Result

********** FINAL REPORT **********

Name: [redacted] **ID #:** [redacted]

Exam: CT Cervical Spine Without Contrast At 0936 Hours **Acc#:** [redacted]

Exam Date: 20120330 **Physician:** [redacted]

Diagnostic Report:

Diagnosis:

CT CERVICAL SPINE

CLINICAL NOTES
Review of possible prior C2 fracture.

TECHNIQUE
CT scan of the
cervical spine has been performed from the basiocciput to the inferior aspect of the C4 vertebral body. Comparison is made with the most recent two CT scans dated 02/03/2012 and 30/01/2012. The MRI dated 31/01/2012 has

also been reviewed.

REPORT
Bilateral defects are seen in the
pedicles of C2, with corticated margins in the bones adjacent to the defect. The bone margins are well opposed and not displaced. There is no associated periosteal reaction to suggest the presence of a healing fracture. The appearance is similar to the previous two CT scans and is consistent with normal variant C2 spondylolysis. No other abnormality is seen at C2.

The degree of apparent lateral displacement of the left lateral mass of C1 has decreased when compared with the previous CT scan.

Overall
normal bone alignment.
No evidence of fracture or other significant
osseous abnormality in the remainder of the visualised cervical vertebral column.
Normal appearance of the visualised perivertebral and neck soft tissue structures.

CONCLUSION
No evidence of fracture.
The
appearance of the pedicles at C2 is consistent with bilateral spondylolysis and appears stable when compared with the previous study.
The apparent
degree of lateral displacement of the C1 left lateral mass has decreased.

Dr [redacted] (Radiology Registrar)
Dr [redacted] (Consultant Radiologist)

*This report was prepared on the 29th of October 2012 at the request of the **Australian Health Practitioner Regulation Agency (AHPRA)** acting on behalf of the **Chiropractor's Board of Australia (CBA)** regarding a notification against Dr [redacted] **(Chiropractor)** arising out of a complaint by Dr [redacted] **(Paediatrician)** concerning treatment of [redacted] **(DOB** [redacted]**)**. The notification was received by AHPRA on 7 February 2012*

I have been provided with a copy of Rule 160 and Supreme Court Practice Direction prior to preparing this report and have read and understood the document.

I consent to the Board releasing this report to the notifyer.

This report has been prepared with reference to the following documents which were provided by the ***Australian Health Practitioner Regulation Agency (AHPRA)***.

1. Notification from Dr [redacted] – 7 February 2012
2. Notification from [redacted] – 8 May 2012
3. [redacted] Paediatric Medical Service Confidential Report – 14 February 2012 (misdated 2011)
4. Practitioner's response at IAC including patient records 28 March 2012
5. Witness statement [redacted] – 19 April 2012
6. Dr [redacted] – 12 July 2012
7. Monash Medical Centre patient records
8. Royal Children's Hospital records (3 CDs)
9. Practitioners response dated 23 August 2012

1. A copy of the clinical records for [redacted] written by Dr [redacted] as well as a transcript have been provided for comment. The case history was hand written on an A5 form. Space for recording notes relating to the case history was quite limited.

2. The case history documents chief complaints (increased full body extension (improving), cervical turning preferred to right, reflux, colic, mild constipation) which appears adequate.

3. Details regarding the birth of [redacted] were then documented. APGAR scores were asked about but not available and recorded as a "?"; the clinical records do not contain any further reference to the APGAR scores which suggests that there were no further efforts to obtain this information. [redacted] gestation appears not to have been recorded; this is relevant as all physical examination findings in infants are adjusted for degree of prematurity when appropriate. For the purpose of this report I am assuming that [redacted] was born on or near her due date. The presentation of [redacted] at birth was not recorded. The most common foetal presentations at birth are "occiput anterior". "occiput posterior" and "breech". The presentation at birth has significant impact on the potential musculoskeletal injuries which may affect the neonate and knowledge of the baby's presentation at birth assist interpretation of physical and examination findings as well as may influence the examination conducted. There were no notes recorded regarding any immediate post birth medical intervention (e.g. oxygen, suction, phototherapy, antibiotics, and resuscitation). There were no notes recorded regarding admission into special care nursery or neonatal intensive care nursery.

4. The clinical notes recorded relating to the birth of [redacted] contains significant gaps and omissions but do reach a minimum acceptable level.

5. Details regarding [redacted] pregnancy were recorded and appear adequate.

6. Details regarding previous chiropractic care at 4 weeks of age were recorded and appear adequate.

7. Details regarding the time period from leaving hospital to presentation at Dr [redacted]'s clinic at [redacted] weeks and [redacted] days of age (date of birth [redacted] and initial consultation 21/12/2011) appear to be included under the section titled "Neonate". The clinical records record [redacted] date of birth as [redacted] which appears to be an error.

8. Details regarding the sleep patterns of [redacted] do not appear to have been obtained. Issues with sleep patterns in infancy may be important indicators of possible underlying conditions and provide a useful measure of response to interventions and treatment.

9. Details recorded regarding feeding are limited to "exclusively breast fed" and "vomiting after every feed". Further information regarding the infant's ability to breast feed and any issues relating to breast feeding are an important part of the case history. Information relating to the ability of the infant to suck, any issues with swallowing (e.g. gagging, choking, dribbling, prolonged feeds), any side preference , any fussiness or attachment issues whilst breastfeeding, length and frequency of breastfeeding should be obtained. Issues with breast feeding may be associated with issues with cranial nerve function and or issues affecting brainstem function which may need to be addressed during the examination and managment.

10. Details regarding systems review were not recorded. The systems review involves questions relating to major body systems and is an important component of the paediatric case history. In particular the system review acts as a screen for other issues which may be affecting the infant and which may indicate a need for further examination, assessment or referral to other health care practitioners. In particular further information relating to bowel function was not recorded. Concerns regarding constipation were noted in the records as one of the chief complaints.

11. Current and past medication uses were appropriately noted.

12. I would recommend that Dr [redacted] review [redacted] case history form and provide increased space for note taking as well as develop an infant appropriate structure. I recommend that Dr [redacted] pay more attention to infant behaviour in relationship to feeding, sleeping and bowel function when obtaining an infant case history. Deviation from expected behaviours with regards to sleeping, feeding and bowel function are the earliest, most sensitive and most common indicators clinicians use to identify potential issues with an infant and as a result clinicians need to pay particular attention to any changes with these behaviours. I recommend that Dr [redacted] include a review of systems component to [redacted] case history taking. The review of systems is a crucial component of clinical information gathering which allows identification of other issues which may be relevant to the patient's examination and management.

