THE PERIOD PREVALENCE OF CONGENITAL CERVICAL SPINE ANOMALIES AND THE ASSOCIATION BETWEEN THE CONGENITAL ANOMALIES WITH THE SUBJECT'S PRESENTING CLINICAL FEATURES

by

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I, Anesha Ganasram, do hereby declare that this dissertation represents my own work in both conception and execution, except where specific assistance is sought and duly acknowledged

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DEDICATION

I would like to dedicate this dissertation:

To God, for the support, guidance and protection he has bestowed upon me through all the hard times and for his helping hand during all the good times.

To my parents, I would like to thank you for your eternal love, support, encouragement and protection throughout this course and in every aspect of my life. I am immensely grateful and appreciative for all the sacrifices you have made to provide me with the best of everything.

To my brother, Arsish, I would like to thank you for all your encouragement and for tolerating me during the worst of times.

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ABSTRACT

Project Design:

This research study was designed in the form of a quantitative, non-experimental, empirical clinical survey.

Objectives:

1) To determine the period prevalence (1 January 1997 – 31 December 2004) of congenital cervical spine anomalies.
2) To determine if there is any association between the presenting clinical features and the congenital cervical spine anomalies in general.
3) To determine if there is any association between the presenting clinical features and individual congenital cervical spine anomalies.
4) To compare subjects presenting clinical features with reported clinical features from literature.

Results:

1) Congenital cervical spine anomalies had a total period prevalence of 46.67% for the period 1 January 1997 to 31 December 2004 with the three most prevalent anomalies being: elongated C7 transverse process, rudimentary posterior ponticle and posterior ponticle.
2) No significant association was found between the subjects reported clinical features and the congenital cervical spine anomaly in general and individually.
3) No significant difference was found between subjects presenting clinical features with clinical features associated with congenital cervical spine anomalies reported in the literature.

Conclusions:

The period prevalence of congenital cervical spine anomalies found in this may appear to be significant; however, this finding is based on patients presenting at the Chiropractic Day Clinic over an eight-year period and thus not a true reflection of the general population. The current literature is sparse on information on the incidence, prevalence and clinical manifestations of the majority of cervical spine congenital anomalies.

This study attempted to provide information on the association between the clinical presentation of an individual patient and cervical spine congenital anomalies. While there were no significant findings identified, we feel that we have provided clinicians with some information which may be very useful in including cervical spine congenital anomalies in differential diagnoses in individuals presenting with neck disorders. Furthermore, the information provided in this study and findings thereof may be useful to clinicians who utilise manipulation of the cervical spine as part of the management of the patient as they may be able to make an informed decision before carrying out the procedure, especially on individuals presenting with neck pain/stiffness and cardiovascular and/or neurological features.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Congenital deformities of the spine result from anomalous vertebral development in the embryo (Letts and Jawadi 2004). According to Menezes (2004) the anomalies that affect the cervical spine extend from the occipitocervical to the cervicothoracic junctions. As there are numerous congenital cervical spine anomalies, the classification system suggested by Yochum and Rowe (1996) was utilised with the inclusion of anomalies suggested by Taylor and Resnick (2000) that are of significance. These anomalies shall be discussed further in Chapter 3, under 3.2.4.1.

According to Hensinger (1991), congenital cervical spine anomalies are regarded as uncommon due to majority of individuals being asymptomatic or presenting with mild restriction in neck motion. Although these anomalies are considered rare, Letts and Jawadi (2004) state that they are worthy of attention because early recognition and careful management may help in preventing neurological compromise and instability. Due to the rarity of these anomalies, difficulty exists in trying to establish their prevalence and incidences. However, some authors have attempted to provide prevalences for some of these anomalies but there appears to be discrepancies in the findings of some authors.

As stated previously by Hensinger (1991), individuals with congenital cervical spine anomalies are commonly asymptomatic or may present with mild restrictions in neck motion. However, each anomaly has the potential for the development of clinical manifestations which an individual may present with. Hensinger (1991), Yochum and Rowe (1996), Letts and Jawadi (2004) and Menezes (2004) all provided clinical features that are thought to be associated with certain anomalies however no conclusive association could be derived from

their findings thus creating further confusion with regards to the association of congenital cervical spine anomalies and the subjects presenting clinical features.

The current study took place at the Chiropractic Day Clinic at the Durban Institute of Technology. Cervical spine radiographs contained at the clinic for the period 1 January 1997 to 31 December 2004 were utilised.

1.2 OBJECTIVES OF THIS STUDY

1.2.1 Objectives

5) To determine the period prevalence (1 January 1997 – 31 December 2004) of congenital cervical spine anomalies.
6) To determine if there is any association between the congenital cervical spine anomalies and the presenting clinical features in general.
7) To determine if there is any association between individual congenital cervical spine anomalies and the presenting clinical features.
8) To compare subjects presenting clinical features with reported clinical features from literature.

1.3 HYPOTHESES

- There shall be a significant number of congenital cervical spine anomalies present for the chosen period of 1 January 1997 to 31 December 2004.
- There shall be a significant association between the congenital cervical spine anomalies and the presenting clinical features in general.
- There shall be a significant association between the individual congenital cervical spine anomalies and the presenting clinical features.
- There shall be a significant association between subjects presenting clinical features with reported clinical features from the literature.

1.4 STATISTICAL ANALYSIS

In this study the SPSS version 11.5 package was used. The period prevalence of congenital cervical spine anomalies was obtained by descriptive analysis and Fisher's exact tests were used in determining the associations between clinical features and presence of any congenital cervical spine anomalies.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Congenital deformities of the spine result from anomalous vertebral development in the embryo (Letts and Jawadi 2004). These anomalies are physical defects that occur in a baby at birth irrespective of whether the defect was caused by a genetic factor or by a prenatal defect (Nace 1999). The anomalies that affect the cervical spine extend from the occipitovertebral junction to the cervicothoracic junction (Menezes 2004).

2.2 BASIC OVERVIEW OF RELEVANT CLINICAL ANATOMY

The cervical spine is made up of two anatomically and functionally different regions namely the upper cervical spine and lower cervical spine. The upper cervical spine is composed of the atlanto-occipital and the atlanto-axial articulations while the lower cervical spine is composed of the third to the seventh cervical vertebrae and their associated articulations (Bergmann *et al.* 1993). For the purpose of this study the embryology of the occiput and vertebra, and the osseous and ligamentous structures of these two regions shall be outlined with incorporation of relevant congenital cervical spine anomalies.

2.2.1 Embryology of the Occiput and Cervical Vertebra

The occipitocervical junctional region is formed from the fifth, sixth and seventh sclerotome. Development of this region is important in that it predetermines the development of the upper cervical vertebra. Any anomalous development of the occiput such as decreased skull base height will result in the dens of the axis lying at or above the level of the foramen magnum and this eventually leads to the posterior arch of the atlas being at the same level as foramen magnum causing basilar invagination (Standring 2005).

A typical cervical vertebra has three ossification centres, one in the centrum and one in each vertebral arch. The centrum unites with the vertebral arches in the third year of life to form the vertebra. The centrum itself has bilateral centres of ossification which may fail to unite and results in a hemivertebra which is one of the causes of scoliosis (Standring 2005).

The atypical vertebrae are the atlas, axis and the seventh cervical vertebra. The atlas has three ossification centres. One in each lateral mass. These centres extend to the posterior arch and unite with it around the third or fourth year. The anterior arch is fibrocartilagenous and unites with the lateral masses by the sixth and eighth year. The axis has five primary centres and two secondary centres. The dens has bilateral centres which appear at six months and unite before birth to form a conical mass with cartilage at its tip. Sometimes ossification is incomplete whereby the apex cartilage may fail to fuse with the dens or the dens may fail to fuse with the body resulting in os odontoideum. The seventh cervical vertebra has ossification centres similar to a typical cervical vertebra but it also has ossific centres for the costal processes which appear about the sixth month and join the body and the transverse processes by the fifth and sixth years. They may remain separate or grow anterior and laterally giving rise to cervical ribs (Standring 2005).

2.2.2 The Upper Cervical Spine

This region encompasses the atlanto-occipital and the atlanto-axial articulations (Bergmann *et al*. 1993). The first articulation occurs between the first cervical vertebra called the atlas and the occipital condyles of the skull. The atlas is an atypical vertebra because it has no body or spinous process but has an anterior arch, a posterior arch and two lateral masses. The posterior surface of the anterior arch of the atlas articulates with odontoid process of the axis. It also attaches superiorly to the occipital bone via the anterior atlanto-occipital membranes and inferiorly via the anterior atlanto-axial ligaments (Standring 2005). The posterior arch attaches superiorly to the occiput via the posterior

atlanto-occipital membranes which, sometimes, calcifies or ossifies to form a posterior ponticle and this superior surface also supports a groove that represents the superior vertebral notch which transmits the vertebral artery and the sub-occipital nerve (Yochum and Rowe 1996; Standring 2005). Inferiorly, the posterior arch attaches to the axis via the posterior atlanto-axial ligaments and also forms the inferior vertebral notch with the axis. The two lateral masses have two facets which allow them to articulate superiorly with the occipital condyles of the skull and inferiorly with the superior facets of the axis. The superior articulation may sometimes become disturbed in occipitalisation of the atlas resulting in a partial or complete fusion of the atlas with the base of the occiput (Yochum and Rowe 1996). This occurs in 1.4 to 2.5 of every 1000 births (Letts and Jawadi 2004).

The second articulation is the atlanto-axial articulation and this is formed between the atlas and the second cervical vertebra, the axis. The axis is also regarded as an atypical vertebra. It has laminae, a very long spinous process, short transverse processes and superior and inferior articular processes. The unique feature of the axis is the odontoid process which is formed by the fusion of the embryologic remnants of the vertebral body of the atlas to the superior aspect of the body of the axis (Bergmann *et al*. 1993). As a result of this fusion various anomalies sometimes develop such as the following:

- Ossiculum terminale persistens whereby there is failure in unison of the secondary growth centre of the odontoid (Yochum and Rowe 1996).
- Os odontoideum which results in the failure of the odontoid fusing with the atlas (Yochum and Rowe 1996).
- Other odontoid anomalies such as agenesis, hypoplasia and posterior inclination of the odontoid (Taylor and Resnick 2000).

The odontoid process articulates with the posterior surface of the anterior arch of the atlas and is held in place via the transverse ligament which also gives of fibres, superiorly to the occipital bone and inferiorly to the axis, to form the cruciate ligament which further reinforces the odontoid process to the atlas. The

odontoid is also attached to the occipital bone through the alar ligaments (Standring 2005).

2.2.3 The Lower Cervical Spine

This region is made up of articulations from the third to the seventh cervical vertebrae. The third to the sixth vertebrae are regarded as typical vertebrae while the seventh vertebra is atypical (Bergmann *et al.* 1993). The typical cervical vertebrae have vertebral bodies, pedicles, laminae, short and bifid spinous processes, superior and inferior articular processes and transverse processes that are pierced by the foramen transversarium which forms the passage way for the vertebral artery and vein and a plexus of sympathetic nerves (Standring 2005). During embryological development two or more adjacent vertebral bodies may fuse resulting in a block vertebra or there may be displacement of one vertebrae in relation to another one due to the absence of pedicles bilaterally, dysplasia of the articular processes or spina bifida occulta resulting in spondylolisthesis (Yochum and Rowe 1996).

The seventh vertebra is regarded as atypical since it has a prominent spinous process called the vertebral prominens. It has a vertebral body, pedicles, laminae, superior and inferior articular processes and transverse processes which also have the foramen transversarium which may contain vertebral artery on the left, the vein on both sides but more commonly both vein and artery passing in front of the transverse process (Standring 2005). The transverse processes may become enlarged or develop cervical ribs which is a separate piece of bone that articulates with the transverse process of one or more cervical vertebra. They commonly occur from the fifth to the seventh cervical vertebrae and are present in 0.5 % of the population. Approximately 66% of cervical ribs occur bilaterally (Yochum and Rowe 1996).

The lower cervical spine is supported by the anterior and posterior longitudinal ligaments, ligamentum flavum, and ligamentum nuchae, interspinal and

intertransverse ligaments. These ligaments support the cervical spine during the movements of flexion, extension, rotation, lateral flexion and circumduction (Standring 2005).

2.3 THE PREVALENCE OF CONGENITAL CERVICAL SPINE ANOMALIES

The congenital cervical spine anomalies that were included in this study were obtained from the classification system suggested by Yochum and Rowe (1996), with the inclusion of anomalies which were suggested by Taylor and Resnick (2000). These anomalies are described in Chapter 3, under 3.2.4.1.

Hensinger (1991), after reviewing the available literature, reported that the majority of cervical spine congenital anomalies are considered rare. This may explain the paucity in the literature concerning the incidence and prevalence of these anomalies. However, some authors have tried to provide an indication of the prevalence of some of these anomalies. The prevalence of some anomalies that were available in the literature will be outlined below:

Yochum and Rowe (1996) reviewed literature on congenital cervical spine anomalies and estimated that 15% of the population had a posterior ponticle and 0.5% had cervical ribs. The population characteristics (e.g. ethnicity, nationality, etc.) were not described in their report. According to this report, it appears that the most common congenital anomaly of the cervical spine is the posterior ponticle. Taylor and Resnick (2000) conducted reviews similar to Yochum and Rowe (1996) and concluded the following:

- Partial agenesis of the posterior arch of atlas occurred in 4% of adults,
- Anterior arch agenesis occurred in 0.1% of the population,
- Posterior ponticle was present in 15% of the population,
- Absent transverse ligament was present in 20% of individuals with Downs syndrome, and
- Cervical ribs occurred in 10 – 15% of individuals with Klippel-Feil syndrome.

Although the population of Taylor and Resnick (2000) is not defined, it appears that the authors reviewed literature pertaining to both the normal population and those with certain clinical syndromes (e.g. Klippel-Feil syndrome). There is also an indication that certain anomalies are more likely to be associated with certain clinical syndromes than being found in the normal population e.g. cervical ribs with Klippel-Feil syndrome. It must be noted that Yochum and Rowe (1996) reported that the prevalence of cervical ribs was much lower (0.5%) in the normal population. It was also noted that the posterior ponticle was the most common congenital cervical spine anomaly, a finding similar to Yochum and Rowe (1996).

Howard (1998) conducted a review on the available literature on congenital anomalies of the craniovertebral junction. The source of the "available literature" or the population characteristics is not commented by the author. This author states that his findings indicated that occipitalisation of the atlas was a common condition as it is present in 1 in every 400 people. The author of the present study disagrees with this statement as 0.25% prevalence is not considered common.

Menezes (2004) carried out a review of various studies which focused on the radiological appearance and neurodiagnostic imaging of congenital cervical spine anomalies and stated that the most frequent anomalies that occur irrespective of location within the cervical spine are the following: proatlantal segmentation failure (the definition of this term was not made clear by the author. It could possibly mean agenesis of the anterior arch of the atlas), basilar invagination, rotary dislocation, atlantal assimilation (occipitalisation), os odontoideum, condylar hypoplasia, C2-C7 spondylolysis, hemivertebra, and segmentation failure (this could relate to the block vertebra anomaly). However, the author gives no specific figures to corroborate his claims and one cannot really evaluate the likely incidence or prevalence of these anomalies. Letts and Jawadi (2004) also conducted a review regarding congenital spinal anomalies on patients that presented at the Pediatric Orthopedic Department at the Children's Hospital in

Eastern Ontario. The result of their review revealed that occipitalisation of the atlas was present in 1.4 – 2.5 per 1000 children. Furthermore, according to these authors, Klippel-Feil syndrome occurred in 1 in every 42 000 births; however, no mention was made of the association of this syndrome and cervical ribs as reported by Taylor and Resnick (2000).

