Mandible fractures
  - 2nd most common
  - 32% of cases

- Orbital fractures
  - 3rd most common
  - ~15% of cases
Treatment Considerations

- Bones heal faster than adults

- Observation and closed techniques
  - Usually all that is required
  - Good results

- If ORIF required
  - Properly align suture lines
  - Avoid extensive periosteal elevation
Maxillomandibular Fixation

- < 2 years
  - Treat as edentulous patient
  - Method
    - Dentist -> acrylic splint
    - Thin posterior edge of splint
      - Prevents premature posterior closure
    - Secure splint in place (circummandibular wires)
    - Immobilize jaw
      - Circummandibular wires
      - Wires through pyriform aperture
Maxillomandibular Fixation

- 2-5 years
  - Deciduous teeth are present, and stable
  - Options
    - Arch bars
    - Cap splints
    - Further support if needed
      - circummandibular wires and wires through the pyriform aperture
Maxillomandibular Fixation

- **6-12 year Consideration**
  - Deciduous tooth roots resorb
  - Permanent teeth are erupting

- **6-7 years**
  - Deciduous molars for fixation

- **8-10 years**
  - Permanent first molars and central incisors

- **10+ years**
  - Multiple permanent teeth available for standard arch bar placement

- May also use orthodontic devices for fixation as well
Plating Pediatric Fractures

Metallic plates

- Possible complications
  - Metal hypersensitivity
  - Bone atrophy
  - Allergy to specific metal
  - Growth restriction
  - Migration of plate into cranium
- One study -> 8% complication rate with metal plates
Plating Pediatric Fractures

Metallic plates

- **Recommendations**
  - Consider other options 1\textsuperscript{st}
    - May be only option
  - Use smallest possible plate
  - Do not cross more than one suture line
  - Later removal - controversial
    - 4-6 weeks later
    - May cause more growth abnormalities
Plating Pediatric Fractures

Resorbable Plates

- High molecular weight poly-alpha-hydroxy acids
  - Broken down by hydrolysis and phagocytosis
  - Degradation products excreted by respiration and/or urine

- Multiple studies: resorbable vs. metallic
  - Similar:
    - Functional outcomes
    - Fixation stability
    - Fixation strength
Plating Pediatric Fractures

Resorbable Plates

- Retains full strength for 4-6 weeks
- Completely resorbed by 12-36 months
- Do not interfere with radiographic studies

Most common complications
- Edema
- Bulkier -> more visible
  - Both of these resolve with time
Nasal Fractures

- **Pediatric nasal bone**
  - More compliant
  - Bends readably when force is applied
  - Forces dissipate into surrounding tissues
    - Greater amount of edema

- **Injury: Septum > Nasal Bone**
  - Septum is more rigid
  - Held tightly in place by perichondrium and surrounding bone
Septal Injuries

- Perichondrium torn from cartilage
  - potential space -> septal hematoma

- Caudal septum is dislocated
  - Nasal obstruction acutely
  - Chronically - twisting deformity

- Cartilage separated from bony septum
  - Nasal obstruction acutely
  - Must be corrected early -> growth disturbances
Nasal Fracture Management

Septal Hematoma Present

- Appearance
  - Purple, compressible bulge
  - Does not shrink with afrin

- Management
  - General anesthesia for child
    1. Hemitransfixion incision to drain
    2. Quilting stitch to close

- Avoid splints - extremely difficult to remove

- Address other nasal injuries, if possible
5 y.o. who sustained blow to nose
Nasal Fracture Management

Septal Hematoma Absent

- Wait 5 days - swelling improves
- Cosmetic defect or nasal obstruction
  - Closed reduction attempt
  - Septum
    - May reduce with nasal bone manipulation
    - Asch forcep manipulation
    - Excision of deviated segment may be required
Nasal Fracture Management

- Indication for open reduction (rhinoplasty)
  - Fractures 2-3 weeks old
  - Failed closed reduction
  - Greenstick fractures causing morbidity
    - Difficult to address without completion osteotomy
  - Better way to address septum
Mandible Fractures