13. The case history taken regarding an infant presenting for chiropractic care is a crucial and vital component of the clinical encounter. A well performed case history of an infant will need to consider the following items:

Case history with an infant typical structure

- presenting complaint(s)
- prenatal history
- perinatal history

- neonatal history
- infancy history
- systems review
- family history
- assessment of development

When asking the parent about the prenatal history the following issues are usually addressed:

- age of mother
- previous pregnancies
- number sibling
- maternal health eg. hypertension, proteinuria, infection, stress etc.
- maternal medication/ drugs use
- X-ray or US exposure
- foetal health, growth and positional issues

When asking about perinatal history the following issues are usually addressed:

- length of gestation
- intervention during labour e.g.. Forceps, ventouse suction
- medication during labour eg. pethidine, epidural
- duration of labour stages
- details of membrane rupture
- type of delivery caesarian or vaginal
- presentation of neonate ie. occiput, brow, face, breech

When asking about neonatal history the following issues are usually addressed:

- need for respirator, resuscitation, suction
- APGAR score
- weight, length, head circumference
- Length of hospital stay, admission into special care nursery or intensive care.
- Medication used
- Post natal interventions such as need for oxygen, use of antibiotics, need for phototherapy.

When asking about the infancy history the following issues are usually addressed:
Sleeping
Night

- Length of sleep
- How often wakes
- How well feeds
- How well settles

Day

- Length of day sleep
- Easily disturbed
- Restless

Feeding

- Breast or Bottle
- Attachment – difficulty attaching, preference for football hold
- Fussiness
- Sucking ability
- Swallow I.e. gagging, coughing, choking, dribbling

- Time taken – fast due to pain, slow due to poor suck or pain, normal 10-20 mins
- How often – pain relief effect of feed lasts approx 2 hrs.
- Reflux and or projectile vomiting – how often, during or after or between feeds
- Name of formula

System review is crucial to avoid missing other conditions or diagnoses.
When performing a review of systems the following issues are usually addressed:

Eyes, ears nose and throat
Eyes: sticky eyes, conjunctivitis, tracks face, responds to smile
Nose: snuffly breathing, mucous
Ears: infections, responds to voice and noise
Throat: infections

Respiratory system
- Rattles, wheezes, vibrations
- Chest infections e.g. bronchiolitis, croup, pneumonia
- Apnoea
- Difficulty breathing
- Respiration rate I.e. increased or decreased

Cardiovascular system
- Blue tongue or lips
- Change in colour of arms or legs

Gastrointestinal system
- How often has bowel motion
- Is there straining if so for how long
- Diarrhoea, hard stools
- Bloating of tummy
- Lot of bowel gas
- Blood or mucous in stools

Genitourinary system
- Smelly urine
- How often wet nappy

Skin
- Rashes
- Spots
- Marks
- Bruises

When asking about the family history the following issue are usually addressed:
- Allergies
- Genetic disorders
- Any significant health issue

When assessing development the following are usually addressed:

- Ask about use and symmetry movement of arms, hands, legs.

- Hand preference should not be evident prior to 12 months of age
- Head control

14. The standard examination of an infant would include noting or measuring birth weight, head circumference and length. The anterior fontanel should be measured and plotted against normal data. The posterior fontanel should be assessed and a note of it being either open or closed made in the patient's record. Cranial nerve assessment should be conducted. Upper and lower extremity muscle stretch reflexes should be assessed and graded. The scapulohumeral reflex should be assessed. Respiratory and cardio-vascular function should be assessed. Primitive reflexes including, but not limited to, Moro reflex, plantar grasp reflex, palmar grasp reflex, rooting and sucking reflex, asymmetric tonic neck reflex, vertical suspension and ventral suspension reflexes, Perez reflex and Galant's reflex should be assessed. Direct, consensual as well as red pupillary reflex need to be assessed. An assessment of muscle tone should be performed. Active and passive range of joint motion for the joints of the cervical, thoracic and lumbo-pelvic spine including the sacrum and coccyx should be assessed. The hip joints should be assessed for dysplasia and associated changes with hip joint flexion and abduction. The skin needs to be assessed for rashes, birth marks, hairy patches or any other blemish. The shape of the head and state of the cranial sutures needs to be assessed.

15. Dr [redacted]s examination noted the resting posture of [redacted] as right head tilt and head rotation to the right, the anterior fontanel as open and medium, moderate right plagiocephaly, right frontal bossing, right eye superior and mild anterior, tension over superior ascending colon, blink with Moro reflex, Palmar and Plantar grasp reflex present, Rooting reflex as absent, Sucking reflex was reported, Placing and Walking reflex as absent – just arched backwards, Babinski as present with one tick for either left or right side (uncertain), Cranial nerves 2,3,4,6,7,8,9,10 were assessed as normal. The following developmental milestones were recorded as having being attained: able to hold head up from table momentarily, head and shoulder can be supported by the forearms, smiles, doesn't reach for familiar objects, primitive grasp reflex present was reported, makes cooing sounds and laughs. Persistent fisting , scissoring of legs, frog leg position, rapid tremors sustained opisthotonus, facial ptosis, asymmetrical movement and ankle clonus were all recorded as being absent.

16. The examination recorded by Dr [redacted] does not include testing of upper or lower extremity muscle stretch reflexes (also known as deep tendon reflexes); it is normal to test Achilles reflex, quadriceps reflex, biceps reflex, brachioradialis reflex and triceps reflex bilaterally. The muscle stretch reflexes provide important information regarding function of some of the cervical and lumbar spinal nerves. Abnormal muscle stretch reflexes may be associated with upper motor neuron issues. Testing muscle stretch reflexes can assist with detecting clonus which may also be associated with upper motor neuron issues.

17. Pull to sitting test was not recorded. Pull to sitting test involves the supine infant being gently held by the hands and pulled to a sitting position. The infant's ability to support their head, the degree of head extension, any head tilt or rotation and degree of arm use are noted. This test provides important information concerning neck flexor function as well as

upper extremity muscle tone. Given the presenting concerns of head asymmetry and head posturing assessing the infant's neck and upper extremity function during the Pull to sitting test would be expected as part of the examination of [redacted]

18. Upper extremity muscle stretch reflexes assist assessment of the lower cervical spine nerves. Upper cervical nerve roots can be assessed by testing for the presence of the scapulohumeral reflex. The scapulohumeral reflex is not normally present and if there is a positive response indicates involvement of one or more of the four upper cervical nerve roots on the side of the positive test. The scapulohumeral reflex may assist in detecting pathology above the C3 disc. (1, Appendix A. 2, Appendix B.)

19. Direct and consensual pupillary reflexes should be tested and recorded. Pupillary reflexes may be altered with brainstem dysfunction and are important in assessing the infant's neurological status.

20. Dr [redacted] recorded dysfunction affecting the C1 vertebra, S1 vertebra, T4/5 level of the spine, right suboccipital, left temporal, right sphenoid and right occiput. No supporting physical examination findings were recorded. Cervical spine active or passive range of motion testing was not recorded in the examination notes. Normally the dysfunction identified at C1 by Dr [redacted] (C1RP) can be expected to be associated with decreased head rotation to the left as well as decreased upper cervical spine right lateral flexion with these findings most apparent during active range of motion assessment.