Beck *et al.* (2004) conducted a study at the New Zealand College of Chiropractic to determine the occurrence rates for radiographically detectable abnormalities (any condition that could have affected the spine and not merely confined to congenital anomalies) of the spine. One thousand and four random radiographs were drawn from their clinic records from 1997 to 2001 and only those with full spine x-rays were included in the study, thus the final sample size was 847. Their findings revealed that 68% had abnormalities of the spine with the five most common in descending order being degenerative joint disease (23.8%), posterior ponticle (13.6%), soft tissue abnormalities (no specifications given) (13.5%), transitional segments (9.8%), and spondylolisthesis (7.8%). It is not clear whether the spondylolisthesis was traumatic, congenital or pathological in origin. Other congenital spinal anomalies found were spina bifida occulta (6.7%), nonunion or agenesis (3.1%) (no specifications were given as to which part/s of the vertebrae was/were involved) and congenital block vertebra (1.4%). These data, however, pertained to the entire spine and not a specific region e.g. lumbar or cervical.

A study conducted by Ricchetti *et al*. (2004) looked at defining and determining the frequency of variations of the occiput and the cervical spine on radiographs of patients with 22q11.2 deletion syndrome and postulating the potential clinical importance of these variations. They utilized plain film radiography as an initial objective tool and advanced imaging (CT/ MRI) as a secondary objective tool in patients. Prior to the radiographs being taken and evaluated, a detailed history and physical examination was conducted. The following data were obtained from the evaluation of the radiographs:

- Platybasia (91%),
- Basilar impression (3%),
- Dysmorphic C1 (unusually small or thin appearance of C1) (75%),
- Dysmorphic dens (58%) (unusual anatomical features of the dens),
- Open posterior arch of C1 (59%),
- Occipitalisation of C1 (3%), and
- C2-C3 fusion (34%) with 15% of this comprising of fusion of the vertebral arches and 13% being complete fusion of both vertebral bodies and vertebral arches.

This study provides data that indicates the association of certain cervical spine anomalies with 22q11.2 deletion syndrome; however, one cannot generalize this with the normal population. The data is therefore reflective of the population from which this sample was taken and not applicable to the normal population.

The author of the present study has concluded that discrepancies seem to exist regarding the incidences and prevalence of the congenital cervical spine anomalies between authors. This may be attributed to the various settings under which those studies took place, the sample size used and/or the method utilized in obtaining the data. As a result, great paucity still exists in the current literature with regards to congenital cervical spine anomalies and thus requires further investigations.

2.4 CLINICAL FEATURES ASSOCIATED WITH CONGENITAL CERVICAL SPINE ANOMALIES

Hensinger (1991) is of the opinion that the majority of individuals that have congenital cervical spine anomalies are either asymptomatic or present with mild restriction in neck motion. However, each anomaly has the potential for the development of clinical manifestations which a patient may present with. Hensinger (1991), Yochum and Rowe (1996), Letts and Jawadi (2004) and Menezes (2004) all provided clinical features that are thought to be associated with certain anomalies and these features have been categorically divided into

three subgroups viz.: musculoskeletal, neurological and other clinical features. These features shall be described with inclusion of their presentation in a normal population and in a population with congenital cervical spine anomalies.

2.4.1 Musculoskeletal Features

2.4.1.1 Neck Pain

According to Haslett *et al.* (1999), 40-50% of all adults experience transient episodes of neck pain i.e. pain specifically in the cervical spine area. They also stated that neck pain can be attributed to various disorders which include mechanical disorders such as poor posture; inflammatory, metabolic, and neoplastic diseases and pain referred from other areas. Hult (1954) as cited by Lakhani (1999) stated that the prevalence of neck pain was between 35 - 71% in industrial and forest workers. Bovim *et al.* (1994) used a randomized cross-sectional questionnaire to determine the prevalence of neck pain in Norwegian adults. Their results revealed that 34.4% of the responders had experienced neck pain within the last year and a total of 13.8% reported neck pain that lasted for more than 6 months. Upon reviewing the results of the above authors, we find that generally there is consistency with respect to the prevalence of neck pain in the general population. Minor variations in the figures may be due to factors affecting the sample population dynamics e.g. occupational, stress factors, etc.
When neck pain in the normal population was compared to the existing literature on congenital cervical spine anomalies, no significant difference was found. Menezes (2004) in his review stated neck pain to be prevalent in 58% of the 4800 subjects with craniovertebral abnormalities, with no elaboration on the specific anomalies. Letts and Jawadi (2004) stated approximately 40% of patients with odontoid abnormalities, basilar impression, occipitalisation of the atlas and Klippel-Feil syndrome had neck pain.

The author, of the current study, is of the opinion that irrespective of the anomaly present in the cervical spine, neck pain will subsequently occur. This assumption

may be justified according to Hensinger (1991), who states that disturbed mechanics of the cervical spine may result in dull aching pain in the occiput and neck with episodic neck stiffness and torticollis. Therefore any condition, congenital or not, that affects the mechanics of the cervical will cause neck pain.

2.4.1.2 Shoulder/ Arm Pain

This may be described as pain experienced from the region of the shoulder to the elbow, with the inclusion of the arm. In the context of this study, shoulder/arm pain was differentiated from radicular pain by its character. According to Magee (2002), radicular pain is experienced along a dermatome, myotome, or sclerotome due to direct involvement of a spinal nerve or nerve root and would be sharp, electrical and/or burning in character. Therefore all other pain felt in this region, excluding radicular pain, was classed as shoulder/arm pain. According to Haslett *et al*. (1999), shoulder/arm pain is the most common complaint among adults and while the most common cause would be overuse syndromes they did attribute some of the pain to be due to the following: inflammatory, degenerative, arthritic and neoplastic diseases and referred pain from other areas.

In the existing literature on congenital cervical spine anomalies, Hensinger (1991) found shoulder/arm pain to be associated with congenital block vertebra. This could be attributed to lack of movement at a specific vertebral level resulting in overloading of the support muscles of the neck leading to the development of trigger points or even muscle strain (Simons *et al.* 1999). Patients often experience arm/shoulder pain due to trigger points of the cervical muscles (Simons *et al.* 1999). Fleming (2000) conducted a review, of the existing literature, on thoracic outlet syndrome and found shoulder/arm pain to be associated with subjects who had cervical ribs.

It thus appears that those with cervical block vertebrae and thoracic outlet syndrome due to cervical ribs, are more likely to experience shoulder/arm pain in the absence of other conditions e.g. degenerative, arthritic, etc.

2.4.1.3 Headaches

According to Magee (2002), headache is defined as pain experienced in the following areas: forehead, side of head, occipital area, frontal area and face. He states that it may be attributed to a variety of factors but it is one of the most frequent neurological symptoms encountered in primary care and hospital practice. Rasmussen *et al*. (1991) conducted a prevalence study to determine the epidemiology of headaches and the results revealed that the lifetime prevalence for migraine headache was 93.8% in men and 99.25% in females while tension-type headache was 69% in men and 88% in women. A survey conducted by Scher (1998) at the Johns Hopkins School of Public Health found 4.1% of the United States population experienced “frequent” headaches of more than 180 days a year in duration.

In the existing literature on congenital cervical spine anomalies, Menezes (2004) stated that headaches were present in 76% of patients with basilar impressions. Singh and Patel (2003), medical doctors at the Department of Neurology and Pain Management at the Medical College of Pennsylvania, conducted a review on patients with thoracic outlet syndrome. Their results revealed that headaches do occur in thoracic outlet syndrome, which is attributed to cervical ribs or elongated C7 transverse processes. Beck *et al*. (2004), in their study on determining the occurrence rates of abnormalities in the spine, found the posterior ponticle to be related to migraine headaches. No reasons were given for this relationship.

Headaches are a common clinical symptom; it may be assumed that, with regards to congenital cervical spine anomalies, they appear to be more likely related to the location of the anomaly especially the upper cervical spine. It must

also be mentioned that headaches may also result from hypertonic cervical muscles (Simons *et al.* 1999). It is possible that hypertonic cervical muscles may be associated with certain anomalies e.g. block vertebra/e and this therefore could be a cause for headaches in such individuals. The causes of headaches are vast and it could entirely be possible that the cause of the headaches in individuals may have nothing to do with any abnormality in the cervical spine e.g. hypertension. The literature does not report on whether these factors were examined in individuals with congenital cervical spine anomalies.

2.4.1.4 Decreased cervical range of motion (CROM)

Normal cervical range of motion (CROM) can be classified as having 80° to 90° of flexion, 70° of extension, 20° to 45° of lateral flexion to right and left and 70° to 90° of rotation to right and left and any decrease in this range during cervical spine motion can be described as decreased cervical range of motion (Magee 2002). This can be determined through observation during active neck motion or through palpation during passive neck motion (Bergmann *et al.* 1993). They also state that a decreased CROM may be attributed to various disorders that affect the cervical spine such as joint subluxation, joint dislocation, effusions, muscle hypertrophy, degenerative joint disease, muscle guarding and fractures.

In subjects with congenital cervical spine anomalies, in the absence of the above, decreased CROM may be present in posterior ponticle (Yochum and Rowe 1996) and severe limitation in cervical motion is a distinct feature, together with a short neck and low posterior hairline, in 40% to 50% of subjects with Klippel-Feil syndrome (Letts and Jawadi 2004). According to Hensinger (1991), any disturbance to cervical spine mechanics will result in episodic neck stiffness and torticollis.

With the exception of the anomalies mentioned above, the literature is silent on the association between decreased CROM and other congenital anomalies.

2.4.1.5 Torticollis

According to Ross and Dufel (2005), torticollis is the presentation of the neck in a twisted or bent position due to involuntary contractions of the neck muscles resulting in abnormal posture and head movements. They also stated that the sternocleidomastoid, splenius, levator scapulae and trapezius muscles are predominantly involved and are of two types, congenital and acquired. The acquired form is more common, with a prevalence of 3 per every 10 000 individuals in the United States. This type is mainly caused by infections, tumors, trauma, and cervical disc disease, drug-induced and in ocular conditions. No figure was given for the prevalence of congenital torticollis.

Torticollis had a prevalence of approximately 20% in subjects with basilar impressions (Hain 2005) and 40% in subjects with odontoid anomalies (Hensinger 1991; Letts and Jawadi 2004). The odontoid anomalies were not specified by Letts and Jawadi (2004).

2.4.2 Neurological Features

2.4.2.1 Muscle Weakness, Muscle Wasting and Hyporeflexia

These features have been grouped together as they indicate the clinical manifestations of a lower motor neuron lesion (Magee 2002). According to Webner (2003), muscle weakness can be defined as a decrease in strength of a local or generalized group of muscles. He also states that it may be attributed to metabolic, neurologic and toxic conditions as well as primary muscle disease. According to Sheth (2005), muscle wasting can be defined as atrophy of muscles from disease or lack of use and may be attributed to damage to the nerve that supplies the muscle or disease of the muscle itself. Hyporeflexia was defined as a decrease in the response of the deep tendon reflexes to appropriate stimuli (Shaik 2005)[1].

[1] Verbal communication Dr J. Shaik , senior lecturer at the Durban Institute of Technology (22 November 2005)

When these features were compared with the existing literature on congenital cervical spine anomalies to determine their association with an anomaly the following was found:

- Hensinger (1991) found muscle weakness to be common in odontoid anomalies and in 85% of cases with basilar impressions. He gives the following reason for this association: a posteriorly unstable odontoid may cause anterior compression of the brain stem. Therefore, it may be presumed, that this compression causes damage to the alpha motor neurons which innervate the extrafusal muscle fibers of skeletal muscle, thus causing a lower motor neuron lesion
- He also found both muscle weakness and wasting to be associated with occipitalisation of the atlas.

No other authors have been found by this researcher who support or refute Hensinger's (1991) findings.

2.4.2.2 Muscle Spasticity and Hyperreflexia

These features have been grouped together as they indicate the clinical manifestations of an upper motor neuron lesion (Magee 2002). Jasmin (2005) defined these features as the presence of rigid muscles or increased muscle tone and exaggerated deep tendon reflexes respectively, which may be attributed to damage to the motor area or subcortical white matter.

When these features were compared to the existing literature on congenital cervical spine anomalies to determine their association with an anomaly the following was found:

- Hensinger (1991) found both these features to be present in occipitalisation of the atlas due to pyramidal tract involvement
- Hain (2005) found hyperreflexia in 56% of subject's with basilar impression

These were the only 2 authors found by this researcher who commented on these findings. Therefore it is difficult to speculate whether similar clinical findings are associated with other congenital cervical spine anomalies.

2.4.2.3 Gait Abnormalities

Abnormalities in gait refer to any changes in the normal gait patterns (Magee 2002). As there are numerous gait abnormalities present, in the context of this study only the ataxic or unsteady gait pattern shall be considered. According to both Hensinger (1991) and Letts and Jawadi (2004), this gait abnormality was found to be associated with occipitalisation of the atlas. Hensinger (1991) also found gait abnormalities in 32% of subject's with basilar impression.

In a population without congenital cervical spine anomalies, this abnormality may be attributed to poor sensation (e.g. peripheral neuropathy) or poor muscle coordination (e.g. cerebellar disorders) thus resulting in poor balance and a broad base (Magee 2002). In those with congenital cervical spine anomalies, specifically in the craniovertebral junction, it may be attributed to damage to the lower motor neurons or the descending corticospinal (pyramidal) tract via compression of the brainstem or even compression of the cerebellum itself.

2.4.2.4 Hypoesthesia and Hyperesthesia

According to Magee (2002), these are defined as a decrease and increase in sensation respectively. When compared to the existing literature on congenital cervical spine anomalies, according to Hensinger (1991), hypoesthesia was found to be associated with a block vertebra. This may be explained as a result of prolonged compression of the spinal nerve as it exits the vertebral foramen due to the fused segment. However, it may also be assumed that these features may present itself in craniovertebral anomalies due to the odontoid process compressing the brainstem and causing damage to the spinothalamic tract which transmits sensation to the brain. This researcher reports that no mention is made

in the literature with respect to any association between a cervical spine congenital anomaly and hyperesthesia.

2.4.2.5 Paraesthesia and Radicular Pain

According to Haslett *et al.* (1999), paraesthesia may be defined as a 'pins and needle' sensation due to peripheral nerve lesions. Lacey *et al.* (2005), through the use of questionnaires, determined the association of physical and psychosocial aspects related to paraesthesia and concurrent neck and upper limb pain in the normal population. From the sample size of 1592 subjects, 13.9% had paraesthesia. The causal factors for the paraesthesia in these individuals were not mentioned.

According to Magee (2002), radicular pain is experienced along a dermatome, myotome, or sclerotome due to direct involvement of a spinal nerve or nerve root and would be sharp, electrical and/or burning in character. Malanga (2004) from the Department of Physical Medicine and Rehabilitation at the University of Medicine and Dentistry, in New Jersey conducted a review on cervical radiculopathy. His results showed that radicular pain occurred in 85 per 100 000 people in the United States.

