Management of Paediatric Spinal Injuries

Considerations, Differences/Similarities to the adult population

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The Orthotic Management of Paediatric vs Adult Spinal Injuries
What stays the same?

• The Fundamentals
  • Prescription Principles
  • Level and Severity of injury
  • Individual patient factors
What stays the same?

- Effectiveness of Orthotic Mx:
  - Rigidity and design of orthosis
  - How well it is fitted
  - Pt’s attempts to move against orthosis
  - Appropriate education and follow up

(Johnson et al;2018)
What makes paediatric Mx different?

- Anatomical differences:
  - Size
  - Proportions
  - Biomechanics of bone and joint

- Impacts on type and location of injury

Fig. 2 Increase in total stature at various ages as compared to the adult. (Modified from Chenoweth and Selrick, “School Health Problems.”)
What makes paediatric Mx different?

- External factors
  - Behaviour
  - Activity level
  - Comprehension
  - Compliance
  - Parents....
Anatomical Differences

• Fulcrum of Motion
Anatomical Differences

- The Paediatric cervical spine also has:
  - Greater mobility
  - Laxity of ligaments
  - Shallow and angled facet joints
  - Underdeveloped spinous processes
Change in Relative Body Proportions from Fetus to Adulthood

(from Robbins et al: Growth, Yale University Press, New Haven, 1928)
Occipital Offset and Neck Angle

A: Occipital Offset with respect posterior aspect of the trunk
B: Occipital angle
C: The chin offset with respect the sternum

(Johnson et al, 2018)
Occipital Offset

- Often forgotten in the acute setting but extremely important
- Crucial to achieving neutral position
- Ensures appropriate shape for airway
- Without offset it produces:
  - Kyphosis of Cx Spine
  - Obstruction of airway
Mechanism of Injury – Trauma

• MVA: 48-61%
  • Passenger: 31-42%
  • Pedestrian: 11-16%
  • Bike rider: 5-6%

• Falls:
  • 18-30% in children <8yo
  • 11% in children >8yo

• Sports Injuries
  • 3% in children < 8yo
  • 20-38% in children >8yo

(Gore et al, 2009)
Mechanism of Injury - Trauma

- **Under 8yo**
  - 72% of spinal injuries are cervical
  - Less likely to sustain a fracture
  - Higher risk of SCI
  - 87-100% at C3 or higher

- **Over 8yo**
  - 80% fracture is primary injury

- **Over 12yo**
  - Similar injury pattern to adults

(Easter et al; 2011)
Non-Trauma related Cx Spine instabilities
Atlanto-axial rotary subluxation

- Rotational subluxation or dislocation C1 on C2
- Causes:
  - Osseous or ligamentous abnormalities
  - Minor Trauma
  - Post Op: tonsillectomy, pharyngectomy
- Presents as torticollis
  - (cock-robin position)

Fielding and Hawkins Classification (Fielding, 1977)
Skeletal Dysplasias

- Achondroplasia
- Mucopolysaccharidoses
- Larsen’s
- Altered cartilage and bone development
- Risk of quadriplegia or sudden death
Other diagnoses

- Downs Syndrome
- Klippel Feil Syndrome
- S.W.A.N.
Other diagnoses

• Downs Syndrome
• Klippel Feil Syndrome
• S.W.A.N.
  • Syndromes Without A Name..!
Chiari Malformation

- Portion of the cerebellar tonsils come down through the foramen magnum at the base of the skull
Syringomyelia (Syrinx)

NORMAL

SYRINX
Post Surgical Stabilization

- Use of orthoses in paeds more prevalent
- Unpredictable behaviours
- May mobilize far too early against instruction
- Excessive loads placed on fixation
Prefab Spinal Orthoses in Paeds

• Papoose
  • Age Range: 0-3 months

• All other CTOs
  • Age Range: Generally 2+

• Age range as a guide only – huge variations in childhood size
whether young footballers should be separated in weight divisions instead of age.