21. Dr [redacted] has conducted an examination which has included and noted a number of tests of [redacted]'s status. There are significant gaps in the examination, in particular assessment of the Pull to sitting test, pupillary reflexes, scapulohumeral reflex as well as upper and lower extremity muscle stretch reflexes. Performance of these tests would have allowed a much better understanding of [redacted]'s neurological function and status at the start of treatment as well as possibly assisting in early identification of any issues such as contraindications to adjusting or treatment. Upper cervical assessment findings supporting the diagnosis of a C1RP were not recorded.

22. Weinstein states that the most common deficit with abnormalities of the craniovertebral junction in children is myelopathy. The most common symptom is neck pain, present in 85%. The child may present with hemiparesis, monoparesis, paraparesis and quadriplegia. Brain stem and cranial nerve deficits were exhibited by abnormalities such as sleep apnea, dysphagia and aspiration pneumonia. Internuclear ophthalmoplegia (impaired external eye muscle function) may be present as downbeat nystagmus. The most common cranial nerve dysfunction was hearing loss which occurred in 25%. There may be bilateral or unilateral paralysis of the soft palate and pharynx which is associated with aspiration pneumonia, poor feeding and poor weight gain. (3) Appendix C

23. The initial treatment notes recorded for the 21 December 2011 document adjustment per examination by hold, CST (craniosacral technique), D/R (dural release technique). These notes indicate low force techniques involving finger pressure were used to correct the identified spinal and cranial dysfunctions.

24. The second treatment occurred on the 23 December 2011 with the clinical notes recording great sleep day after the adjustment, bit of tummy pain today as well as using bowels now after almost every feed. The spinal and cranial areas treated at the initial visit were again treated except for the right suboccipital (? This is referring to muscles). The type of correction or technique used is not noted. The written statement provided by Dr [redacted] infers but does not clearly state that the same techniques were used. The statement provided by Mrs [redacted] indicates that similar treatment was provided. Abdominal assessment was noted and recorded as no abnormality detected.

25. The next consultation was recorded as occurring on the 16 January 2012 at which time [redacted] was approximately 3.5 months of age. The clinical notes report that [redacted] has been much improved post adjustment but had gone backwards over three weeks. Treatment of C1RP, left temporal, right sphenoid, right occiput, T5 and lumbosacral mobilisation was noted. The type of correction or technique used is not noted. The written statement provided by Dr [redacted] states that the same techniques used at the initial visit were used. The statement provided by [redacted] indicates that similar treatment was provided. Decreased left rotation and right lateral flexion are noted in the clinical notes. It is not clear if this is referring to the cervical spine or elsewhere such as the lumbar spine, it is also not clear as to whether the restricted motion was assessed before or after the treatment provided on the 16 January. There is also a note that there was 7 days between poos (bowel motions) and that [redacted] was exclusively breastfed still.

26. I note that at the 16 January consultation, after not seeing [redacted] for a period of three weeks, no further examination or assessment was noted other than confirming the spinal and cranial dysfunction. [redacted]'s resting posture, degree of head control, presence or absence of the Moro reflex, hip joint function, upper and lower extremity reflexes, presence or absence of clonus were not noted. It is important when involved in the care of infants that regular assessment of neurological status and neuromuscular development occurs. In addition regular assessment of hip joint function with reference to detection of dysplasia or dislocation is performed. Physical growth parameters such a weight, length and head circumference should be regularly assessed. It would be expected that not having seen an infant under six months of age for a period of three weeks that a basic examination as noted in this paragraph would be performed and recorded.

27. [redacted] was next seen by Dr [redacted] on the 18 January 2012. The clinical notes record that [redacted] was now nearly 4 months of age and that she had been 'pretty terrible' post last adjustment. Left rotation is noted as having improved but still restricted. C1RP, right occiput, right sphenoid, lumbosacral mobilisation, ileocaecal valve and bowel massage were reported as being treated/performed. Thoracic spine and hips were reported as having no

abnormality detected. Decreased movement of the transverse colon leading to (?) bowel massage was noted. Big shift in facial asymmetry was noted; it is not clear if this is an improvement or deterioration.

28. I note that at the 18 January consultation in spite of there being a report of worse behaviour after the previous treatment that no attempt to identify a possible cause for the poor response was recorded. Whenever infants respond poorly or are worse after a consultation it is important for the chiropractor to try to ascertain the reason for the response as this could be early signs of an underlying serious issue. There may be a simple explanation such as failure to have a bowel motion, teething, upper respiratory infection, maternal diet related upset or there may be a more serious issue such a urinary tract infection or aggravation due to treatment. When there is poor response or an infant is worse after a treatment typically some further physical examination is conducted to try to eliminate possible common causes of irritability; neurological re-examination is conducted to identify and possible neurological deterioration and further questions are asked of the mother to try to ascertain any possible cause for the poor response. It would be prudent to check the infant's temperature as a possible sign of infection. If the aggravation was possibly due to the treatment provided at the previous consultation then future treatment should be reassessed and the need for further investigation addressed.

29. On the 23 January 2012 Dr [redacted] recorded that [redacted] showed definite improvement with tummy time. Treatment was recorded as involving C1RP, right occiput right coronal suture separation, T4, lumbosacral mobilisation and right sphenoid. Improvement with facial balance was noted. The type of correction or technique used is not noted. The written statement provided by Dr [redacted] does not state that the same techniques used at the initial visit were used but I do not see any reason to suspect that different treatment was provided. The statement provided by [redacted] indicates that treatment similar to previous treatments was provided.

30. [redacted] was seen again by Dr [redacted] on the 25 January with [redacted] clinical records noting "cranky today – teething". Almost 4 months of age. Treatment of C1RP, right occiput, right sphenoid, suture separation, Thoracic no abnormality detected, lumbosacral no abnormality detected, frontal lift. The written statement provided by Dr [redacted] does not state that the same techniques used at the initial visit were used but I do not see any reason to suspect that different treatment was provided. The statement provided by [redacted] indicates that treatment similar to previous treatments was provided.

31. Clinical records note [redacted]'s mother calling the clinic concerned regarding an issue with poor head control on the 30 January 2012. The poor head control was noted in Dr [redacted]'s clinical records as being reported as becoming an issue from 27/28th January some two days after the last treatment with Dr [redacted]. Advice was provided by Dr [redacted] that [redacted] should be taken to hospital emergency department. There is no reference to history of recent accidents or trauma. [redacted] witness statement reported issues with [redacted]'s head control being noticed on Friday 27 January 2012 and that movement appeared to upset [redacted] on Saturday 28 January 2012. [redacted] also

states that on Thursday 26 January [redacted] and her parents attended a friend's barbeque. My personal experience of infants receiving care for musculoskeletal issues is that there may be aggravation of their underlying condition as a result of increased handling as well as handling by inexperienced people which may occur at parties and gatherings. It is very difficult to exclude an incident which may have not been reported to the parent's unless the parents are able to confirm that they were holding [redacted] the entire time they were at the function.