Fractures by site
- Condyle
  - 55-72% of fractures – most common
    - Subcondyle most common subsite
- Parasympyseal - 27%
- Body – 9%
- Angle – 8%
- Multiple fracture sites
  - 1/3 of cases
  - Increased incidence with increased age
- Age increases – more body and angle fractures
Mandible Fractures

General Treatment Considerations

- Primary goal is to restore:
  - Occlusion
  - Function
  - Facial balance

- Callus formation occurs quickly (5-7 days)
  - Must be removed for proper reduction
Management – Condyle Fractures

“Self Correcting”

- Unilateral condyle; normal occlusion and function
  - Observation
  - Range of motion exercises

- Unilateral condyle; normal occlusion; mild deviation from midline
  - Elastic guiding bands for 6-8 weeks
  - Range of motion exercises

- Bilateral condyle; normal occlusion and function
  - Elastic guiding bands for 6-8 weeks
  - Range of motion exercises
Management – Condlye Fracture

- Any fracture: open bite, severe functional impairment, or severe deviation from midline
  - Immobilize for 2-3 weeks
  - 6-8 weeks of guiding elastic

- Open repair
  - Condyle is displaced into middle cranial fossa
  - Fracture prohibiting mandible movement
  - Controversial when growth center involved
Adolescent following interpersonal violence
- Right Subcondyle
- Left parasymphysis
Right image shows a left condylar head fracture
Management – Arch Fractures

- Non-displaced or greenstick fractures (any location)
  - Observation
    - Must follow closely
      - Any change (pain, functional impairment) -> new films

- Anterior fractures (symphyseal/parasymphyseal)
  - Attempt closed reduction
    - Manipulation under general anesthesia
    - Immobilize for 2-3 weeks followed by elastics for 6-8 weeks
  - Closed reduction unsuccessful
    - MMF followed by ORIF
      - Avoid injury to tooth buds
Severely displaced left parasymphysseal fracture – repaired with resorbable plates
Management – Body and Angle Fractures

- Non-displaced and greenstick fractures
  - Observation – follow closely
  - Most common type

- Displaced fractures
  - Attempt closed reduction
    - MMF for 2-3 weeks followed by 6-8 weeks of elastics
  - Unable to align inferior border of mandible
    - MMF followed by ORIF
A – Resorbable plate on left symphyseal fracture
B – Resorbable plate on right angle fracture
Management – Dentoalveolar Fractures

- **Teeth are primary concern**
  - **Avulsed tooth**
    - Permanent tooth – return within 1 hour
    - Deciduous tooth – may act as spacer
  - **No fractures present**
    - Dentist to secure tooth with flexible splint for 2 weeks
  - **Fractured bone segment present**
    - Reduce with manipulation
      - MMF for 2-3 weeks
      - Plates or wires may be needed
      - Secure reimplanted teeth at this time with wires
  - **Further treatment**
    - F/U with dentist for further procedures (root canal)
Orbital Fractures

- Floor and roof - most common
  - Age
    - < 7 – roof fractures more common
    - > 7 – floor fractures more common
  - Mixed fractures – 35% of cases
  - Medial wall fractures – 5-19%
Orbital Roof Fractures

- Classic history
  - Blow to the head with late developing periorbital hematoma

- Typically associated with neurocranial injuries

- 3 types
  - Type I – comminuted fracture, non-displaced
    - Most common
  - Type II – blow-out fracture, displaced superiorly
  - Type III – blow-in fracture, displaced into orbit
    - Surgical intervention usually required
13 y.o. with right orbital blow-in fracture (Type III)
Orbital Roof Fractures

- **Management**
  - **Type I fracture**
    - Almost never need intervention
  - **Type II and Type III fractures**
    - Observe for 7-10 days initially, unless severe injury