FOOTY'S GENTLE GIANT
The seven-year-old player as big as kids twice his age
What about the 3 month to 2 year olds???

- Commonly have high cervical injuries that require external fixation to skull and thorax
RCH Infant Spinal Immobilizer

- In-house sizes from premature up to approx 4yo
- Allows immediate fitting in acute setting
- Suitable for non-ambulant pts
Halo Management at RCH

• Fit between 5-10 Halos per year
• Age range: 2-18yo
• Estimate
  • 60:40 Trauma vs Planned Surgical fixation
• Referring team
  • Majority referred from Orthopaedics
  • Occasionally by Neurosurgery – joint consults with ortho if structural instabilities
Halo Management at RCH

- Majority applied in theatre
- Referring team responsible for ring and pin selection, placement, number of pins and torque
  - Orthotics assist in ring size selection and pin placement where required
- Orthotics measure and fit jacket and suprastructure
Skull thickness in millimeters as measured from CT scans, stratified by age, gender, and location (A: left posterior, B: right posterior, C left frontal, and D right frontal) (Letts et al)
Halo Management at RCH

- Halos are reviewed 1/7 post fitting
  - Orthotist checks jacket and suprastructure
  - Ortho medical staff retention pins 24/24 post application
- Reviewed weekly while an IP
- Reviewed 3/52 as OP
- Liner changes if required but not standard
  - Case dependent: pts can find process quite traumatic
Considerations of Halo fitting in a child

- Ensuring shell lengths don’t extend past costal margins is crucial to a good fit
- Children spend more time:
  - Floor playing
  - Sitting
  - Running around
  - Being unaware of the gravity of the situation
P2 – P3 Vest Comparison

Anterior

Posterior

P3 – Adult Short Comparison

Anterior

Posterior
Sitting and standing height birth to adulthood

Changes in sitting height from birth to adulthood

(Canavese et al; 2013)

(Huelke; 1998)
Case Study: 3yo Trisomy 21 with C1-C2 Instability

- 3/12 history of decline in motor function
- MRI showed C1-C2 instability with cord signal change
- Pt placed in aspen pre surgery
- Pt booked for C1-C2 fusion surgery
  - CTO to be fitted post surgery in theatre
- 3D imaging to fabricate a custom CTO
Pt is wiggly and non compliant+++!
Case Study: 3yo Trisomy 21 with C1-C2 Instability

• Fitted with CTO post surgery
• RCH Infant Spinal Immobiliser posterior shell
• Anterior section combination:
  • Modified anterior Paediatric Minerva section
  • attached to a Miami J PD 2 collar
• Rotational control improved with Miami J due to more contoured chin section
Case Study:
3yo Trisomy 21 with C1-C2 Instability

• C1-C2 fusion with wires failed
• Required revision fusion and application of Halo post surgery to maintain fixation
• Prior to surgery significant modifications were required to Bremer Toddler Halo vest to achieve satisfactory fit
Case Study:
3yo Trisomy 21 with C1-C2 Instability

• Problem: How to transport pt in 5 point harness car seat?
• RCH had not recently fitted a Halo to a pt this young that required a car seat with a 5 point harness system
Case Study: Cervical Kyphosis 2\textsuperscript{nd} to Larsen’s Syndrome

• Referral for ‘Brace for Cervical Kyphosis’

112 degree Kyphosis
Case Study: Cervical Kyphosis 2nd to Larsen’s Syndrome

- As well as Cervical Kyphosis:
  - Congenital bilateral knee dislocations
  - Valgus deformity and instability of knees
  - Severe hip dysplasia
  - Rigid CTEV
  - Growth disturbances in proximal tibias
- Just beginning to pull to stand from floor
Case Study: Cervical Kyphosis 2nd to Larsen’s Syndrome