32. I note that Dr [redacted] responded promptly to the contact received by the clinic on the 30 January by [redacted]s mother. I also note that the advice recorded as being provided by Dr [redacted] was appropriate, timely and adequate given the concerns expressed by [redacted]s mother. Dr [redacted] clinical notes record a good level of contact being maintained during that day.

33. The initial radiology opinion was that [redacted] had suffered a bilateral fracture of the posterior arch of axis vertebra (C2). CT cervical spine without contrast performed on the 30 March 2012 was reported as follows": *"Bilateral defects are seen in the pedicles of C2, with corticated margins in the bones adjacent to the defect. The bone margins are well opposed and not displaced. There is no associated periosteal reaction to suggest the presence of a healing fracture. The appearance is similar to the previous two CT scans and is consistent with normal variant C2 spondylolysis. No other abnormality is seen at C2. The degree of apparent lateral displacement of the left lateral mass of C1 has decreased when compared with the previous CT scan. Overall normal bone alignment. No evidence of fracture or other significant osseous abnormality in the remainder of the visualised cervical vertebral column. Normal appearance of the visualised perivertebral and neck soft tissue structures. CONCLUSION No evidence of fracture. The appearance of the pedicles at C2 is consistent with bilateral spondylolysis and appears stable when compared with the previous study. The apparent degree of lateral displacement of the C1 left lateral mass has decreased".*

34. The final CT scan performed on the 6 July 2012 report recorded: *"There are bilateral defects seen within the pedicles of C2 in keeping with developmental C2 spondylolisis. However, the morphology of the left-sided defect has changed slightly since the previous study with overall narrowing of the defect and minor new bone formation which may indicate healing of a concurrent fracture. Unchanged appearances of the right sided defect. Unchanged appearances of the C1 lateral masses with persistent but mild left sided asymmetry. Bony alignment is maintained. No other significant osseous abnormality demonstrated within the remainder of the visualised cervical column. Normal appearances of the adjacent soft tissues. Conclusion: Evidence of some healing involving the left C2 pedicle defect suggesting a likely previous underlying trauma/ fracture superimposed on a developmental spondylolisis."*

35. I note that the response of the pars defect noted on the final CT scan on the 6 July 2012 as minor new bone formation over four months after [redacted] was treated by Dr [redacted] does not match well with the healing response of a fracture of the posterior arch of axis reported by Parisi et al (8) after two months in a three month old infant and referred to in paragraph 43 of this report.

36. Development of C2 or axis vertebra. The axis develops from five primary centers of ossification, which are usually present at birth. There is one center for the body of the axis, two for the odontoid process (which represents the body of the atlas), and two for the vertebral arch. The neurocentral synchondrosis, the cartilaginous structure that joins the body to the two posterior centers of ossification, ossifies between the ages of three and six years. Spondylolysis of the axis has been reported in adults and may represent a persistent neurocentral synchondrosis. With increasing ossification, the radiolucent image of the synchondrosis becomes narrow. (4) Appendix D

37. Congenital defects, such as the absence of the pedicles, are rare but may be associated with clinical symptoms or signs of instability. The synchondrosis between the body and the posterior arch of the second cervical vertebra is a normal stage in the ossification of the bone. The defect may be seen on a lateral roentgenogram, and there may be considerable variation in its appearance. (4)

38. The C2 posterior arches fuse in the midline by 2 to 3 years and fuse with the body by 3 to 6 years. (5) Appendix E. Incomplete ossification and physiologic hypermobility of the pediatric cervical spine contribute to imaging findings that can be confused with pathological conditions. (5) On both CT and plain X-rays synchondroses can be mistaken for fracture lines. Conversely, fractures through synchondroses can be misinterpreted as within the realm of normal. (5)

39. Hangman's fractures and spondylolysis in infants. Hangman's fracture comprises an avulsion fracture of the posterior elements of C2 in combination with an anterolisthesis of C2 on C3. Congenital C2 spondylolysis consists of a division of the portio interacticularis with an unclear etiology, as the site of the defect does not correspond to a primary ossification center. (6) Appendix F

40. It has been suggested by Currarino that the underlying cause is a primitive defect of chondrification of mesenchymal precursors of the vertebrae (7) Appendix G. Currarino et al. described three entities: first, a congenital defect, spondylolysis, with no abnormal motion; secondly, an acquired traumatic spondylolysis with abnormal motion; and thirdly, a clear hangman's fracture (7). This differential diagnosis may have important therapeutic consequences and a large impact on medico-legal proceedings. (6)

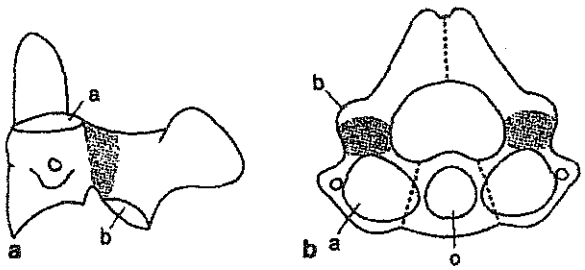


Fig.4 a and b. Normal axis vertebra seen from the side (a) and from above (b). The odontoid (o), superior articular surface (*a*) and inferior articular surface (*b*) are indicated. Dotted lines in b indicate the sites of fusion of 3 primary ossification centers: an anterior center for the body and 2 lateral centers for the posterior arch (the odontoid develops separately from several centers). The shaded areas are the sites of the defect discussed in this paper

From Currarino, G. (1989). "Primary spondylolysis of the axis vertebra (C2) in three children, including one with pyknodysostosis." Pediatric Radiology 19(8): 535-538.

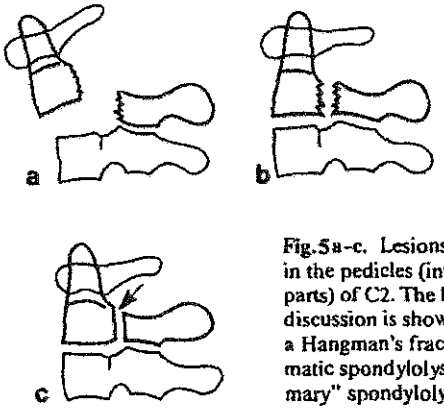


Fig.5 a–c. Lesions that can occur in the pedicles (interarticular parts) of C2. The lesion under discussion is shown in c, *arrow*. a Hangman's fracture; b Traumatic spondylolysis; c "Primary" spondylolysis

From Currarino, G. (1989). "Primary spondylolysis of the axis vertebra (C2) in three children, including one with pyknodysostosis." Pediatric Radiology 19(8): 535-538.