In subjects with congenital cervical spine anomalies, Letts and Jawadi (2004) found paraesthesia and radicular pain to be present in Klippel-Feil syndrome and in occipitalisation of the atlas, Hensinger (1991) found paraesthesia in 85% of subjects with basilar impression and Fleming (2000) found paraesthesia in subjects suffering from thoracic outlet syndrome due to cervical ribs or elongated C7 transverse processes.

It may be assumed that any disorder (congenital or otherwise) that affects peripheral nerves will at some stage result in paraesthesia in an individual, and it is also likely that should the condition affect the spinal nerve/s or nerve root/s radicular pain may also develop.

2.4.2.6 Decreased Vibration Sense and Proprioception

According to Letts and Jawadi (2004) and Howard (1998) decreased vibration sense and proprioception have been found in relation to odontoid anomalies. This may be attributed to the odontoid compressing the brainstem resulting in damage to the spinocerebellar tracts. This could also account for the gait abnormalities seen in these individuals as described in 2.4.2.3.

However, it must be remembered that any condition affecting the dorsal column-medial lemniscal pathway may also result in abnormalities of vibration and proprioception (Shaik 2005)[1].

2.4.2.7 Tinnitus

According to Yost (1994) as cited by Sanders (2004), tinnitus may be defined as ringing in the ears, or as other head noises that occur independently from an external noise source. Sanders (2004) also conducted a study on tinnitus among 590 randomly selected subjects aged between 20 and 80, and found it to be prevalent in 13.2% of the general population.

Hensinger (1991) found tinnitus to be associated with occipitalisation of the atlas and he attributed it to cranial nerve involvement, most likely the vestibule-cochlear nerve. It may be assumed that should tinnitus occur in subjects with congenital cervical spine anomalies it will most likely be associated with anomalies predominantly of the upper cervical spine.

2.4.2.8 Dizziness, Vertigo and Nystagmus

According to Haslett *et al.* (1999) dizziness may be defined as an episode of lost or altered consciousness while vertigo was defined as dizziness due to an abnormal perception of movement of the environment. They also stated that vertigo was caused by an alteration in function of the peripheral vestibular organs or central control areas for posture and balance. They also defined nystagmus as oscillatory movement of the eye due to defective eye movement control

systems. Zagaria (2003) conducted a review and found dizziness to be a functional disability and to be present in 13% to 30% of the population.

In subjects with congenital cervical spine anomalies, literature revealed the following:

- Hensinger (1991) stated that nystagmus occurred in occipitalisation of the atlas and attributed it to posterior cerebellar compression by the odontoid process.
- He also stated that vertigo is commonly associated with odontoid anomalies due to brainstem ischemia.
- Beck *et al*. (2004) found both dizziness and vertigo to be associated with posterior ponticle and they attributed it to brainstem ischemia.
- Letts and Jawadi (2004) stated that vertigo was present in occipitalisation of the atlas.
- Menezes (2004) in his review of congenital cervical spine anomalies stated that vertigo and nystagmus were common symptoms.

Dizziness, vertigo and nystagmus are common clinical features found in individuals with and without congenital cervical spine anomalies. The most likely anomalies which cause these symptoms appear to be those affecting the upper cervical spine.

2.4.2.9 Positive Wallenberg's Test

This test is also known as George's test and is used to exclude the presence of vertebral basilar arterial insufficiency (Bragman 2004). It involves active rotation and hyperextension of the cervical spine. This position is held for 3 - 5 seconds while assessing the patient's symptoms. A positive test will include the presence of any one of the following: headache, nausea, vomiting, and nystagmus, numbness, visual disturbances, gait disturbances, dizziness, and vertigo, suboccipital tenderness, blanching around the mouth, dysarthria, dysphagia and "drop attacks" (Leach 1986). No mention is made in the literature with respect to the association of this test and congenital cervical spine anomalies.

Nonetheless, this test was included in this study to determine if there is any association between vertebral basilar arterial insufficiency and congenital cervical spine anomalies.

2.4.3 Other Clinical features

2.4.3.1 Swallowing and Speech Abnormalities

In the context of this study, this included any abnormalities related to swallowing and speech that occurred in conjunction with congenital cervical spine anomalies. The literature describes swallowing abnormalities such as dysphagia and speech abnormalities such as hoarseness occurred in association with occipitalisation of the atlas (Hensinger 1991; Letts and Jawadi 2004). According to Hensinger (1991) these may be attributed to cranial nerve involvement.

2.4.3.2 Respiratory Abnormalities

According to Menezes (2004) repeated respiratory aspirations and eventual respiratory failure was found in upper cervical spine anomalies due to chronic deficits. No specific details were given by this author.

The author of the current study is of the opinion that this may be attributed to a congenital cervical spine anomaly, depending on its type and location, affecting the vagus nerve which provides the parasympathetic fibers to the lung and the phrenic nerve, which supplies the mediastinal and diaphragmatic pleura (Moore and Dalley 1999). This is merely a speculation at this stage.

2.4.3.3 Double Vision

According to Haslett *et al.* (1999), double vision or diplopia occurs when eye movement is impaired and the image of an object is not projected to homologous points on the two retinas. It may be attributed to central disorders, ocular muscle and motor nerve disorders and disorders at the neuromuscular junction. Letts

and Jawadi (2004) stated that double vision occurred in subjects with occipitalisation of the atlas.

2.5 SUMMARY

Congenital cervical spine anomalies are considered uncommon (Hensinger 1991). As a result very little information exists regarding the prevalence of individual anomalies. Furthermore, as discussed in this chapter under 2.3, discrepancies appear to be present in the available literature regarding the prevalence of these anomalies.

According to the literature, a patient with a congenital cervical spine anomaly could theoretically present with certain signs and symptoms related to that anomaly. However, no research has been done to determine whether there is a strong correlation between the congenital anomaly and the clinical presentation reported by the various authors in the literature. It has been found that literature is scant regarding the clinical manifestations of congenital cervical spine anomalies as discussed earlier in this chapter under 2.4.

From the above, one observes the lack of depth with respect to congenital cervical spine anomalies and therefore the purpose of this study would be first to determine the prevalence of congenital anomalies in this region, and then to determine if there is an association between the subjects presenting signs and symptoms with what literature reports. This knowledge may allow us to incorporate congenital spinal anomalies as a differential diagnosis in subjects who are not responding to treatment and also help in creating awareness for improving patient management.

CHAPTER 3

MATERIALS AND METHODS

3.1 INTRODUCTION

This chapter will include a detailed description of the study design, the selection of the cervical spine radiographs and patient files and data collection. The statistical procedures that were implemented in analysing the data have been included in this chapter.

3.2 STUDY DESIGN

This research study was designed in the form of a quantitative, non-experimental, empirical clinical survey. Data was obtained from the cervical spine radiographs and corresponding patient files that were present at the Chiropractic Day Clinic at the Durban Institute of Technology from 1 January 1997 to 31 December 2004. This time frame was selected due to the availability of the radiographs as all radiographs taken prior to 1 January 1997 were either given to patients or used for teaching purposes.

3.2.1 Patient Confidentiality

Steps were undertaken to maintain patient confidentiality throughout the process of the study. All information that was obtained from the radiographs and patient files were reduced to code form. To further maintain confidentiality, only the researcher and the research supervisor examined the patient files and radiographs. When required, an external radiologist helped in identifying and verifying images.

3.2.2 Sampling and Sample Allocation

In this study, convenience sampling was used. Data was obtained from cervical spine radiographs contained in the Chiropractic Day Clinic at the Durban Institute of Technology from 1 January 1997 to 31 December 2004 and from the corresponding patient files. To improve reliability and avoid confusion this study

took place in four phases. All the information collected was recorded on data collection sheets and patient files were evaluated first to avoid researcher bias.

3.2.3 Inclusion and Exclusion Criteria

Inclusion Criteria

1) This study was limited to patients' radiographs and files within the archives of the Chiropractic Day Clinic at the Durban Institute of Technology from 1 January 1997 to 31 December 2004.
2) All cervical spine radiographs and corresponding files, with the exception of those that met the exclusion criteria, were used and those that did not have a congenital cervical spine anomaly were considered a control.

Exclusion Criteria

1) Patient files that revealed a past or present history of trauma to the cervical spine area were excluded to avoid confusion that may have arisen with regards to the clinical manifestations.
2) Any radiographs that did not fall in the allocated time period (1 January 1997 to 31 December 2004) were excluded.

3.2.4 Data Collection

Data collection involved both primary data and secondary data.

3.2.4.1 The Primary Data

The primary data was obtained from patient files and from the cervical spine radiographs.

(A) File Selection

Patient files, corresponding to cervical spine radiographs that were present at the Chiropractic Day Clinic, were evaluated with focus on the following:

- Presenting complaint
- Medical history

- Regional examination of the cervical spine
- Management protocol applied to that particular patient, with focus on cervical spine manipulation. The present author is of the opinion that controversy still exists in the literature to whether cervical spine manipulation is an appropriate treatment intervention for those with congenital anomalies. For example, with respect to posterior ponticle and spina bifida etc., some authors are of the opinion that it is unsafe to manipulate the cervical spine of individuals with these spinal anomalies (Bragman 2004). Yochum and Rowe (1996) have also mentioned that a clinician must consider the possibility of initiating a vertebral artery spasm post cervical manipulation especially in individuals with a posterior ponticle. However, other authors state that manipulation is not contraindicated in congenital anomalies unless it is quite serious and produces major neurological involvement (Kent 2004). These authors did not specify what ought to be considered a "serious" anomaly.

(B) Radiograph Selection

All the cervical spine radiographs were evaluated and a baseline of congenital cervical spine anomalies was used. For the purpose of this study, the classification system suggested by Yochum and Rowe (1996) was utilised with the inclusion of anomalies suggested by Taylor and Resnick (2000) that are of significance such as Mach band effect and paraodontoid notch that simulate fractures of the atlas, asymmetry of the atlas and incomplete fusion of neural arches of C2. The anomalies were sub-divided into cervical spine vertebral levels.

They are as follows:

1) <u>Craniovertebral junction</u>

- Occipitalisation of the atlas - fusion of atlas to base of the occiput which may be complete or partial.

- Occipital vertebra - developmental anomalies of the spine that occur at the occipitocervical junction and are composed of the following: third condyle (failure of fusion resulting in small bony ossicles near foramen magnum), epitransverse and paracondylar processes (articulation of the transverse process with the base of the skull), accessory ossicles (bony fragments in the ligaments around foramen magnum).
- Platybasia - flattening of the base of the skull due to maldevelopment of the sphenoid and occipital bones.

2) <u>The atlas</u>

- Agenesis of the anterior and the posterior arch - lack of development of the cartilage during the ossification process.
- Spina bifida occulta - failure in unison of the spinous processes resulting in a small void in osseous development.
- Posterior ponticle - calcification or ossification of the oblique portion of the atlanto-occipital ligament.
- Asymmetrical development of the lateral masses of the atlas (Taylor and Resnick 2000).

3) <u>The axis</u>

- Ossiculum terminale persistens - failure in unison of the secondary growth centre with the subadjacent odontoid process and thus remains as a separate ossicle.
- Odontoid anomalies - include the following: agenesis, hypoplasia and posterior inclination of the odontoid (Taylor and Resnick 2000).
- Os odontoideum - failure in fusion of the odontoid process to the atlas.
- Mach band effect and paraodontoid notch – the former is a transverse zone of radiolucency overlying the base of the odontoid adjacent to overlapping the posterior arch of the atlas and may simulate an odontoid fracture, while the latter is normal bilateral notches adjacent to the base of the odontoid which may simulate fractures (Taylor and Resnick 2000).

- Hypoplastic odontoid - present in 20% of individuals with Downs Syndrome and may indicate atlanto-axial instability (Taylor and Resnick 2000).
- C2 Congenital spondylolysis - incomplete fusion of C2 neural arches to vertebral body (Taylor and Resnick 2000).

4) C3 through to C7

- Block vertebra - osseous fusion of two adjacent vertebrae from birth.
- Klippel-Feil syndrome – a syndrome associated with a low hairline, limited cervical range of motion and a webbed neck.
- Sprengle's deformity - congenital elevation of the scapula.
- Cervical spondylolisthesis - displacement of one vertebrae in relation to another one due to absence of pedicles bilaterally, dysplasia of the articular processes or spina bifida occulta.
- Cervical ribs - separate piece of bone that articulates with the transverse process of one or more cervical vertebra.
- Hemivertebra – failure in growth of the ossification centres. Lateral hemivertebra is the most common type and predisposes to the development of structural scoliosis.
- Congenital absence of cervical pedicle – failure in development of the cartilage for the neural arches.

3.2.4.2 The Secondary Data

This was obtained from various sources which included journals, books, the Internet and conversations with radiologists and anatomists.

3.2.5 Research Procedure

This research took place in four phases to maintain order and to avoid any confusion that would have arisen.

3.2.5.1 Phase One

Radiographs contained in the confines of the Chiropractic Day Clinic at the Durban Institute of Technology were sorted. All the cervical spine radiographs from 1 January 1997 to 31 December 2004 were obtained and placed aside.

3.2.5.2 Phase Two

Patient names present on the radiograph envelopes were recorded to help assist the researcher in obtaining the corresponding patient files by means of the Chiropractic Day Clinic computer system. Once the patient files were drawn patient names were converted to code form to maintain patient confidentiality. The files were evaluated with focus on the presenting complaint, medical history, regional examination of the cervical spine and treatment protocol.

All information that was gathered was recorded on Data Collection Sheet 1 (Appendix 1) which contained the following:

- Code
- Congenital anomaly present or not
- The presenting complaint
- Clinical features, as described in the literature, related to the anomaly
- Management of the patient

3.2.5.3 Phase Three

Patient files were evaluated and those that had a past or present history of trauma to the cervical spine area were excluded.

3.2.5.4 Phase Four

All the cervical spine radiographs, with the exclusion of those that indicated trauma, from the Chiropractic Day Clinic at the Durban Institute of Technology were evaluated using the Alignment, Bone, Cartilage and Soft tissue (ABCS) criteria (Yochum and Rowe 1996). It must be noted that all these radiographs

had been reported on and evaluated by a radiologist prior to the examination by this researcher.

All information that was gathered was recorded on Data Collection Sheet 2 (Appendix 2) and contained the following:

- Code
- Date
- The type of cervical spine anomaly that is present or not
- The location of the anomaly
- The description of the anomaly
- Whether it was identified by the researcher or the radiologist or both.

3.3 STATISTICAL ANALYSIS

The statistical package SPSS, Version 11.5 (as supplied by SPSS Incorporated, Marketing Department- 1999, Chicago, USA) was used in the analysis of the data in this study.

3.3.1 Method of data analysis

The period prevalence of congenital cervical spine anomalies was determined using descriptive analysis which included proportions and counts that were presented for categorical variables, and means and standard deviations that were presented for quantitative variables. The α level of significance was set at 0.05.

In determining the associations between clinical features and presence of any congenital cervical spine anomalies, Fisher's exact tests were used. Sensitivity, specificity and 95% confidence intervals were calculated using EpiCalc 2000 (Gilman and Myatt 1998).

3.3.2 Hypotheses

1) The Null Hypothesis (H_o) states that there shall be a significant number of congenital cervical spine anomalies present for the chosen period of 1 January 1997 to 31 December 2004.

   The Alternate Hypothesis (H_a) states that there shall not be a significant number of congenital cervical spine anomalies present for the chosen period of 1 January 1997 to 31 December 2004.