- Treatment of Cervical Kyphosis in Larsen’s
  - Differing opinions
  - Surgical and orthotic interventions can be successful or catastrophic
    - Surgery not always feasible due to anaesthetic risk and pseudoarthrosis post surgery
    - Orthotic intervention requires close observation
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• “Cervical Kyphosis in Larsen’s can cause Spontaneous Death...”
Case Study: Cervical Kyphosis 2nd to Larsen’s Syndrome

3/12 post fitting: 62 degrees
6/12 post fitting: 46 degrees
18/12 post fitting: Plateaued at 39 degrees
Case Study: Cervical Kyphosis 2nd to Larsen’s Syndrome

Pre Orthotic Intervention

1 year post removal of orthosis
Case Study: 17yo with Severe Cervico-Thoracic Kyphoscoliosis

- Referral for Halo fixation post cervical spine fusion
- Fragile X Syndrome
  - Intellectual Disability
  - ADHD and Autism
  - High Anxiety
- Aggressive – Hits out and swears almost as much as me!
Case Study: 17yo with Severe Cervico-Thoracic Kyphoscoliosis
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17yo with Severe Cervico-Thoracic Kyphoscoliosis
Case Study:
SCI in a child with Achondroplasia

- Hyperflexion/extension injury after sliding down a playground slide at age 18/12
- Immediate deterioration of use of limbs
- MRI post injury
  - Pre-existing severe upper cervical canal stenosis
  - Signal changes at C1-C2
- Pt ICU – medically unstable
Case Study: SCI in a child with Achondroplasia

• Referral to Orthotics for Spinal Orthosis
  • No pre-fab options available in general for this age range
  • Head : Torso ratio significantly larger
  • Unable to take custom mould
  • Measurements + Aluminium strip + creative artwork = custom RCH Infant Spinal Immobiliser!
Case Study:
SCI in a child with Achondroplasia
Case Study: SCI in a child with Achondroplasia

• Pt remained in RCH Infant Spinal Immobiliser with anterior Aspen collar for 6/12
• Regained almost complete function and began walking again
• Required change in Orthotic Prescription to provide flexion and rotational control
Case Study:
SCI in a child with Achondroplasia

• Pt remained in a custom CTO for 2.5 yrs
  • Last 12/12 was able to use an aspen for short periods to increase neck muscle strength
• September 2017
  • Posterior Fossa Decompression
  • Fitted with and currently wearing a Miami J P2
• Has MRI booked this month
• All going well will be brace free for the first time in 3.5 years
1st Li’l Angel Halo fitted at RCH

• 9yo female
• MVA: Head-on collision 100km/h
• Multi-system trauma
  • Cranio-Cervical dislocation
  • Diffuse axonal brain injury
  • Subdural haemotoma
  • Pulmonary contusion
  • Splenic laceration
  • Pancreas contusion
  • Liver Laceraction
  • Haemoperitoneum
  • Open pelvic fracture
  • Sacral Fracture
1st Li’l Angel Halo fitted at RCH

- Ex Fix applied for temporary stabilization of pelvic fractures
- Halo fitting delayed due to extent of internal injuries requiring surgery
1st Li’l Angel Halo fitted at RCH

• Fitted with Aspen collar with full spinal precautions until Halo able to be applied
• Pt in ICU: Multiple surgeries to stabilize internal injuries
• 4 days post admission internal injuries stable enough to allow halo vest fitting
1st Li’l Angel Halo fitted at RCH

- Halo fitted in theatre with Ortho, Neuro and Gen Surg present
1st Li’l Angel Halo fitted at RCH

- No pressure allowed over abdominal area
  - Suture line extending from Xyphoid process – abdomen
- P3 6-12yo vest too long – vest below costal margin
- Pt fitted with a P2 2-6yo vest – abdomen clear of any pressure
- Open back halo ring applied
1st Li’l Angel Halo fitted at RCH

- Things to Watch
  - Height of Distraction assembly sits quite low – obscured view of cranio-cervical junction on xray. Required adjustment
  - New final checklist procedure – making sure no screws are missed!
  - Re-Education of ward staff on CPR procedure
References


References