38. Hangman's fracture and congenital spondylolysis of the cervical axis in children are rare entities, with only several reported cases in peer reviewed literature (n =24; 11 cases of spondylolysis and 13 cases of a hangman's fracture, mean age approximately 2 years and 6 months, range 2 months to 16 years) (6)

39. A number of differentiating features between a hangman's fracture and spondylolysis on CT imaging have been presented. Spondylolysis, in contrast to a hangman's fracture, should show a sclerotic margin. On the other hand, in case of a hangman's fracture, the fracture elements are supposed to fit as pieces of a jigsaw puzzle. On follow-up imaging callus formation can be demonstrated in case of a hangman's fracture. On MRI, disruption of the intervertebral disk, ligamentous injury, and hematoma can be demonstrated in case of hangman's fracture, although only one case in which MRI was performed has been published. (6)

Table 1. Radiological parameters helpful in distinguishing between spondylolysis and hangman's fracture

Technique	Sign	Hangman's #	Spondylolysis
CXR	Soft tissue swelling	✓	-
	Posterior cervical line	>1.5 mm	<1.5 mm
CT	Sclerotic margins	-	✓
	Calcification in between segments	-	✓
	Callus formation	✓	-
	Fragments fit as jigsaw puzzle	✓	-
MRI	Hematoma	✓	-
	Ligamentous injury	✓	-
	Disk disruption	✓	-

From van Rijn, R. R., D. R. Kool, et al.(2005). "An abused five-month-old girl: Hangman's fracture or congenital arch defect?" The Journal of Emergency Medicine 29(1): 61-65.

40. In some cases definite signs of child abuse led to the diagnosis of a hangman's fracture. Other authors came to a diagnosis of spondylolysis even with significant trauma in the patient's history. The absence of neurological deficit is an insensitive sign in making the distinction. This case reported by van Rijn emphasizes that the differentiation between a hangman's fracture and a congenital arch defect is difficult even with a history of physical child abuse. (6)

41. Traumatic spondylolysis of C2, commonly known as hangman's fracture, is a well-recognized injury occurring secondary to forced hyperextension. In childhood, it is usually seen following a fall or a motor vehicle accident (8) Appendix H. Refer to Table 1 included below. In their 1997 article, Kleinman and Shelton stated that only two previous instances of Hangman's fracture in cases of child abuse have been reported, with limited radiologic evaluation. They described the plain film, CT and MR imaging features of a hangman's fracture in an abused 6month old infant. The rib and metaphyseal fractures noted in their case are features typically encountered in shaken infants, and a hyperextension injury with shaking probably explains this infant's C2 fracture. (9) Appendix I

Table 1. Summary of findings reported in children under one year of age with hangman's fracture

Author/year	Age	Sex	Mechanism of injury	Treatment employed	Time to union	Neurologic deficits
Present case	3 mo	Male	MVA unrestrained	Bed rest and CTO brace	12 wks	None
McGory (1977)	4 mo	Male	Shaking	Minerva cast	NA	Unsustained ankle clonus
Finnegan (1982)	5 mo	NA	MVA unrestrained	Soft collar with bed rest	4 wks	None
Pizzutillo (1986)	6 mo	Male	Fall with hyperextension	Surgical fusion (nonunion in Minerva)	20 wks	None
	7 mo	Female	Struck by automobile	Minerva Cast	24 wks	None
	10 mo	Female	Unknown	Traction and Minerva cast	10 wks	Left hemiparesis
Gille (1980)	11 mo	NA	Battered child	NA	NA	NA
Weiss (1973)	12 mo	Female	MVA unrestrained	Hoen's traction with one pound	3 wks	Central cord syndrome

From Parisi, M., R. Lieberson, et al. (1991). "Hangman's fracture or primary spondylolysis: A patient and a brief review." Pediatric Radiology 21(5): 367-368.

42. Avellino et al. (10, Appendix J) reported on the misdiagnosis of synchondrosis and cervical spine injuries in children over a 12-year period and found that 19% of these injuries were misdiagnosed; 5% were missed fractures and 14% were normal or developmental variations interpreted to be fractures or dislocations. The error rate for infants and children under 8

years of age was 24%, while for children over 9 years of age the error rate was 15%. The occiput to C2 region was the most common site of diagnostic error, including the hangman's fracture or missed C1 ring fracture of the spine.

43. Parisi et al present a case of a three month old female infant presented to the emergency room two days following a high speed motor vehicle accident. The child had not been restrained and impacted the windshield. The repeat CT scan two months after injury show obvious progressive sclerosis and narrowing of the arch defect consistent with a fracture. (8)

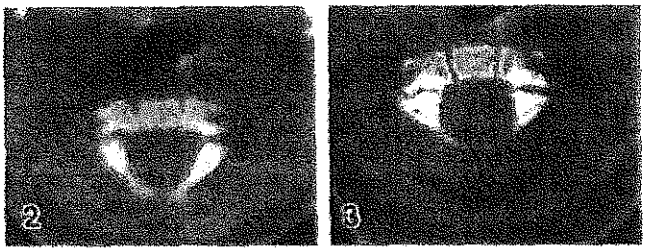
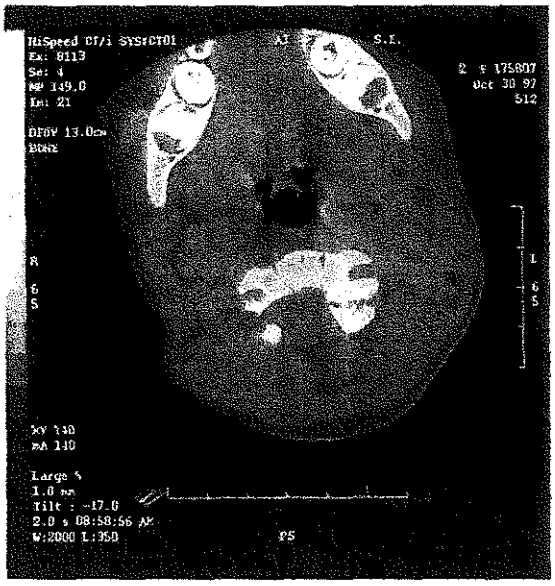


Fig. 2. Initial CT scan, C2 level, confirming bilateral pedicle defects with smooth margins. Differential diagnosis included primary spondylolysis vs Hangman's fracture

Fig. 3. CT scan at two months following admission, C2 level. There is progressive sclerosis and narrowing of the pedicle defects confirming the diagnosis of Hangman's fracture

From Parisi, M., R. Lieberson, et al. (1991). "Hangman's fracture or primary spondylolysis: A patient and a brief review." Pediatric Radiology 21(5): 367-368.