2) The Null Hypothesis (H_o) states that there shall be a significant association between the congenital cervical spine anomalies and the presenting clinical features in general.

   The Alternate Hypothesis (H_a) states that there shall be no significant association between the congenital cervical spine anomalies and the presenting clinical features in general.

3) The Null Hypothesis (H_o) states that there shall be a significant association between the individual congenital cervical spine anomalies and the presenting clinical features.

   The Alternate Hypothesis (H_a) states that there shall be no significant association between the individual congenital cervical spine anomalies and the presenting clinical features.

4) The Null Hypothesis (H_o) states that there shall be a significant association between subjects presenting clinical features with reported clinical features from the literature.

   The Alternate Hypothesis (H_a) states that there shall be little/no significant association between the subjects presenting clinical features with reported clinical features from the literature.

CHAPTER 4

RESULTS

4.1 INTRODUCTION

SPSS version 11.5 (SPSS Inc, Chicago, Ill, USA) was used for the analysis of data. The period prevalence of the congenital cervical spine anomalies were determined using descriptive analysis which included proportions and counts that were used as categorical variables, and means and standard deviations that were used as quantitative variables. Fisher's exact tests were used to examine associations between presenting clinical features and presence of any congenital cervical spine anomalies. Sensitivity, specificity and 95% confidence intervals were calculated using EpiCalc 2000 (Gilman and Myatt 1998). An α level of 0.05 was used to classify statistical significance.

4.2 THE RESULTS

4.2.1 THE PERIOD PREVALENCE OF CONGENITAL CERVICAL SPINE ANOMALIES

4.2.1.1 Ratio of congenital cervical spine anomalies per subject

Through the research procedure 403 cervical spine radiographs were located in the confines of the Chiropractic Day Clinic at the Durban Institute of Technology from 1 January 1997 to 31 December 2004. Due to the exclusion criteria of a past or present history of trauma to the cervical spine area, 193 radiographs were excluded. Of the remaining 210 radiographs meeting the inclusion criteria for this study, 98 (46.7%) were positive for any congenital cervical spine anomaly. This was a period prevalence of 46.7% (95% CI 39.81 to 53.65).

The number of congenital cervical spine anomalies per subject ranged from zero to three. These are shown in Table 1.

	Frequency	Percent
0	112	53.3
1	76	36.2
2	19	9.0
3	3	1.4
Total	210	100.0

Table 1: Number of congenital cervical spine anomalies per subject (Obtained from the 210 radiographs)

From the total of the 210 radiographs, it was found that 36.2% had only one anomaly, 9% had two and 1.4% had three anomalies.

4.2.1.2 Prevalence of the individual congenital cervical spine anomalies

The most common type of anomaly found was elongated C7 transverse process (n=43, 20.5% of sample, 35.0% of all anomalies), followed by rudimentary posterior ponticle (n=18, 8.6% of sample, 14.6% of all anomalies) and posterior ponticle (n=17, 8.1% of sample, 13.8% of all anomalies). These are shown in Table 2 and in Figure 4.1 which includes only those congenital cervical spine anomalies that were identified from the 98 radiographs.

Subjects who had more than one anomaly were also mainly of type elongated C7 transverse process (n=14, 60.9% of those with >1 anomaly).

Type of Anomaly	Count	Column %
Elongated C7 Transverse Process	43	35.0%
Rudimentary Posterior Ponticle	18	14.6%
Posterior Ponticle	17	13.8%
Cervical Ribs	8	6.5%
Fusion of Posterior Elements of Vertebral Bodies	6	4.9%
Hypoplastic Spinous Process of C3	6	4.9%
Incomplete Spina Bifida	5	4.1%
Spondylolisthesis	5	4.1%
Hypoplasia of Posterior Arch of C1	4	3.3%
Spinous Process Structural Abnormalities (inferiorly hooked spinous, bifid spinous and upturned spinous)	3	2.4%
Partial Occipitalisation of Atlas	2	1.6%
Complete Spina Bifida	1	0.8%
Complete Block Vertebra	1	0.8%
Bifid Posterior Arch of C1	1	0.8%
Partial Body Fusion	1	0.8%
Prominent Transverse Process of C1	1	0.8%
Bifid anterior end of first rib	1	0.8%
Complete Occipitalisation of Atlas	0	0.0%
Occipital Vertebra	0	0.0%
Platybasia	0	0.0%
Agenesis of C1	0	0.0%
Asymmetry of Atlas	0	0.0%
Ossiculum Terminale Persistens	0	0.0%
Odontoid Abnormalities	0	0.0%
Os Odontoideum	0	0.0%
Mach Band Effect	0	0.0%
Absent Transverse Ligament	0	0.0%
C2 Spondylolysis	0	0.0%
Fusion of Anterior Elements of Vertebral Bodies	0	0.0%
Klippel-Feil Syndrome	0	0.0%
Hemivertebra	0	0.0%
Congenital Absence of Pedicle	0	0.0%
Total	123	100.0%

Table 2: Types of congenital cervical spine anomalies

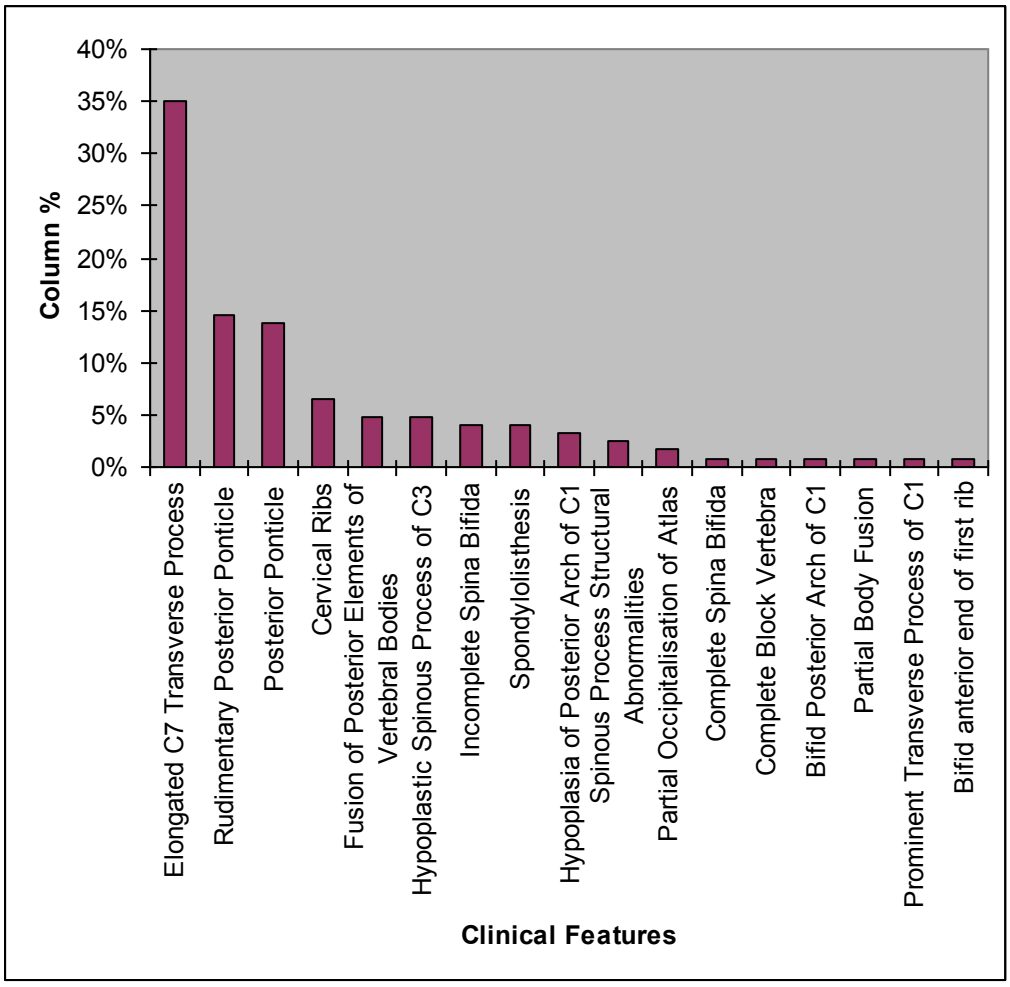

Figure 4.1: Types of congenital cervical spine anomalies identified

From the data obtained it has been shown that number of congenital cervical spine anomalies present for the chosen period of 1 January 1997 to 31 December 2004 is of no significance. Therefore, we fail to accept the null hypothesis and accept the alternate hypothesis with respect to the prevalence of congenital cervical spine anomalies for the period 1 January 1997 to 31 December 2004.

4.2.2 ASSOCIATION BETWEEN THE CONGENITAL CERVICAL SPINE ANOMALIES AND THE CLINICAL FEATURES

4.2.2.1 Association between congenital cervical spine anomalies and clinical features in general.

There were many clinical features in subjects with any congenital cervical spine anomaly. This is illustrated in Figure 4.2. Figure 4.3 illustrates the prevalence of clinical features in subjects without any congenital cervical spine anomalies. The type and percentage of clinical features was similar in both groups.

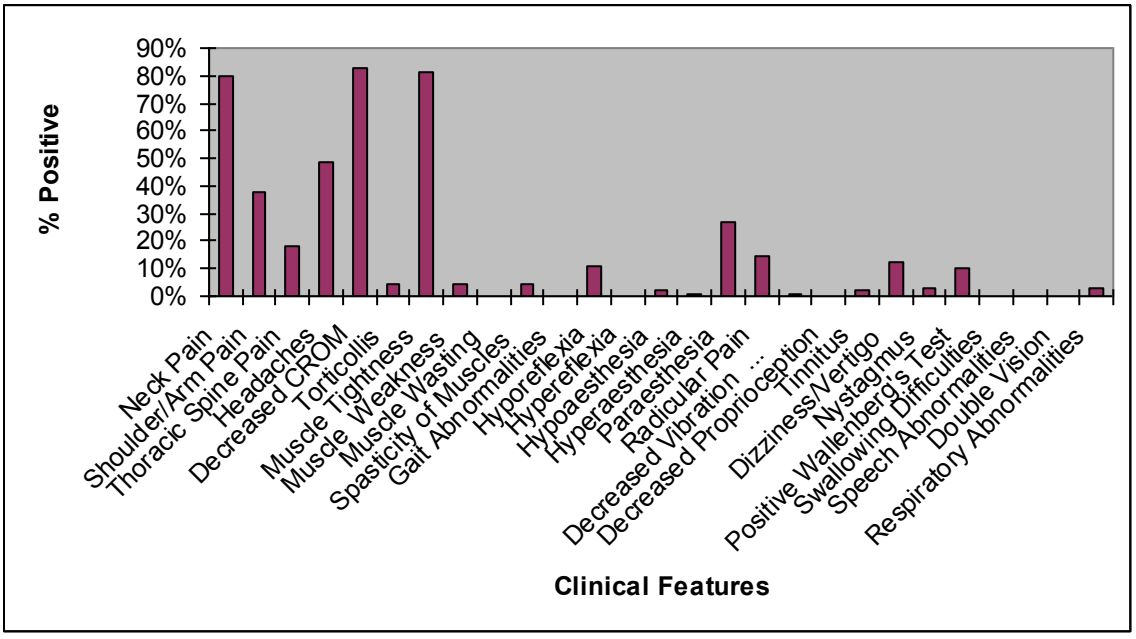

Figure 4.2: Prevalence of clinical features in subjects with congenital cervical spine anomalies (n=98)

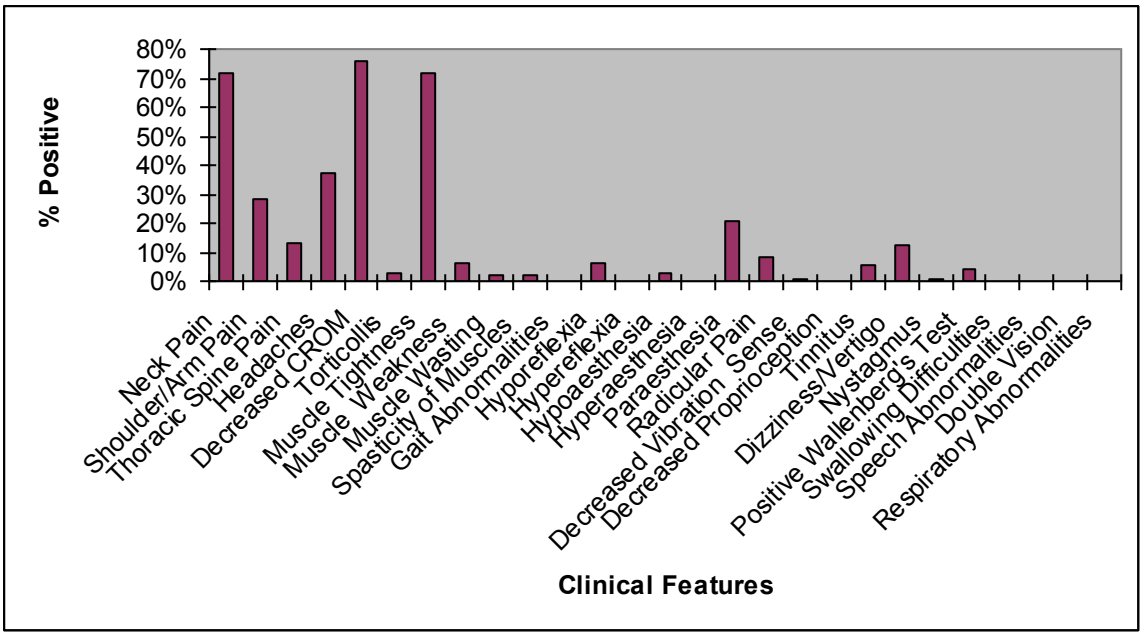

Figure 4.3: Prevalence of clinical features in subjects without congenital cervical spine anomalies (n=112)

There were no clinical features that were significantly associated with the presence of any congenital cervical spine anomaly when compared with the control group, with no congenital cervical spine anomalies. These are shown in Table 3.

The proportions of subjects with each clinical symptom were similar in both groups (those who had any congenital cervical spine anomalies and those who did not have any congenital cervical spine anomalies). The # chi square statistic could not be calculated because no congenital cervical spine anomaly had the clinical feature present.