- **Fixation required**
  - Functional disability after 7-10 days
  - Aesthetic deformity
  - Neurocranial injury (encephalocele, non-resolving CSF leak)
  - Approaches vary greatly with extent of injury
  - Use of material controversial
    - alloplastic material, cartilage (costal), or bone
Orbital Floor Fractures

- Incidence increases with maxillary sinus development

- Signs/Symptoms
  - Ecchymosis
  - Edema
  - Entrapment
  - Enophthalmus
  - Diplopia
  - Infraorbital anesthesia

- Management
  - Most fractures
    - Observation for 7-10 days
10 y.o. with left orbital floor frx and entrapped inferior rectus
Lateral and superior gaze restriction
Orbital Floor Fractures

- Surgical intervention required
  - Entrapment
  - Oculocardiac reflex
    - Bradycardia from compression of globe or traction on extraocular muscles
  - Severe nausea and emesis
  - Floor fracture > 50% (high risk of late enophthalmus)
  - Failed observation
Pediatric Trapdoor Fracture

“White-eyed” fracture

Pathophysiology
- Elastic bone of orbital floor bends and breaks along infraorbital canal
  - Bony segment displaced inferiorly
- Orbital soft tissue prolapses inferiorly
- Bony segment snaps back -> soft tissue trapped -> entrapment

Presentation
- Severe nausea, emesis
- Oculocardiac reflex
- Minimal to no edema
- Decreased supraduction
- CT may show subtle floor fracture or nothing at all
Pediatric Trapdoor Fracture

Management

- No entrapment - observe

- Entrapment
  - Operate early
    - Some authors recommend same day surgery
    - Others recommend within 2-5 days
    - Delay -> necrosis and fibrosis -> permanent functional deficit
    - Cover fracture site to prevent recurrence
Orbital Floor Fracture Repair

- Approaches similar to adult
  - Transconjunctival, subciliary, subtarsal
  - Endoscopic approaches
    - Must have adequate maxillary sinus

- Material for repair - controversial
  - Some recommend calvarial bone only
  - Others have used alloplastic materials with minimal complication
Zygomaticomaxillary Complex Fractures (ZMC)

- Rare, especially < 5 years
- Incidence increases with development of maxillary sinus
- Non-displaced, greenstick or incomplete fractures – typical presentation

Signs/Symptoms
- Depression over ZMC, periorbital hematoma, subconjunctival hemorrhage, ecchymosis
ZMC Management

- Greenstick and non-displaced fractures
  - Conservative management

- Repair indicated:
  - Aesthetic deformity
  - Presence of trismus

- Isolated, displaced fracture of zygomatic arch
  - Gillies approach with reduction
Other displaced fractures

- Approaches similar to adults (may require multiple)
- Medial displacement of zygomaticomaxillary buttress + greenstick fractures of the frontozygomatic suture and zygomatic arch
  - Common ZMC fracture pattern in pediatrics
  - 1-point fixation at zygomaticomaxillary suture
- More extensive fractures – 2-3 point fixation
  - Frontozygomatic suture, zygomaticomaxillary suture, infraorbital rim
Midface Fractures

- Rare
  - Lack of sinus development and unerupted maxillary teeth
  - More soft tissue overlying midface
  - Soft, elastic bone

- Result from high velocity impacts
  - Associated injuries
LeFort Fractures

- LeFort I
  - Palate + alveolus separated from maxilla
  - Structures involved
    - Anterolateral and medial maxillary walls
    - Septum at the floor of the nose
    - Floor of nose
    - Pterygoid plate

- LeFort II
  - Pyramidal fracture
  - Structures involved
    - Nasofrontal suture
    - Medial and inferior orbit
    - High septum
    - Frontal process of maxilla
    - Anterior wall of maxillary sinus
    - Pterygoid plate
LeFort Fractures

- **LeFort III**
  - Separates facial skeleton from skull base
  - **Structures involved**
    - Nasofrontal suture
    - Medial and lateral orbital walls
    - Orbital floor
    - Frontozygomatic suture
    - Zygomatic arch
    - Nasal septum
    - Pterygoid plate
LeFort Fracture Management