44. Congenital defects of C2 are rare and can be confused with Hangman's fractures. CT has been advocated as aiding in differentiation between an acute fracture and congenital defects. Williams et al present a case of a 2-year-old recent accident victim, who was erroneously diagnosed by plain film and CT as having a Hangman's fracture. The CT demonstrated an atypical appearance of a congenital defect which is quite similar to that seen with [redacted] They conclude that their case shows that the radiographic differentiation between a Hangman's fracture and a congenital defect is more difficult than previously described. (11) Appendix K

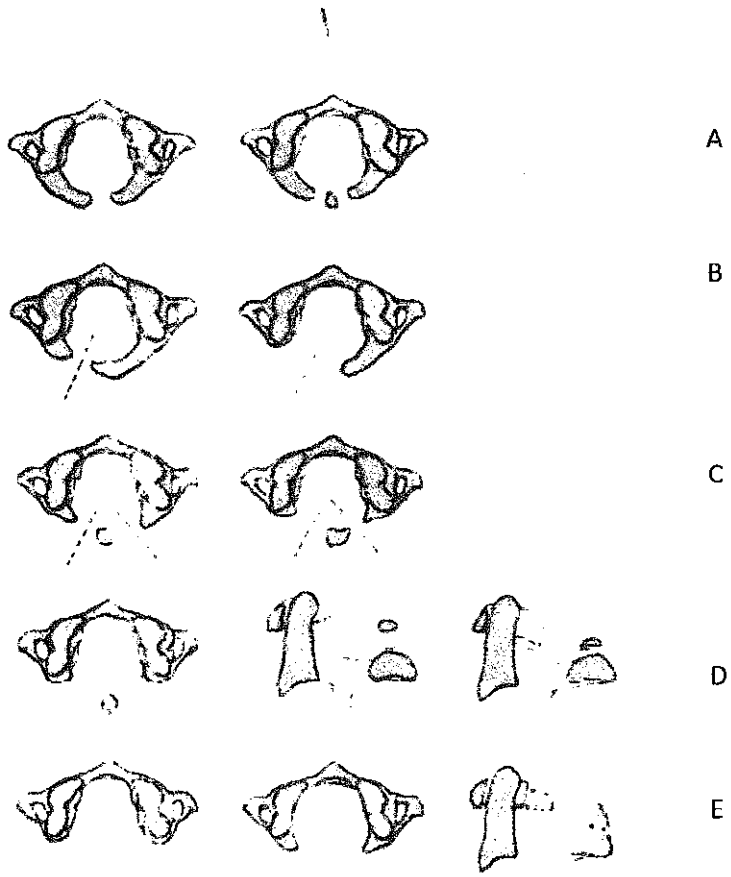


CTscan through C2 demonstrating typical pedicle defect on the right and atypical pedicle defect on the left. From Williams Iii, J. P., D. H. Baker, et al. (1999). "CT appearance of congenital defect resembling the Hangman's fracture." Pediatric Radiology **29**(7): 549-550.

45. Atlas. There are three primary ossification centers of the atlas: an anterior ossification center that forms the anterior tubercle and two lateral centers from which the lateral masses and the posterior arch form. In 2% of the population, a fourth center forms the

posterior tubercle. By the seventh gestational week, the lateral centers have extended dorsally to form the posterior arch. At birth, the posterior arches are nearly fused except for several millimeters of cartilage, and union occurs by the age of 4. The anterior center unites with the lateral centers at 5 to 9 years of age. Defects of the posterior arch are thought to occur because of a failure of local chondrogenesis rather than subsequent ossification. This has been supported by the finding at autopsies or intraoperatively, including this case, that connective tissue bridges the bony defect. (12) Appendix L

46. Anomalies of the posterior arch can be of two types: median clefts or hypoplasia. Currarino et al. developed a classification system of congenital defects of the posterior arch of cervical vertebra 1 (C1). Type A denotes the failure of posterior midline fusion, with a small gap or fissure. Type B involves unilateral clefts and defects range from a small gap to a complete absence of the hemi-arch including the posterior tubercle. In type C, there are bilateral clefts and a bony defect present in the lateral aspect of the arch bilaterally with preservation of the most dorsal part of the arch. Type D refers to the absence of the posterior arch with persistent posterior tubercle. In type E, the entire arch is absent, including the posterior tubercle. To date, there have been 11 cases of total aplasia (type E). Most of them were incidentally found by X-ray examination, and some of them caused non-specific neck pain. Until now, there have been no reports of patients with type E defects of the C1 posterior arch showing neurological deficits. Ogata et al describe a case of cervical myelopathy caused by atlantoaxial instability in a patient with total aplasia of the C1 posterior arch. (13) Appendix M



Classification of posterior arch defects of the atlas. A : Failure of posterior midline fusion of the two hemiarches. Sometimes a small separate ossicle is seen within the gap. B : Unilateral cleft, ranging from a small gap to a complete

absence of the hemiarch and posterior tubercle. C : Bilateral clefts of the lateral aspects of the arches with preservation of the most dorsal part of the arch. D : Complete absence of the posterior arch with a persistent isolated tubercle. This anomaly is conceivably a more extensive form of bilateral clefts. The lateral parts of the posterior arch are absent except for the posterior tubercle. E : Absence of the entire posterior arch including the tubercle. Reproduced with permission from Currarino G, Rollins N, Diehl JT : Congenital defects of the posterior arch of the atlas : a report of seven cases including an affected mother and son. AJNR Am J Neuroradiol 15 : 249-254, (10)

47. Congenital defects of the posterior arch of the atlas are uncommon. They are thought to be due to a failure of normal posterior arch chondrification processes. Clefts of the posterior arch of the atlas, mainly median, were found in 4% of 1,613 dissection specimens. About 97% of posterior arch defects are type A. Congenital absence or hypoplasia of the posterior arch of C1 may also be associated with several diseases, such as the Arnold-Chiari malformation, gonadal dysgenesis, Klippel-Feil syndrome, and Turner and Down syndromes. Samartzis et al. reported that congenital anomalies, such as aplasia or hypoplasia of the anterior or posterior arch of the atlas, increase the risk of neural injury in a patient with atlantoaxial subluxation and/or fixation . Type A congenital defects are relatively common. Patients with the type B defect also rarely show neurological deficits. (13)

48. When an isolated tubercle is present (type C or D), a higher risk of spinal cord compression may be expected. Out of 26 reported cases of type C or D defects 13 cases (50%) showed neurological deficits such as myelopathy, numbness, sensory disturbance and muscle weakness. A total of 11 cases of type E defects have been reported. Most of them were found incidentally. Three patients complained of slight neck pain, and the other patients showed no clinical symptoms. There have been no reports describing neurological symptoms in patients with type E anomalies. (13)

49. Saltzman et al in 1991 describe a family where nine of twelve family members from three generations were affected by an inherited form of cervical vertebral dysplasia. All of the affected people had an abnormality of the first cervical vertebra. Some also had defects of the axis and caudad to it. The mode of transmission of the disorder was autosomal dominant, with apparently complete penetrance and variable expressivity. Two patients had symptoms. One had a passively correctable tilt of the head, with an associated audible clunk and hypoplasia of the left superior facet of the second cervical vertebra. This patient had no local symptoms, neurological involvement, or muscle spasm. Nine members of the family had abnormalities of the atlas. Three had hypertrophy of the anterior arch; three, bilateral enlargement of the lateral masses; six, partial absence of the posterior arch with ossification of the posterior tubercle; one, total absence of the posterior arch; one five-year-old had a partial anterior cleft; one seven-year-old had a complete anterior cleft; and one family member had thinning of the posterior arch. Six members of the family had abnormalities of the axis: three, partial absence of the posterior arch; one, dysplasia of the posterior arch; two, a spondylolysis of the second cervical vertebra and a posterior fusion between the second and third cervical vertebrae; five, a shallow, hypoplastic left superior facet of the second cervical vertebra; and two, a hypoplastic, posteriorly tilted odontoid process. (14) Appendix N

50. No other reports regarding Familial Cervical Dysplasia were found in the literature. Motateanu et al report a case of mother and daughter with partial absence of the posterior

arch of the atlas. (15) Appendix O. Currarino reported an affected mother and son, suggesting an autosomal dominant inheritance. (Currarino G, Rollins N, Diehl JT. Congenital defects of the posterior arch of the atlas : a report of seven cases including an affected mother and son. Am J Neuroradiol 1994 ; 15 : 249-254.)