		Any abnormalities		*p* value
		no	yes	
Neck Pain	no	32	20	0.210
	yes	80	78	
Shoulder/Arm Pain	no	80	61	0.186
	yes	32	37	
Thoracic Spine Pain	no	97	80	0.347
	yes	15	18	
Headaches	no	70	50	0.096
	yes	42	48	
Decreased Cervical Range of Motion (CROM)	no	27	17	0.240
	yes	85	81	
Torticollis	no	109	94	0.708
	yes	3	4	
Muscle tightness	no	32	18	0.104
	yes	80	80	
Muscle weakness	no	105	94	0.548
	yes	7	4	
Muscle wasting	no	110	98	0.500
	yes	2	0	
Spasticity of muscles	no	110	94	0.421
	yes	2	4	
Gait abnormalities	no	112	98	#
	yes	0	0	
Hyporeflexia	no	105	87	0.224
	yes	7	11	
Hyperreflexia	no	112	98	#
	yes	0	0	
Hypoaesthesia	no	109	96	1.000
	yes	3	2	
Hyperaesthesia	no	112	97	0.467
	yes	0	1	
Paraesthesia	no	89	72	0.330
	yes	23	26	

Radicular pain	no	103	84	0.185
	yes	9	14	
Vibration Sense	no	111	97	1.000
	yes	1	1	
Proprioception	no	112	98	#
	yes	0	0	
Tinnitus	no	106	96	0.289
	yes	6	2	
Dizziness/Vertigo	no	98	86	1.000
	yes	14	12	
Nystagmus	no	111	95	0.341
	yes	1	3	
Positive Wallenberg's test	no	107	88	0.117
	yes	5	10	
Swallowing Difficulty/Dysphagia	no	112	98	#
	yes	0	0	
Speech Abnormalities/Hoarseness	no	112	98	#
	yes	0	0	
Double Vision	no	112	98	#
	yes	0	0	
Respiratory abnormalities	no	112	95	0.100
	yes	0	3	

Table 3: Association between clinical features and presence of any congenital cervical spine anomaly

4.2.2.2 Association between individual congenital cervical spine anomalies and clinical features.

The following figures show the clinical features that were found with each congenital cervical spine anomaly. They are listed below in numerically descending order with respect to the congenital cervical spine anomalies.

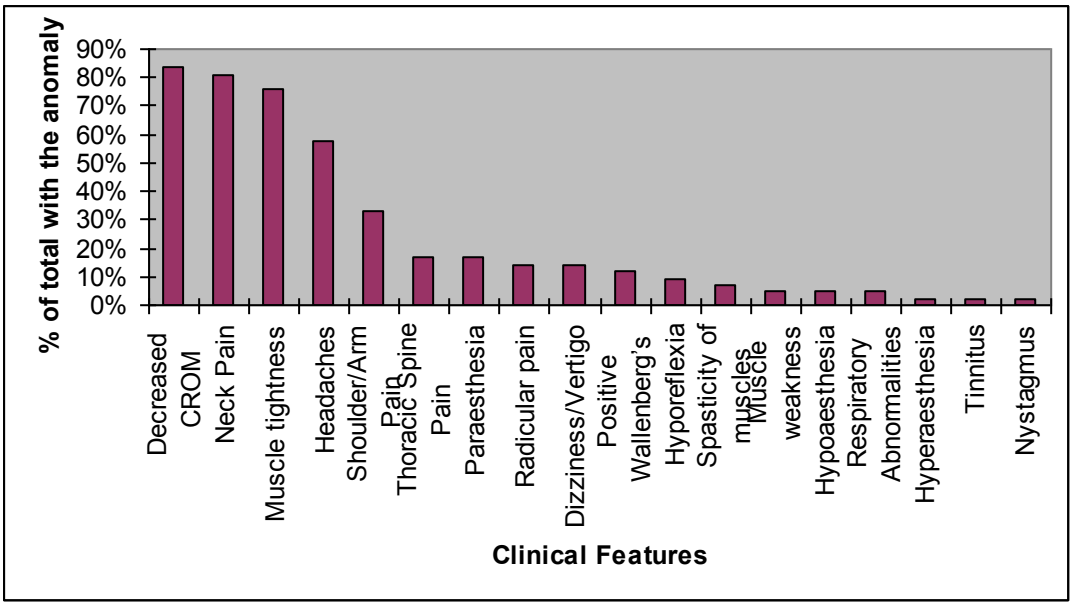

Figure 4.4: Clinical features in subjects with elongated C7 transverse process (n=43)

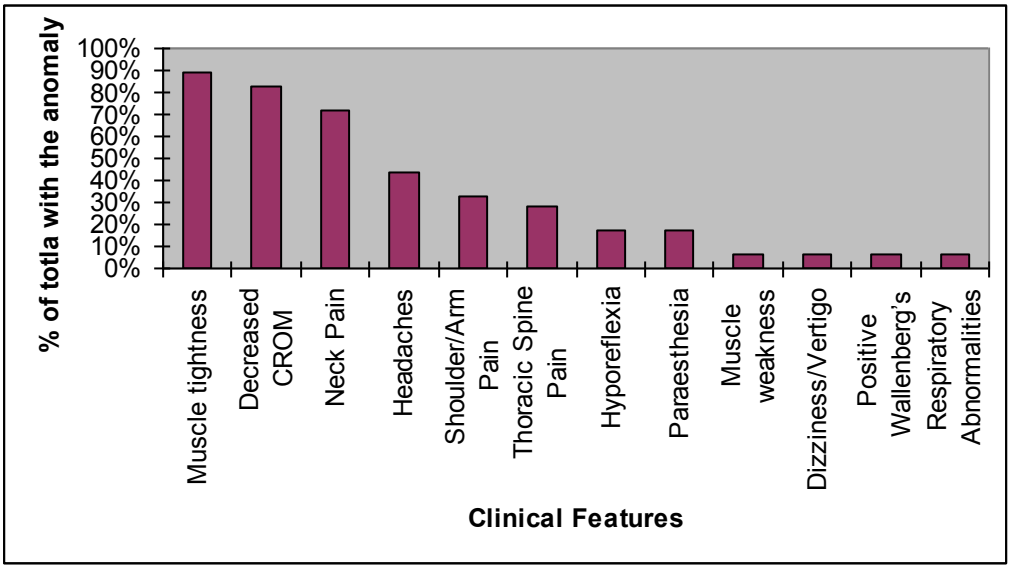

Figure 4.5: Clinical features in subjects with rudimentary posterior ponticle (n=18)

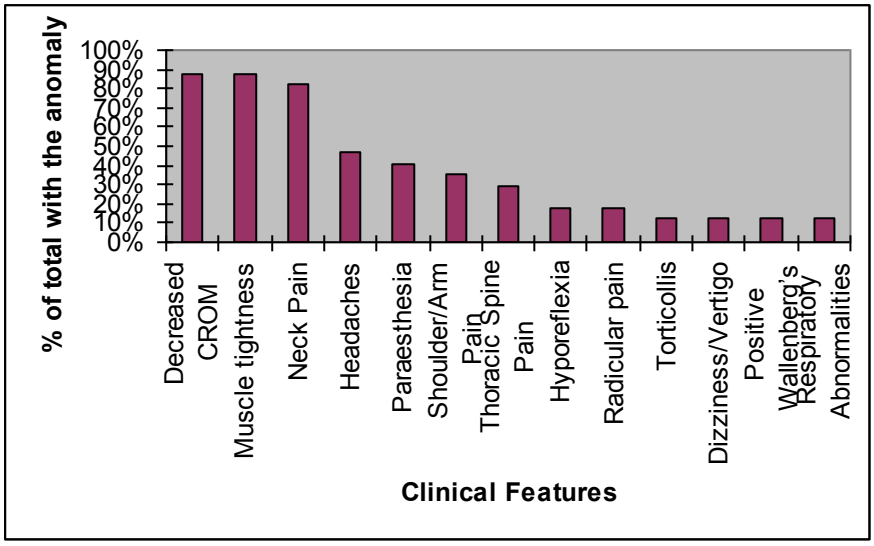

Figure 4.6: Clinical features in subjects with posterior ponticle (n=17)

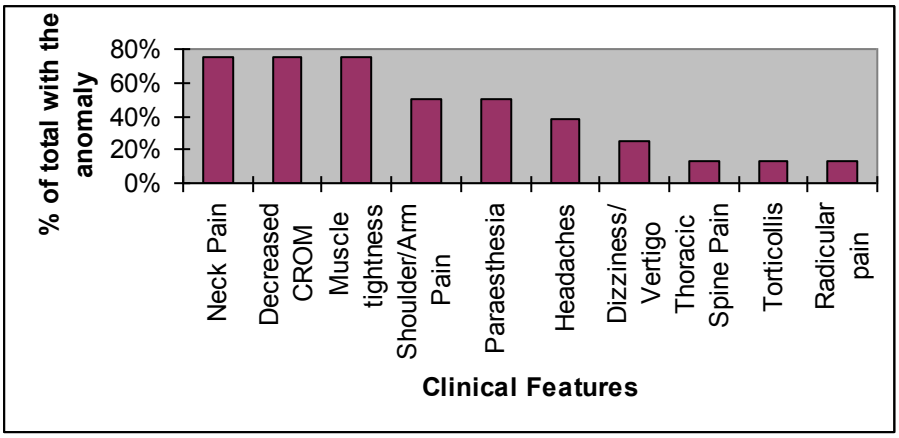

Figure 4.7: Clinical features in subjects with cervical ribs (n=8)

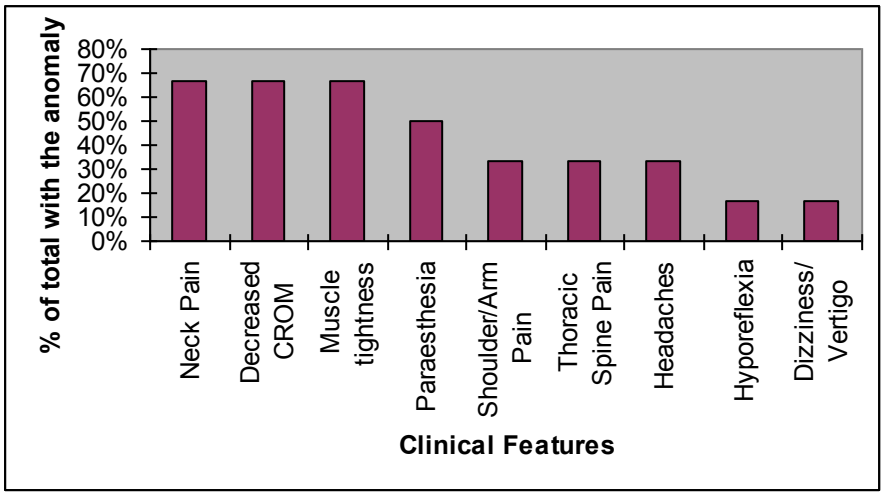

Figure 4.8: Clinical features in subjects with fusion of posterior elements of vertebral bodies (n= 6)

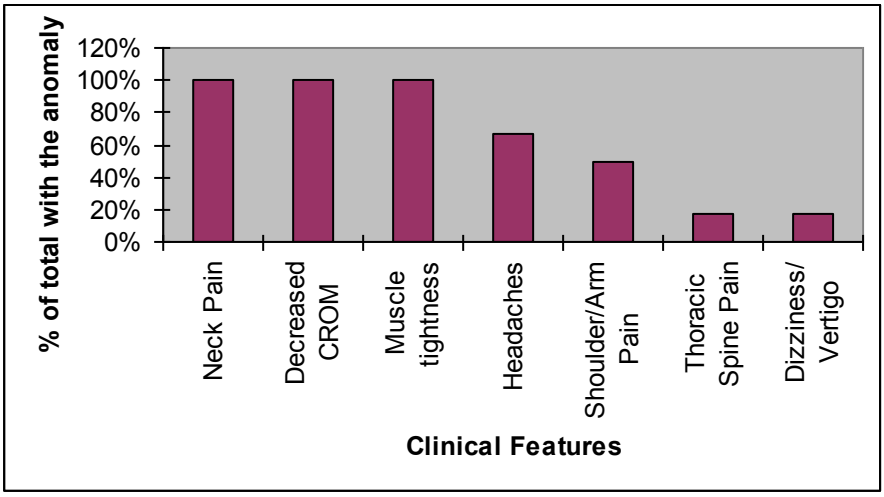

Figure 4.9: Clinical features in subjects with hypoplastic spinous process of C3 (n=6)

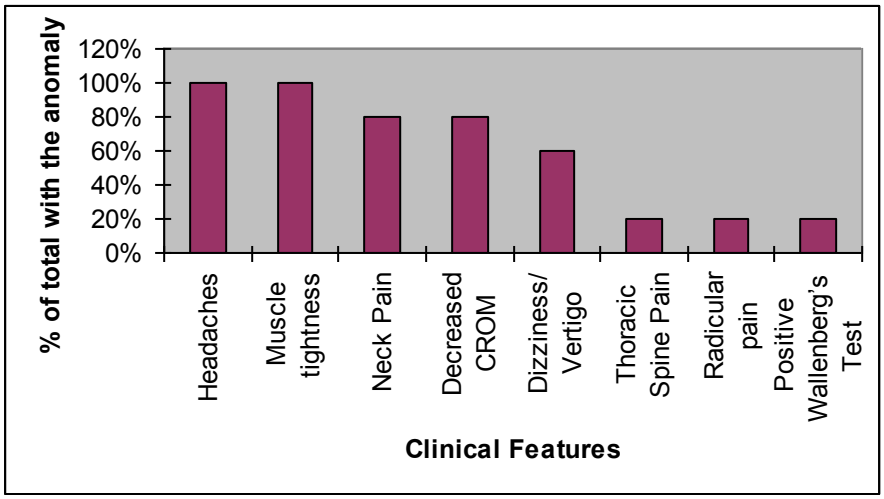

Figure 4.10: Clinical features in subjects with incomplete spina bifida (n=5)

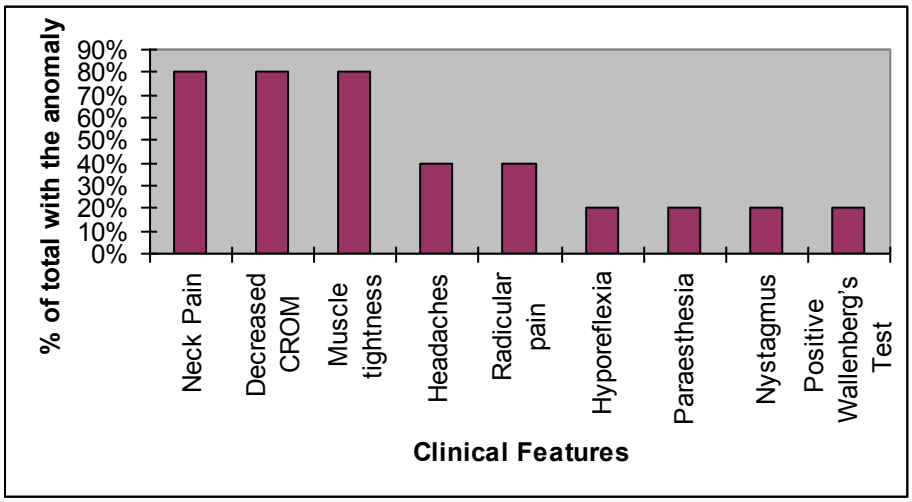

Figure 4.11: Clinical features in subjects with congenital spondylolisthesis (n=5)

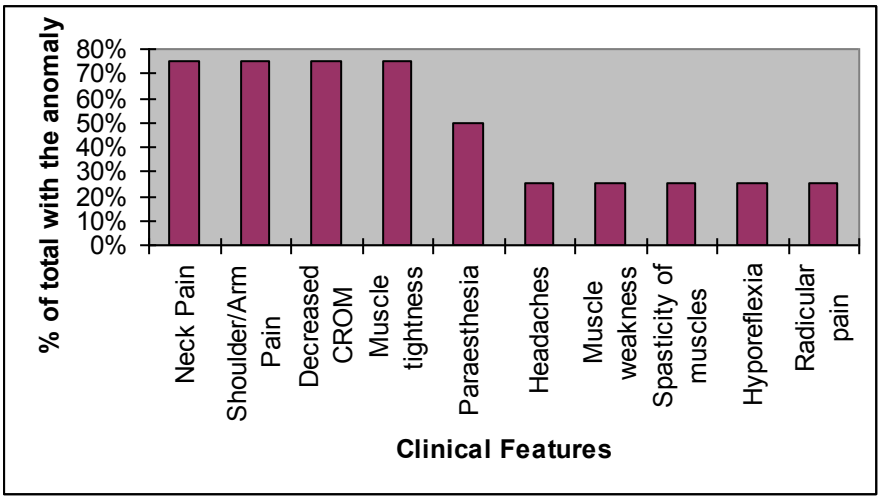

Figure 4.12: Clinical features in subjects with hypoplasia of posterior arch of C1 (n=4)