- Primary goal is to establish:
  - Occlusion
  - Normal facial proportions
  - Normal facial symmetry

- Extreme forces involved in injury -> significant edema
  - Best to wait a few days prior to operation
  - Repair within 1 week
LeFort I Repair

- Gingivobuccal sulcus incision
- Reduce fracture and place in MMF
- 4 plates ideal
  - 1 on each side of pyriform aperture
  - 1 on each zygomaticomaxillary suture
- Release MMF once plated
LeFort II Repair

- Place in MMF (stable base)
- Nasal root reduced if displaced
  - Plates on both sides of root
- Zygomaticomaxillary buttress reduced and plated
- Orbit addressed as previously discussed
- Release MMF once complete
LeFort III Repair

- Much more complex and typically requires multiple approaches
- Place in MMF (stable base)
- Work from lateral (zygoma and zygomaticomaxillary buttress) to medial
Naso-orbito-ethmoid Fractures (NOE)

- Very rare in children
  - Underdevelopment and lack of prominence of facial skeleton

- NOE anatomy
  - Nasal, lacrimal, ethmoid, maxillary (frontal process), and frontal bones
  - Medial canthal tendon (MCT)
    - Arises from lacrimal crest
    - Extension of obicularis muscle
    - Acts as pump for lacrimal sac (surrounds it)
    - Maintains intercanthral distance
Pediatric Intercanthal Distance

- Infants < 22mm
- 4 years – 25mm
- 12 years – 28mm
- > 12 years ~ 30mm (adult distance)

Pathologic
- Variation of 5mm – suspect injury
- Variation of 10mm – diagnostic for injury
Signs of NOE Injury

- Flattened nasal root
- Telecanthus
- Rounding of medial canthus (MCT injury)
- Bowstring sign
  - Grasp medial eyebrow near lash line and pull lateral
  - Let go -> should snap back medially
  - + test if does not snap back -> MCT injury
- Central bony segment mobile
  - Child under general anesthesia
  - Insert hemostat into ipsilateral nasal cavity directed at medial orbital wall
  - Mobility with palpation of medial wall -> central segment likely displaced (repair required)
- CSF leak
Classification of MCT Injury

- **Type I**
  - Single, non-comminuted fracture of central bony segment
  - MCT remains attached
  - May be displaced or non-displaced

- **Type II**
  - Comminuted fracture of central bony segment
  - MCT remains attached
  - Unstable fracture

- **Type III**
  - Comminuted fracture + MCT is detached
NOE Management

- Address other injuries prior to NOE
- Very difficult to manage
  - Multiple injury patterns
  - Multiple approaches usually needed
- MCT repair
  - Priority over other NOE injuries
MCT Repair

- **Type I fractures**
  - Non-displaced - observation
  - Displaced – expose fractured central segment + 2 plates
    - frontal bone to central bony fragment
    - maxilla to central bony fragment

- **Type II fractures**
  - Central fragment wired to opposite medial orbital wall (28 gauge wires)
  - Bilateral – wire central fragments to each other in midline
MCT Repair

- Type III fractures
  - Wire/suture MCT to central fragment
  - No fragment for MCT attachment
    - Reconstruct medial wall with calvarial bone – attach MCT
  - Wire fragment to opposite side
  - Bilateral – wire to each other in midline

- Severe nasal injuries with loss of projection may require a calvarial onlay graft
Conclusion

- Trauma - significant cause of morbidity and mortality
- Pediatric facial fractures are rare
  - Incidence, type, and severity increase with age
- Most fractures can be managed conservatively
- If surgery required, care must be taken to avoid further morbidity
Conclusion

- Use of alloplastic material - controversial
  - Very few long term studies involving their use
  - Fear of complications
  - Some reports have shown good results with minimal complications if properly utilized
  - Metallic materials remain an option for pediatric fracture repair, but other options should be considered