51. Kaissi et al report two siblings and their mother, with congenital, persistent torticollis, plagiocephaly, facial asymmetry, grooved tongues, and asymptomatic "dolicho-odontoid process". All are of normal intelligence. No associated Neurological dysfunction, paresis, apnoea, or failures to thrive were encountered. Radiographs of the cervical spine were non-contributory, but 3D CT scanning of this area allowed further visualisation of the cervico-cranial malformation complex in this family and might possibly explain the sudden early juvenile mortality. Agenesis of the posterior arch of the atlas and bifidity/clefting of anterior arch of the atlas associated with asymptomatic "dolicho-odontoid process" were the hallmark in the proband and his female sibling. Some of the features were present in the mother. All the family subjects were investigated. To the best of their knowledge the constellation of malformation complex in this family has not been previously reported. (16) Appendix P.

52. During the period of [redacted]'s care under Dr [redacted], [redacted]'s father, was x-rayed by Dr [redacted] (exact date not available to me) with the x-ray revealing absence of the posterior arch of C1 with an ossified posterior tubercule. The radiological report for [redacted] was not available to me whilst writing this report. This description appears to be consistent with a type D congenital anomaly of C1. This type of congenital anomaly affecting C1 is not common and I was only able to find four published papers describing familial inheritance of congenital posterior of C1 anomalies. It is recognised that a patient with one congenital anomaly is more likely to have other congenital anomalies and that as a result it is prudent to image other spinal areas prior to chiropractic care. In addition, as other body systems may be involved a screening examination of these areas may be necessary.

53. The issue of x-raying all family members of people with posterior arch anomalies of C1 without any other significant clinical indication prior to chiropractic care has not to my knowledge been conclusively addressed in the literature. I am not aware of any guidelines or recommendations suggesting that a child of a person with Type D or E absence of the posterior arch of atlas should be x-rayed prior to chiropractic care. As a result of the literature search conducted for this report articles by Saltzman(14), Motateanu (15), Currarino (Paragraph 50) and Kaissi (16) were identified which report possible autosomal dominant pattern of inheritance of some upper cervical spine anomalies. Given the rare nature of Type E absence of the posterior arch of atlas and the possibility of familial inheritance occurring, I suggest that future guidelines and recommendations adopt the position that when Type D or E atlas posterior arch anomalies are detected or known then all close genetic relations of that individual undergo cervical spine x-ray examination prior to receiving chiropractic care. This recommendation is balanced with the need to minimise radiation exposure from x-rays in children which is well known and accepted within the chiropractic profession as well as all other health care professions.

54. When considering x-ray investigation of children the potential gain must be assessed as being greater than the radiation exposure risk. It is my opinion that the presence of the posterior arch defect in [redacted]s father did not on its own provide enough clinical justification for obtaining immediate x-rays of [redacted] in light of guidelines and recommendations applying at that time. The clinical presentation and examination findings reported in Dr [redacted]s clinical notes do not provide sufficient clinical reason to obtain x-rays of [redacted] prior to 18 January 2012. It is possible that the poor response to treatment provided on the 18 January may have been sufficient to warrant obtaining cervical spine x-rays. This is difficult to determine as no physical examination notes were made at the consultation on the 18 January 2012.

55. A family history of a genetic syndrome or physical examination findings suggestive of a genetic syndrome indicate need for spinal x-rays in infants. See Table 1 (Page 17) below from McKay et al (17) Appendix Q

56. Posterior arch fractures of C2 are generally felt to be the result of forced hyperextension of the cervical spine with reported cases mostly occurring as a result of motor vehicle accidents or child abuse. The treatment described by Dr [redacted] is conducted with the infant supine; this position will result in the infant's cervical spine being placed in 10 to 15 degrees of flexion due to the prominent occipital bone and as a result avoiding any extension stress on upper cervical spine structures during treatment. (3. Weinstein SL. (2001) "The Pediatric Spine". 2nd Edition. Lippincott Williams and Wilkins. 553-4.) Recommendations relating to spine immobilisation in infants with suspected spinal injury include elevating the supine infant's thorax 2-3 cm above the head to straighten the cervical spine and remove any cervical spine flexion. The treatment described as being used by Dr [redacted] is regarded as low force and does not involve cervical spine hyper-extension when correctly performed. It is my opinion that the treatment described by Dr [redacted] would not create sufficient force to cause a C2 fracture. The forces expected with the treatment described by Dr [redacted] would not create more force on the upper cervical spine than dressing and undressing the infant. It is likely that trying to force tight fitting clothing over the head of an infant would create more stress on upper cervical spinal structures as well as possible extension of the cervical spine when compared to the treatment described by Dr [redacted]

57. Typically examination of the cervical spine in infants involves assessment of active as well as passive cervical spine range of motion. Active range of motion is usually assessed by attracting the infant's attention, typically by means of a light or high contrast object and getting the infant to follow with the degree of head rotation to the left and right as well as flexion and extension noted. Asymmetry of head rotation is clinically significant. Passive cervical spine range of motion is usually assessed by having the infant supported by the parent's hands and held in a sitting position whilst the chiropractor gently holds the infants head and turns the infant's head to the left and the right noting the degree of rotation possible before there is either tissue tension or the infant reacts. Cervical spine flexion, extension as well as left and right lateral flexion range of motion are all typically assessed.

TABLE 1. Syndromes That Have Cervical Spine–Associated Problems. The Affected Portion of the Cervical Spine Is Listed for Each Syndrome[22, 82–87]