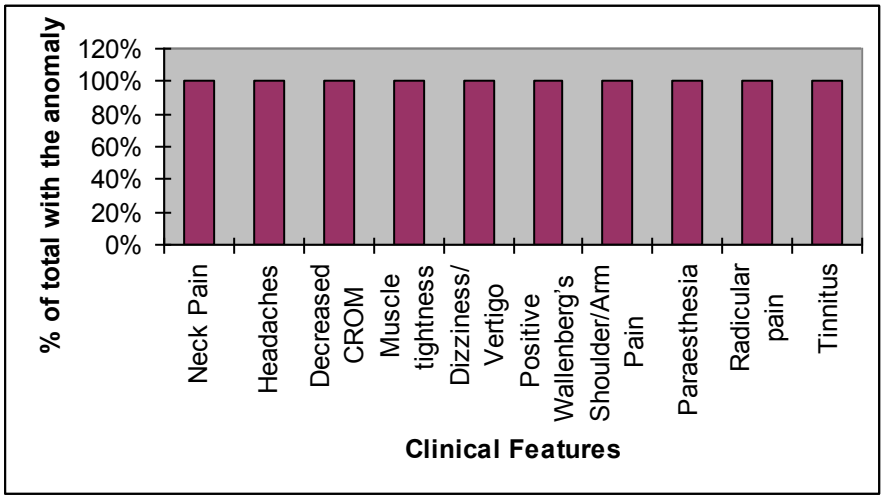

Figure 4.13: Clinical features in subjects with spinous process structural abnormalities (n=3)

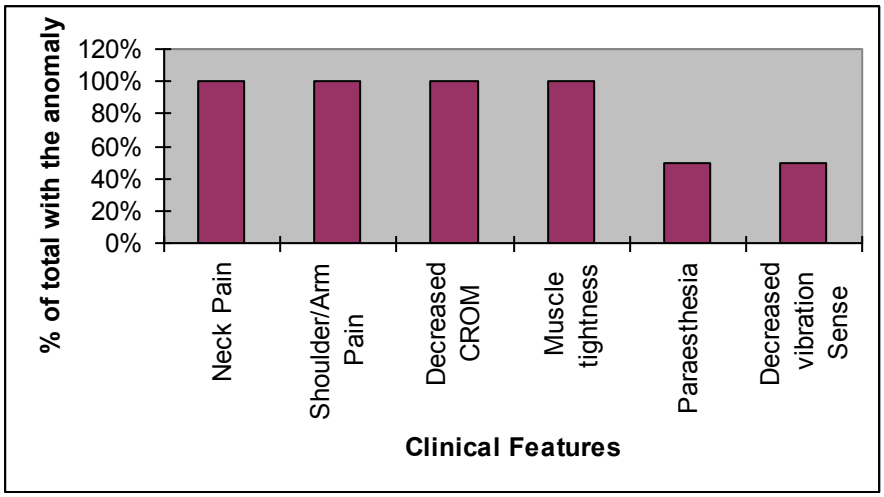

Figure 4.14: Clinical features in subjects with partial occipitalisation of atlas (n=2)

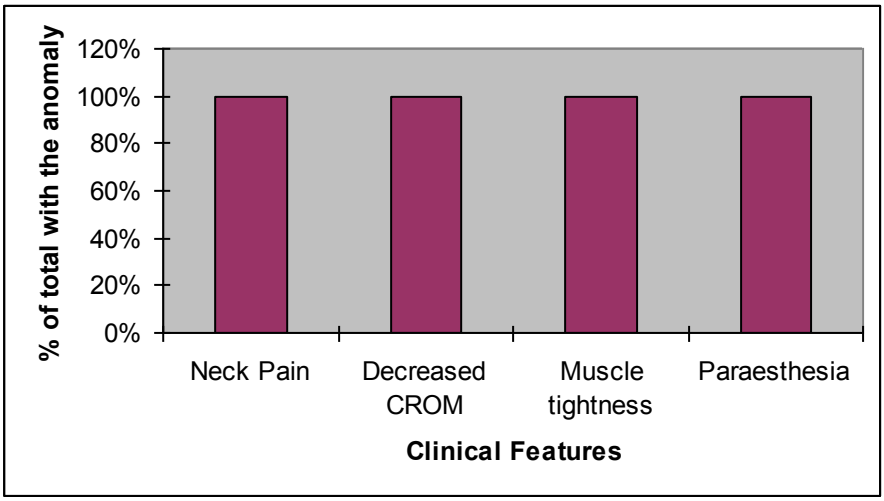

Figure 4.15: Clinical features in subjects with complete spina bifida (n=1)

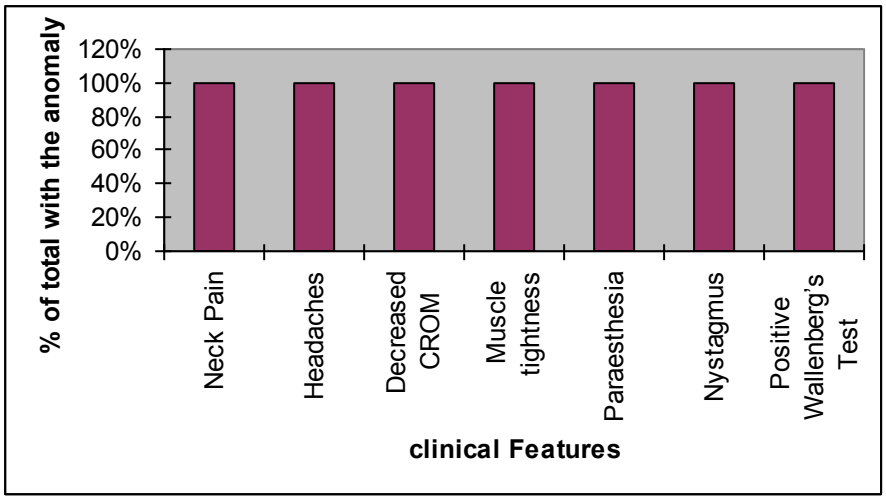

Figure 4.16: Clinical features in subjects with complete block vertebra (n=1)

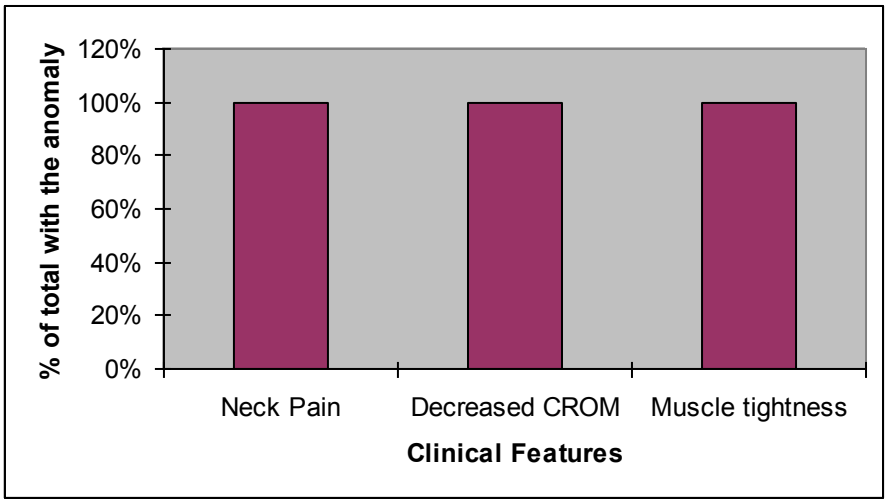

Figure 4.17: Clinical features of subjects with bifid posterior arch of C1 (n=1)

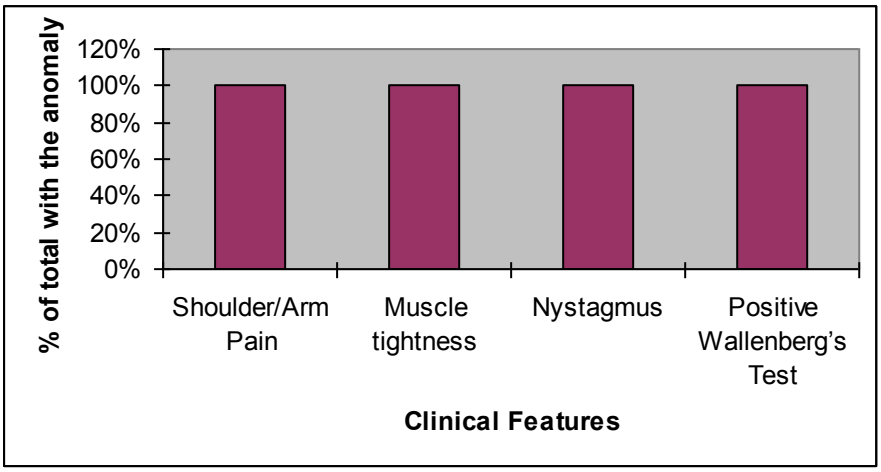

Figure 4.18: Clinical features in subjects with partial body fusion (n=1)

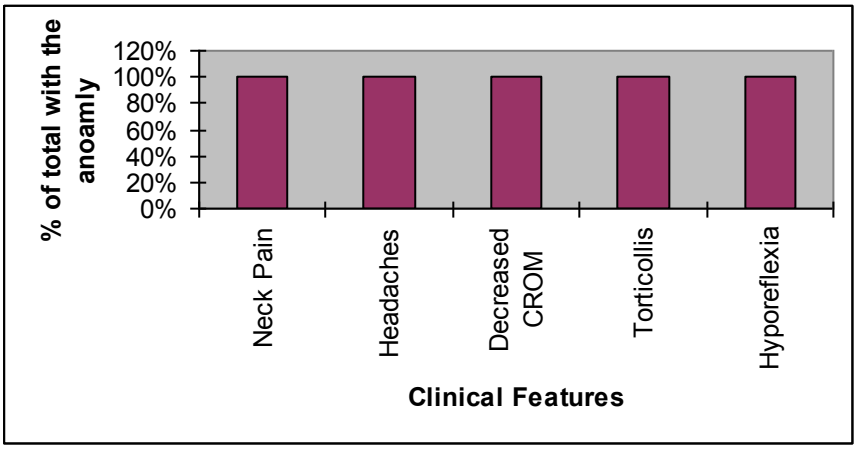

Figure 4.19: Clinical features in subjects with prominent transverse process of C1 (n=1)

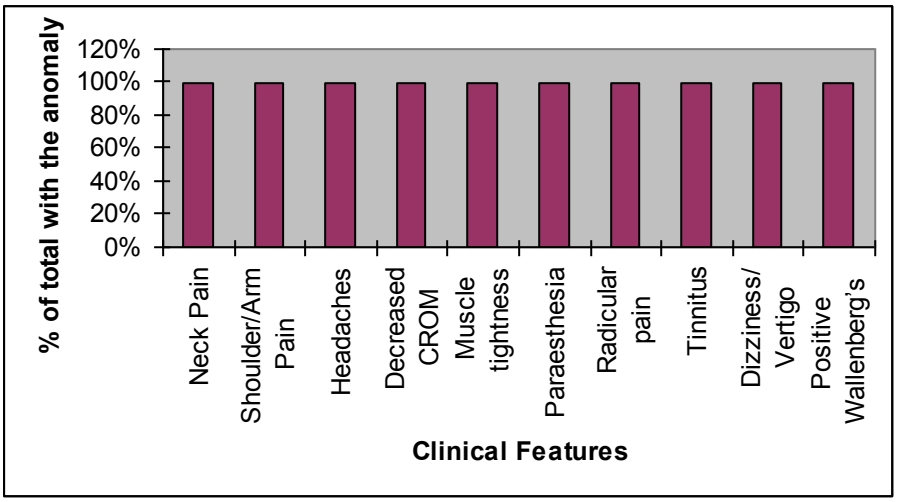

Figure 4.20: Clinical features in subjects with bifid anterior end of first rib (n=1)

4.2.3 MANAGEMENT PROTOCOL OF SUBJECTS WITH CONGENITAL CERVICAL SPINE ANOMALIES

Treatment of the subjects took place at the Chiropractic Day Clinic at the Durban Institute of Technology by fifth and sixth year chiropractic students. Of the 98 subjects with congenital cervical spine anomalies, 73% (n=72) had received soft tissue therapy (which included massage; ischemic compression and dry needling); 60.2% (n=59) had received stretch therapy (which included static stretching; proprioceptive neuromuscular facilitation and muscle energy techniques), and 57% (n=56) had received manipulation of the cervical spine from the atlanto-occipital to the cervicothoracic junctions. These are shown in Figure 4.21. No cervical manipulation was administered to 14.3% with congenital cervical spine anomalies.

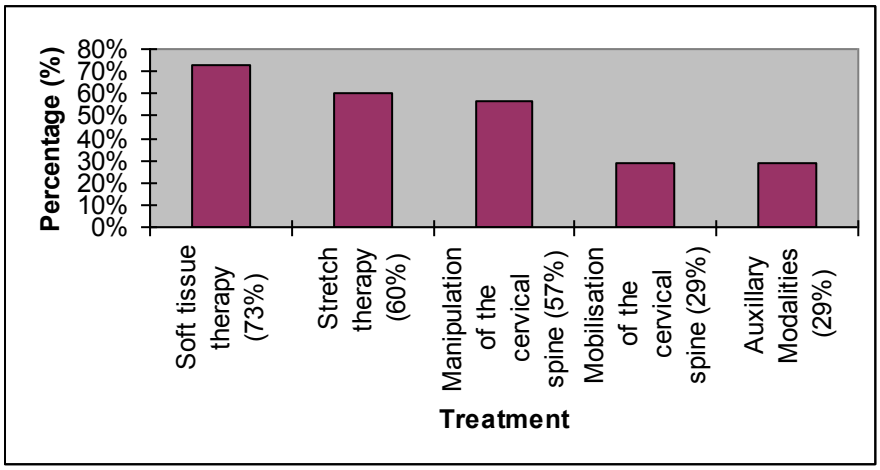

Figure 4.21: Percentage of chiropractic treatment received by subjects with any congenital cervical spine anomalies (n=98)

Of the 56 subjects that were manipulated, it was found that the most frequent congenital cervical spine anomaly that occurred was an elongated C7 transverse process, followed by a rudimentary posterior ponticle. The frequencies of these and the remainder of the congenital cervical spine anomalies are shown in Table 4.