Syndrome	Cervical Spine Involvement
Aarskog syndrome	Cervical vertebral anomalies including hypoplasia and synostosis of 1 or more cervical vertebrae
Apert syndrome	Fusion of cervical vertebrae usually at C5 to C6
Atelosteogenesis, type 1	Abnormally segmented and fused cervical vertebrae
Campomelic dysplasia	Short and somewhat flat cervical vertebrae
Cervico-occulo-acoustic syndrome (Wildervanck syndrome)	Klippel-Feil anomaly (fusion of 2 or more cervical vertebrae, torticollis)
Chondrodyplasia punctata	Subaxial canal stenosis, coronal clefts or hypoplasia of vertebral bodies, upper cervical instability from os odontoideum
Diastrophic dysplasia	Hypoplasia of cervical vertebral bodies with kyphosis and subluxation, spina bifida occulta from C3 to C4 to upper thoracic vertebrae
22q11.2 deletion syndrome	Upper cervical instability from odontoid hypoplasia or os odontoideum, congenital C2 to C3 fusion
Cleidocranial dysostosis	Basilar impression with enlarged foramen magnum
Down syndrome (trisomy 21)	Upper cervical instability from odontoid hypoplasia, os odontoideum, and ligamentous laxity
Dyggve-Melchoir-Clausen syndrome	Odontoid hypoplasia, cervical spine instability, flattened vertebrae
Ehlers-Danlos syndrome IV	Atlantoaxial instability
Fetal alcohol syndrome	Cervical vertebral malformations
Fibrodysplasia ossificans progressive	Large posterior elements, tall narrow vertebral bodies, enlarged pedicles, fusion of the facet joints, lateral masses, and spinous processes. May lead to severe chin-on-chest deformity
Frontometaphyseal dysplasia	Wide foramen magnum, cervical vertebral anomalies, wide interpedicular distance
Goldenhar syndrome	Occipitalization of the atlas, fusion of cervical spine, odontoid hypoplasia, and basillar impression
Hajdu-Cheney syndrome	Cervical vertebrae osteolysis, cervical spine instability
Hurler syndrome	Odontoid hypoplasia, atlantoaxial instability
Klippel-Feil syndrome	Congenital fusion of cervical vertebrae, occipitalization of the atlas, stenosis of cervical spine, instability
Kniest dysplasia	Atlantoaxial instability
Kozlowski spondylometaphyseal dysplasia	Odontoid hypoplasia, cervical spine instability
Larsen syndrome	Cervical kyphosis, which can be progressive
Marfan syndrome	Atlantoaxial and other cervical vertebrae subluxation, focal kyphosis, absence of cervical lordosis, basilar impression
Maroteaux-Lamy mucopolysaccharidosis syndrome	Odontoid hypoplasia, cervical myopathy due to thickening of the cervical dura mater
Marshall-Smith syndrome	Instability of the craniocervical junction with severe spinal stenosis
Metaphyseal chondrodysplasia	Atlantoaxial instability due to ligamentous laxity
Metatropic dysplasia	Odontoid hypoplasia, C1 to C2 subluxation
Morquio syndrome	Odontoid hypoplasia, C1 to C2 subluxation, C2 to C3 subluxation
Mucopolysaccharidoses	Odontoid hypoplasia, abnormal soft tissue thickening C1 to C2
Multiple epiphyseal dysplasia	Upper cervical instability due to os odontoideum
Osteopathin striata	Kyphosis due to vertebral dysplasia and hypotonia

TABLE 1. (*Continued*)

Syndrome	Cervical Spine Involvement
Osteopoikilosis	Cervical central canal stenosis
Pseudoachondroplasia	Odontoid aplasia or hypoplasia, C1 to C2 instability
Pyknodysostosis	Kyphosis due to C2 and/or C3 spondylolysis
Spondylocarpotarsal synostosis syndrome	Failure of vertebral segmentation, odontoid hypoplasia, cervical spine instability
Spondyloepimetaphyseal dysplasia	Upper cervical instability due to odontoid hypoplasia
Spondyloepiphyseal dysplasia congenital	Upper cervical instability and underlying stenosis
Weaver syndrome	Instability of the upper cervical spine

From McKay, S. D., A. Al-Omari, et al.(2012). "Review of Cervical Spine Anomalies in Genetic Syndromes." Spine 37(5): E269-E277

58. Loss of range of motion in one or more direction is important clinical information for the chiropractor and an important indicator for the need for treatment, with improved range of motion an important clinical outcome measure. Restricted cervical spine movement in any direction is typically associated with pain response. In the infant a pain response is typically noted as tensing of muscles, stiffening, frowning and crying. Infants are not able to verbally communicate pain other than by crying. Many physical examination procedures used within both chiropractic and medicine are designed to detect abnormal findings with one of the most common abnormal response being pain which generally is associated with crying in an infant. All clinicians are and should be aware that any discomfort experienced by the patient needs to be kept to the minimum required to obtain the necessary clinical information.

59. Passive cervical range of motion assessment of infants is part of a typical and standard examination and is typically performed before and usually after any treatment. Dr [redacted] appears to have followed standard examination procedure when examining passive cervical spine range of motion in [redacted]'s case.

60. The reported development of decreased head control on the Friday, two days after the last treatment provided by Dr [redacted] on the preceding Wednesday, as well as the "very grizzly" behaviour reported on the Saturday suggest either aggravation of an underlying issue or another separate issue affecting the infant. [redacted] reported that [redacted] appeared to react more strongly than previously to the examination and treatment provided by Dr [redacted] on the 25 January but appeared to settle over the next three hours.

61. Given the low force techniques used by Dr [redacted] which may be exceeded by or matched by forces produced by normal handling as well as inability to completely rule out any other occurrence during the period 25 January to 27 January it is difficult to link without reasonable doubt the examination and treatment provided by Dr [redacted] and [redacted]'s loss of head control. Temporal relationship does not automatically confirm cause and effect.

62. The response of the pars defect noted on the final CT scan on the 6 July 2012 as minor new bone formation over four months later does not match well with the healing response of a fracture of the posterior arch of axis reported by Parisi et al (8) after two months in a three month old infant and referred to in paragraph 43 of this report.

63. The presenting complaint and presenting concerns which brought [redacted] to see Dr [redacted] are commonly seen and managed by chiropractors. The diagnosis and treatment provided by Dr [redacted] is consistent with and appropriate given the limited examination findings recorded in Dr [redacted]'s clinical records from the initial examination.

Summary:

1. Dr [redacted] did not allocate sufficient space to record paediatric case history details in [redacted] clinical form.
2. Dr [redacted] failed to conduct and record a systems review as part of [redacted] paediatric case history.
3. Dr [redacted] did not record adequate progress treatment notes which clearly document subjective reported information, objective findings, treatment provided, post treatment examination findings and recommendations given to the patient.
4. Dr [redacted] failed to include assessment of muscle stretch reflexes, scapulohumeral reflex, pupillary reflexes and pull to sitting test as part of her standard infant examination.
5. Dr [redacted] did not record physical examination findings which support her diagnosis.
6. Dr [redacted] failed to perform a re-examination and/or record re-examination findings when her patient's presentation worsened.
7. Dr [redacted] responded rapidly and appropriately when notified of concerns regarding [redacted] head control.
8. Dr [redacted]'s decision not to x-ray [redacted] was appropriate.
9. The treatment reported as provided by Dr [redacted] would not be expected to produce sufficient force to cause a fracture to C1 or C2 vertebra in an infant.
10. The loss of head control apparent with [redacted] two days after treatment by Dr [redacted] could have been the result of unrelated factors.

Yours sincerely,

Signed: Date:

Dr [redacted]
[redacted]
[redacted]

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17. McKay, S. D., A. Al-Omari, et al.(2012). "Review of Cervical Spine Anomalies in Genetic Syndromes." Spine 37(5): E269-E277 Appendix Q