	Count	Column %
Elongated C7 Transverse Processes	20	31.7
Rudimentary Posterior Ponticle	14	22.2
Posterior Ponticle	7	11.1
Hypoplastic spinous process of C3	5	7.9
Cervical Ribs	4	6.3
Fusion of Posterior elements	3	4.8
Partial Occipitalisation of atlas	2	3.2
Incomplete Spina Bifida	2	3.2
Hypoplasia of Posterior arch of C1	1	1.6
Complete Spina Bifida	1	1.6
Bifid posterior arch of C1	1	1.6
Partial body fusion	1	1.6
Prominent transverse process of C1	1	1.6
Spinous process structural abnormalities	1	1.6
Total abnormalities	63	100%

Table 4: Anomalies in subjects (n=56) with congenital cervical spine anomalies who had received manipulation of the cervical spine (n=63)

4.2.4 RESEARCHER AND RADIOLOGIST SENSITIVITY

Of the 98 congenital cervical spine anomalies identified, 96 were reported by the researcher and 40 were reported by the radiologist. The result was the following:

Researcher: Sensitivity: 98% (92% to 100%)

Radiologist: Sensitivity: 41% (31% to 51%)

This is indicated in Table 5.

	Sensitivity	
	Mean %	% Range
Researcher	98	92 – 100
Radiologist	41	31 - 51

Table 5: Sensitivity of the researcher and the radiologist

4.3 SUMMARY

The eight year period from 1 January 1997 to 31 December 2004 showed the prevalence of congenital cervical spine anomalies to be 46.67% (95% CI 39.81 to 53.65). However, this prevalence can only be generalized to a similar population from which this sample was taken, i.e. subjects attending a chiropractic day clinic and having a radiograph done. Furthermore, not all subjects attending the clinic routinely have radiographs done. It is assumed that the chiropractor may have suspected an anomaly for this to happen or the patient may not have been responding well to the treatment administered or there could have been a change in the clinical presentation of the patient. This is not a reflection of the general population, thus in the normal population the prevalence would presume to be much lower.

Neck pain, decreased cervical range of motion and muscle tightness was common amongst subjects with and without congenital cervical spine anomalies. It was found that subjects with congenital cervical spine anomalies did not have a

significantly higher risk of any clinical feature or symptom than subjects without congenital cervical spine anomalies.

The majority of subjects with congenital cervical spine anomalies received soft tissue therapy, stretch therapy and manipulation of the cervical spine for their condition without any adverse effects being noted.

CHAPTER 5

DISCUSSION OF RESULTS

5.1 INTRODUCTION

This chapter discusses the results obtained through the statistical analysis of the data.

The sample size for the present study included 403 radiographs obtained from the confines of the Chiropractic Day Clinic at the Durban Institute of Technology for the selected time period 1 January 1997 to 31 December 2004. From this, 193 were excluded due to the exclusion criteria of past or present history of trauma to the cervical spine area, resulting in 210 radiographs making up the final sample size.

5.2 INTERPRETATION OF DATA

5.2.1 THE PERIOD PREVALENCE OF CONGENITAL CERVCIAL SPINE ANOMALIES

The data associated with the period prevalence of congenital cervical spine anomalies was presented in Chapter 4 under 4.2.1. From the 210 radiographs that were included, 98 were positive for congenital cervical spine anomalies of any type, resulting in a total period prevalence of 46.7%. This may be assumed to be of significance as it is a large value, however since it was obtained from a population formed by patients who were radiographed and managed at the Chiropractic Day Clinic at the Durban Institute of Technology for the period 1 January 1997 to 31 December 2004, it is thus not a reflection of the general population but more accurately associated to the population from which the sample was obtained. Since not all patients presenting at the Chiropractic Day Clinic are radiographed, it is not possible to state the true prevalence of the congenital cervical spine anomalies during the 8-year period.

Majority of the subjects in the sample size presented with more than one anomaly with 36.2% of subjects having one anomaly, 9.0% having two anomalies and 1.4% having three anomalies. The findings regarding the individual anomalies shall be discussed below:

- Elongated C7 transverse process and rudimentary posterior ponticle had a prevalence of 35.0% and 14.6% respectively. These were the two most commonly identified anomalies in the selected sample. It is therefore quite surprising that there appears to be no information available on the prevalence of these anomalies despite and an exhaustive literature search (books, journals, Internet, etc.).
- Posterior ponticle had a prevalence of 13.8% in the selected sample size. This finding is comparable with those of Taylor and Resnick (2000) and Yochum and Rowe (1996) who found this anomaly to have a prevalence of 15% in the general population.
- Cervical ribs had a prevalence of 6.5%. This appears to be higher the 0.5% that was reported by Yochum and Rowe (1996). This might appear to indicate that cervical ribs have a higher prevalence than was previously thought. The discrepancy in the finding may be due to the selection of the samples. It is possible that a larger sample size of the general population may reveal a finding similar to Yochum and Rowe (1996).
- Fusion of the posterior elements of vertebral bodies and complete block vertebra had a prevalence of 4.9% and 0.8% respectively. Although they represent features of a block vertebra, they have been separated to determine which type is more prevalent and the findings reveal that incomplete fusion is more common that complete fusion. These findings cannot be compared to existing data as currently no such data exists.
- Hypoplasia of the spinous process of C3, hypoplasia of the posterior arch of C1, structural abnormalities of spinous processes and bifid posterior arch of C1 had a prevalence of 4.9%, 3.3%, 2.4% and 0.8% respectively. It thus appears that these anomalies are uncommon and this may explain the paucity in the literature with respect to the prevalence of these

anomalies. One must note that currently “normal” measurements of the spinous process and other vertebral structures do not exist. Therefore the terms such as “hypoplasia” are quite vague and what might appear as a hypoplastic structure to one individual may not appear hypoplastic to another. This could also explain why these anomalies are often not reported by radiologists and therefore the prevalence of these conditions is very difficult to ascertain.

- Incomplete spina bifida had a prevalence of 4.1% while the complete type had 0.8% prevalence; spondylolisthesis had a prevalence of 4.1% and partial occipitalisation of the atlas had prevalence of 1.6%. In the available literature there is little information on these anomalies. Rarer anomalies which included a partial body fusion (1 case), bifid anterior end of first rib (1 case) and a prominent transverse process of C1 (1 case) were found. According to Moore and Dalley (1999) bifid anterior end of first rib is present in 1% of the population. It is possible that anomalies such as bifid anterior end of first rib and prominent transverse process of C1 are not reported by radiologists as they may be considered to be insignificant.
- With respect to other anomalies mentioned in the literature and described in Chapter 3, under 3.2.4.1, which are not mentioned here, it is possible that these may indeed be very rare anomalies in the general population and therefore not identified in this study.

5.2.2 ASSOCIATION BETWEEN THE CONGENITAL CERVICAL SPINE ANOMALIES AND THE CLINICAL FEATURES

5.2.2.1 Association between congenital cervical spine anomalies and the clinical features in general

The data was presented in Chapter Four under 4.2.2.1. A comparison was done to determine any statistical significance in clinical features between the group that was positive for a congenital cervical spine anomaly and the control group which had no congenital cervical spine anomalies. These have been illustrated in

Figures 4.2 and 4.3 respectively. No statistical significance was noted. Therefore we accept the alternate hypothesis and fail to accept the null hypothesis with respect to the association between congenital cervical spine anomalies and presenting clinical features in general. However, the most common clinical feature was decreased cervical range of motion (CROM), followed by muscle tightness and neck pain, which were all present in more than 80% of subjects with congenital cervical spine anomalies. However, when we examine the data of subjects with no cervical spine congenital anomalies, we find a similar trend with more than 70% of individuals complaining of similar clinical features. This indicates that neck pain, decreased CROM and muscle tightness are the most likely presenting features irrespective of whether an individual has a cervical spine congenital anomaly or not. It is almost impossible for a clinician to positively determine whether an individual presenting with neck pain or stiffness has a congenital spine anomaly without eliciting more clinical features or utilizing radiographs.

5.2.2.2 Association between individual congenital cervical spine anomalies and clinical features

The clinical features were compared to the individual congenital cervical spine anomalies that were identified in the present study. The data are indicated in Figures 4.4 to 4.20. Decreased cervical range of motion, muscle tightness and neck pain are not discussed here as they appear to be common findings in individuals presenting with neck pain irrespective of whether they have a congenital cervical spine anomaly or not.

Elongated C7 Transverse Process (TVP) (43 cases)

- This anomaly is regarded as one of the possible causal factors involved in the development of thoracic outlet syndrome. According to Singh and Patel (2003) it may be commonly associated with the true (neurological) type of thoracic outlet syndrome. The findings of the present study seem to support this claim as many of the recognized clinical features

associated with thoracic outlet syndrome (Singh and Patel 2003) (paraesthesia, radicular pain, hypo/hyperesthesia, and hyporeflexia, spasticity of muscles, tinnitus, nystagmus, dizziness/vertigo and muscle weakness) were present in subjects with this type of anomaly. These can be attributed to compression of the lower nerve roots and inferior trunk of the brachial plexus by an elongated C7 TVP thus producing these neurological clinical features.

- The findings also revealed that just fewer than 60% of subjects with this anomaly experienced headaches. Headaches as discussed earlier in Chapter 2, under 2.4.1.3 have various causal factors. However, with respect to this particular anomaly its presence may be attributed to biomechanical changes in the cervical spine producing decreased motion at the involved segment and resultant hypertonic cervical muscles.

- Shoulder/arm and thoracic spine pain were found to be fairly common. Again these may be attributed to hypertonic muscles due to biomechanical changes. However shoulder/arm pain could also be as a result of neurovascular compression leading to thoracic outlet syndrome.

- The findings also revealed that just over 10% of the subjects presented with dizziness and vertigo. A small percentage of subjects (5%) also experienced nystagmus. At a glance this may cause confusion with regards to this occurring in relation to this particular anomaly. However, Sucher (2005) stated that this may be attributed to an autonomic phenomenon that occurs due to the proximity of the stellate ganglion to the first rib articulation, which often becomes dysfunctional or restricted in thoracic outlet syndrome. This may also account for the 10% of the subjects had a positive Wallenberg's test. The vertebral arteries traverse through the cervical spine via the transverse foramina. We speculate that there might be a possibility of a change in the diameter of these foramina

(possibly a decrease) in certain individuals with an elongated C7 TVP resulting in temporary occlusion of one or both the arteries during neck movements associated with the Wallenberg's test. However, the positive test may be entirely due to other coexisting conditions (e.g. abnormal proprioception in the neck). Also the possibility of vertebral basilar artery insufficiency is not entirely discounted in these individuals. We therefore recommend further anatomical and clinical studies to verify or refute the above claims.

- Respiratory abnormalities and tinnitus occurred in less than 5% of the subjects and we presume that these may be due to other disorders and not directly related to the congenital anomaly.

- Muscle spasticity was also found in less than 5% of individuals with this type of anomaly. This finding is questionable as it is a clinical manifestation of an upper motor neuron lesion and no other features were present to support this claim therefore its presence may be due to incorrect terminology used by the students who examined these subjects. Inexperience of the students with determining true muscle spasticity in patients could also account for the incorrect terminology.

It can be concluded that although this anomaly has been found to be associated primarily with the neurological type of thoracic outlet syndrome, the clinician should be aware that this anomaly could feature in individuals complaining of dizziness, vertigo and nystagmus.

Rudimentary Posterior Ponticle (18 cases)

- This anomaly can also be defined as a partial posterior ponticle. The findings revealed that approximately 45% of the subjects experienced headaches. This finding is not entirely unexpected due to the location of the anomaly and as a result it may be attributed to hypertonic cervical

spine muscles due to decreased range of motion in the upper cervical spine. It could also be attributed to partial compression of the vertebral artery and/or suboccipital nerve as it/they pass through the superior vertebral notch thus affecting blood supply to the brain or affecting the postural muscles (two obliquus and two rectus capitus posterior) supplied by the suboccipital nerve leading to a headache. Although we did not differentiate the type of headaches affecting the individual subject's whose data was included in this study, our finding supports the views of Beck *et al.* (2004) who reported that migraine headaches were associated with posterior ponticle. It also must be mentioned that underlying conditions such as hypertension etc. have not being ruled out therefore they could also be contributory factors and not solely related to the congenital cervical spine anomaly.

- Shoulder/Arm and thoracic spine pain may be attributed to biomechanical changes. This may be true as a decrease in cervical range of motion and/or hypomobility in the upper cervical spine, results in compensatory hypermobility in adjacent vertebral segments below thus changing the biomechanics of the cervical spine and eventually causing compensatory shoulder/arm and thoracic spine pain (Bergmann *et al.* 1993).

- The findings also revealed the presence of paraesthesia, hyporeflexia and muscles weakness. Hyporeflexia and muscle weakness are clinical manifestations of a lower motor neuron lesion. These symptoms could also be a result of some other coexisting diseases that was not taken into account for example cervical spondylosis or even hypothyroidism. These features are thus not pathognomonic for a rudimentary posterior ponticle.

- Dizziness and vertigo have been stated in literature as common symptoms associated with congenital cervical spine anomalies (Menezes 2004). However, very little is mentioned on its mechanism of occurrence. With

respect to this particular type of anomaly it could be attributed to irritation of the suboccipital nerve thus affecting the small postural muscles of the neck. Buxton and Peck (1989) as cited by Moore and Dalley (1999) state that the small muscles act as “kinesiological monitors” - organs of proprioception. A disruption of this mechanism can therefore lead to symptoms of dizziness/vertigo.

- About 5% of subjects had a positive Wallenberg’s test. This could possibly indicate the presence of vertebral basilar arterial insufficiency since the amount of available space around the vertebral artery (superior vertebral notch) decreases as this anomaly progresses. We therefore recommend clinicians intending to manipulate the upper cervical spine in these individuals proceed with caution as there is a possibility of initiating a vertebral artery spasm during and post cervical spine manipulation (Yochum and Rowe 1996).

Posterior Ponticle (17 cases)

The findings were similar to that of the rudimentary posterior ponticle as the mechanism resulting in its formation is the same. However, certain differences were noted and are as follows:

- A greater percentage of subjects (35%) experienced paraesthesia of the upper limb. A compression of the vertebral artery at the superior vertebral notch may have repercussions on the vascular tree distally even at the level of the subclavian arteries which are main source of blood supply to the upper limb. An aberrant vascular supply could lead to paraesthesia of the upper limb.

- Hyporeflexia was present however it occurred in the absence of muscle weakness. This rules out the possibility of a lower motor neuron lesion but reinforces the possibility that hypertonic cervical muscles compressing the

branches of the brachial plexus and/or some other underlying condition may be the cause.

- Just over 10% of the subjects presented with radicular pain. Again this may be due to hypertonic deep cervical muscles compressing spinal nerves. This possibility of cervical disc disease is not discounted in these individuals.

- The findings revealed that just over 10% of the subjects experienced torticollis. This may be attributed to irritation of the spinal root of the accessory nerve which supplies the sternocleidomastoid muscle. According to Moore and Dalley (1999), the spinal root arises as a series of rootlets from the first five cervical segments of the spinal cord. This predisposes the nerve to easy irritation especially due to its close proximity to the anomaly.

It may be concluded that a large percentage of the symptoms that subjects experienced may be attributed to a large degree to muscle spasm especially, the deep cervical muscles and possibly temporary occlusion of the vertebral arteries and/or irritation of the suboccipital nerve. The clinician should therefore consider these factors in determining the diagnosis and managing individuals presenting with the above clinical features.

Cervical Ribs (8 cases)

The findings were similar to that of the elongated C7 transverse process**.** The findings revealed that 50% of the subjects experienced shoulder/arm pain and paraesthesia while approximately 40% of the subjects experienced headaches. These have been discussed in relation to the elongated C7 transverse process and as their mechanism of occurrence is the same, the attributing factors for the development of these features would presumably be the same. It was found that subjects with cervical ribs experienced a torticollis while those with the elongated

C7 transverse process did not. This could be attributed to direct irritation of the scalenes and sternocleidomastoid (SCM) muscles. Since the SCM's distal points of attachment are the anterior surface of the manubrium and superior surface of medial third of clavicle (Moore and Dalley 1999), it lies in close proximity to the thoracic outlet and therefore easily susceptible to irritation. It can be concluded both cervical ribs and elongated C7 TVP's play a role in the development of neurogenic thoracic outlet syndrome concurring with the views of Fleming (2000) and Singh and Patel (2003).

Fusion of the Posterior Elements of Vertebral Bodies (6 cases)

- This is also regarded as an incomplete block vertebra. Approximately 50% of the subjects experienced paraesthesia. This finding is possibly due to hypomobility occurring at the involved fused segments and hypermobility of adjacent vertebral structures leading to disc degeneration of the segments above and below the involved area (Bergmann *et al.* 1993). This may lead to compression of the spinal nerves arising from hypermobile segments and could account for the finding of hyporeflexia in 20% of the subjects.

- The findings also indicate that approximately 35% of the subjects experienced thoracic spine pain, shoulder/arm pain (concurring with Hensinger 1991) and headaches. These may be attributed to a change in the biomechanical nature of the spine due to the presence of a fused segment resulting in surrounding muscle spasm and also possible premature degeneration of areas of the spine above and below the involved segment and thus predisposing the subject to these symptoms.

- Dizziness and vertigo were found in 20% of the subjects. This may be attributed to disturbed proprioception of the neck as a result of the fused segment leading to the development of these symptoms.

Hypoplastic Spinous Process of C3 (6 cases)

A hypoplastic spinous process refers to a spinous that is much smaller in size as compared to adjacent spinous processes. This is of significance during cervical spine motion especially extension which may become slightly exaggerated due to the lack in the length of the spinous to allow approximation to occur with adjacent spinouses thus increasing motion in that area. Therefore one would expect to find features that would occur as a result of this. This is true as the subjects presented with headaches, shoulder/arm pain, thoracic spine pain and dizziness/vertigo. All these features can be attributed to hypertonic cervical spine muscles which may be due to overloading of the muscles to maintain and control normal cervical range of motion.

Incomplete Spina Bifida (5 cases)

The findings of this particular anomaly revealed that all of 5 subjects that presented with this anomaly experienced headaches, 60% experienced dizziness/vertigo and 20% experienced thoracic spine pain, radicular pain and had a positive Wallenberg's test. There is a possibility that other underlying conditions may be the cause for these symptoms. According to Yochum and Rowe (1996) this type of spina bifida is clinically insignificant; however, the possibility of this anomaly causing certain symptoms and signs cannot be excluded even though the number of cases appears small.

Congenital Spondylolisthesis (5 cases)

This anomaly results in the translation of one vertebra in relation to another. Spinal nerve arising from those segments may become compressed and depending on the degree of translation that occurs, other structures such as blood vessels that lie within the vicinity may become compressed or stretched as well. There is also the possibility of premature disc degeneration at the involved segments. This may explain the following findings associated with this anomaly: radicular pain, hyporeflexia, paraesthesia, nystagmus and positive Wallenberg's test. It must be noted that a feature such as nystagmus does not always have a

pathological cause; it could be a physiological feature (Haslett *et al.* 1999). The number of cases is small and therefore no definite conclusions may be arrived at for this congenital anomaly.

Anomalies found in less than 5 cases:

These anomalies were found in less than 5 cases and shall not be discussed in depth as this is not a significant number to make conclusive findings. However they shall be outlined briefly as follows:

- **Hypoplasia of Posterior Arch of C1 (4 cases)**

  Majority of the clinical findings that were present (paraesthesia, muscle weakness, spasticity of muscles, hyporeflexia and radicular pain) show some sort of neurological involvement. Spasticity of muscles may indicate an upper motor neuron lesion; however, in this instance it could be attributed to misinterpretation of term by the student that examined the subjects. The rest of the neurological symptoms could be assumed to be as a result of some other underlying condition/s as not all subjects experienced them.

- **Spinous Process Structural Anomalies (3 cases)**

  This included abnormalities of spinous processes that were found in this study which included the following: an inferiorly hooked spinous, bifid spinous and an upturned spinous process. All 3 cases presented with headaches, dizziness/vertigo, positive Wallenberg's test, shoulder/arm pain, paraesthesia, radicular pain and tinnitus. These symptoms could all be attributed to hypertonic cervical spine muscles or other underlying disorders.

- **Partial Occipitalisation of the Atlas (2 cases)**

  In these 2 cases, one presented with paraesthesia in the upper limb while the other with a decrease in vibration sense (upper limb). The

paraesthesia could be as a result of possible nerve compression due to the partial fusion of the base of the skull to the atlas. The decrease in vibration sense could be as a result of the odontoid process possibly projected into the brainstem as stated in literature by Letts and Jawadi (2004). However, in this case, it is most probably due to some other underlying disease. Hensinger (1991) found that muscle spasticity and hyperreflexia to be associated with occipitalisation of the atlas. We did not find any indication of these 2 signs in our 2 cases. It's possible that these only manifest when there is a complete occipitalisation of the atlas and not a partial one.

- **Complete Spina Bifida, Complete Block Vertebra, Bifid Posterior Arch of C1, Partial Body Fusion, Prominent Transverse Process of C1 and Bifid Anterior End of First Rib**
  These all are individual cases that occurred in only one person each and therefore no conclusive information may be gathered from it. More research is needed in this area.

Therefore we fail to accept the null hypotheses. However, we do accept the alternate hypotheses which states that:

- There is no significant association between the congenital cervical spine anomalies and the presenting clinical features in general,
- There is no significant association between the individual congenital cervical spine anomalies and the presenting clinical features, and
- There is little/no significant association between the subjects presenting clinical features with reported clinical features from the literature.

5.2.3 Management protocol of subjects with congenital cervical spine anomalies

The subjects' at the Chiropractic Day Clinic were managed with soft tissue therapy, stretch therapy, manipulation and mobilization of the cervical spine and

auxiliary modalities as shown in Figure 4.21. The author of the present study concentrated specifically on manipulation of the cervical spine as controversy still surrounds this aspect of treatment especially with respect to congenital cervical spine anomalies as discussed in Chapter 3, under 3.2.4.1. According to Sandoz (1976) as cited by Vernon and Mrozek (2003), manipulation of the spine can be defined as low amplitude, high velocity thrust in which the vertebrae are carried beyond the normal physiological range of movement without exceeding the boundaries of anatomic integrity.

In this present study, those subjects with congenital cervical spine anomalies, 57% (n=56) were manipulated with no adverse effects being noted. Only 14.3% received no manipulation and this may be due to the presence of some other condition, e.g. rheumatoid arthritis in which manipulation of the cervical spine. The data also revealed that the three most common anomalies, in descending order, that were present in those subjects that received a cervical manipulation where the following: elongated C7 transverse processes, rudimentary posterior ponticle and posterior ponticle.

It has been stated in literature by some authors that manipulation of the cervical spine should be contraindicated if a congenital cervical spine anomaly is present. Yochum and Rowe (1996) state that manipulation of the cervical spine be contraindicated if a subject has a posterior ponticle as they are at risk of developing vertebral basilar arterial insufficiency especially on rotational maneuvers. Bragman (2004), states that manipulation is unsafe in subjects with congenital cervical spine anomalies such as posterior ponticle and spina bifida etc. However majority of subjects with congenital cervical spine anomalies are unaware of its presence and very rarely are they picked up on clinical examination. They are more commonly identified as incidental findings on radiographs. To detect cervical spine anomalies accurately implies that all patients be radiographed first before any attempt is made to manipulate their cervical spine. This is impractical as it is highly costly especially for those with no

medical aid or medical insurance and the literature does not specify the ages when these anomalies become apparent on radiographs. It is also possible that some of the anomalies, especially the rare ones, may even be missed by the person interpreting the radiograph or even dismissed as an irrelevant finding by such a person. There is also the danger of exposing patients to high amounts of radiation which could be detrimental to their health in the long term.

However, other authors such as Beck *et al*. (2004) and Kent (2004) state that manipulation should not be contraindicated in those with anomalies except in the presence of symptoms that indicate possible vertebral basilar arterial insufficiency and/or severe neurological involvement. Therefore it can be concluded that although controversy still surrounds manipulation of the cervical spine with respect to congenital cervical spine anomalies, its application depends on mainly on the clinical presentation of the subject and if applicable/available the radiographic/diagnostic imaging findings. We recommend that any patient presenting with neck pain/stiffness and abnormal cardiovascular and/or neurological symptoms be thoroughly examined by a qualified physician and/or chiropractor before any decision is made regarding manipulating that patient's cervical spine.

5.2.4 Researcher and radiologist sensitivity

The data has been shown in Table 5. In this study, it appeared that the researcher was more sensitive when compared to the radiologists, on reporting congenital cervical spine anomalies. However, the possible explanations for this include:

- The information requested on the request form by the student/intern or doctor may not have been related to a cervical spine congenital anomaly but rather to exclude other disorders of the cervical spine e.g. arthritic, infective, etc.

- The anomaly would have been most likely noted but not reported due to the possibility of it being considered clinically insignificant or an incidental finding by the radiologist.

This researcher does not make any claims at being “more qualified” than a radiologist in the interpretation and reporting of x-rays.

5.3 CONCLUSION

The period prevalence of congenital cervical spine anomalies found in this may appear to be significant; however, this finding is based on patient’s presenting at the Chiropractic Day Clinic over an 8-year period and thus not a true reflection of the general population. The current literature is sparse on information on the incidence, prevalence and clinical manifestations of the majority of cervical spine congenital anomalies.

This study attempted to provide information on the association between the clinical presentation of an individual patient and cervical spine congenital anomalies. While there were no significant findings identified, we feel that we have provided clinicians with some information which may be very useful in including cervical spine congenital anomalies in differential diagnoses in individuals presenting with neck disorders. Furthermore, the information provided in this study and findings thereof may be useful to clinicians who utilise manipulation of the cervical spine as part of the management of the patient as they may be able to make an informed decision before carrying out the procedure, especially on individuals presenting with neck pain/stiffness and cardiovascular and/or neurological features.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

From the findings of this study the following conclusions were drawn:

- There were no significant differences in the prevalence of congenital cervical spine anomalies when compared to what's reported in the literature. However, the high prevalence of elongated C7 transverse process and rudimentary posterior ponticle in population from which the sample was obtained indicates that these anomalies should not be regarded as insignificant.
- There were no significant associations found between the congenital cervical spine anomalies and presenting clinical features, however the following should be noted:

  (1) Elongated C7 transverse process has been regarded in literature as solely being involved in the neurological type of thoracic outlet syndrome however clinicians should be aware that this anomaly could feature in individuals complaining of dizziness, vertigo and nystagmus.

  (2) The clinical features identified with regards to the rudimentary and complete posterior ponticle indicate major involvement of the deep postural muscles and also possibly temporary obstruction of the vertebral artery/ies and therefore one should proceed with caution when treating patients, especially cervical spine manipulation, with these anomalies.
- One of the weaknesses of this study was that other coexisting disorders in subjects were not recorded. This may have helped in distinguishing whether some of the clinical features that were present were related to that disorder or to the congenital anomaly.
- Another weakness of this study was that there was no inclusion of whether the manipulation took place before or after the radiograph was taken.

6.2 RECOMMENDATIONS

In this study, the author is of the opinion the following recommendations shall improve the validity of future studies being conducted regarding the prevalence of congenital cervical spine anomalies and their association with the patients presenting clinical features. They are as follows:

- This study did not include demographics such as age and sex of the subjects, however future studies should include these to ascertain a more descriptive prevalence of congenital cervical spine anomalies.
- Future studies should include the thoracic and lumbar spine views to determine the presence of any other congenital spinal anomaly or the compensatory effects of a spinal anomaly on the rest of the spine, if any.
- The time period may be expanded beyond eight years, depending on the availability of radiographs, to obtain a larger sample size so that an appropriate equivalency to the general population can be made.
- Future studies should take into account other coexisting disorders in the subjects with congenital anomalies.
- Future studies that may be carried out in a similar setting should include a more detailed description on treatment especially regarding manipulation. The author suggests that future researchers take note of the level being manipulated and the direction of the force being applied to determine if there is any clinical significance with regards to patient treatment. One should also note whether the manipulation was administered before or after the radiograph was taken.
- Any congenital spinal anomaly seen on radiographs should be noted by the person interpreting the radiographs and not dismissed as incidental findings or insignificant.
- An attempt should be made to investigate the rarer types of congenital cervical spine anomalies. These can be done through cadaveric and/or radiographic studies.

REFERENCES

1) Beck, R.W.; Holt, K.R.; Fox, M.A. and Hurtgen-Grace, K.L. 2004. Radiographic Anomalies That May Alter Chiropractic Intervention Strategies Found in a New Zealand Population. *Journal of Manipulative and Physiologic Therapeutics* 27(9): 554-559.

2) Bergman, T.F.; Peterson, D.H. and Lawrence, D.J. 1993. *Chiropractic Technique.* Philadelphia, Pennsylvania, Churchill Livingstone Inc.

3) Bovim, G.; Schrader, H. and Sand, T. 1994. Neck pain in the general population. *Spine* 19(12): 1307-1309.

4) Bragman, A.H. 2004. Stroke due to cervical manipulation. http://www.bodyzone.com/articles/article.html?id=119 Accessed on 10 October 2005

5) Fleming, J.F.R. 2000. Thoracic Outlet Syndrome. http://www.wsiat.on.ca/english/mlo/thoracic_screen.htm. Accessed on 10 October 2005

6) Gilman, J. and Myatt, M. 1998. EpiCalc 2000. http://www.brixtonhealth.com/ Accessed on 10 October 2005

7) Hain, T.C. 2005. Basilar Invagination and Basilar Impression. http://www.dizziness-and-balance.com/disorders/central/cerebellar/basilar%20invagination.htm Accessed on: 8 January 2005

8) Haslett, C.; Chilvers, E.R.; Hunter, J.A.A. and Boon, N.A. 1999. *Davidson's Principles and Practice of Medicine*. 18th Edition. Churchill Livingstone, Harcourt Publisher's Limited.

9) Hensinger, R.N. 1991. Congenital Anomalies of the Cervical Spine. *Clinical Orthopedics* 264: 16-38.

10) Howard, G. 1998. Abnormalities of the Craniovertebral Junction. http://www.ots.utoronto.ca/users/howardg/cvjunction.html. Accessed on: 8 January 2005

11) Jasmin. 2005. Spasticity of Muscles http://www.nlm.nih.gov/medlineplus/ency/article/003297.htm Accessed on: 10 October 2005

12) Kent, C. 2005. Congenital Anomalies of the Cervical Spine. http://www.chiropaediatrics.com Accessed on: 8 January 2005

13) Lacey, R.J.; Lewis, M. and Sim, J. 2005. The relationship between hand paraesthesia and occupational factors: results from a population study. http://www.rheumatology.oxfordjournals.org/misc/terms.shtml. Accessed on: 10 October 2005

14) Lakhani, E. 1999. *The efficacy of motion palpation used as a post-adjustive assessment toll in the cervical spine to monitor patient progress.* M. Tech: Dissertation Chiropractic, Technikon Natal, Durban. (Unpublished).

15) Leach, R.A. 1986. *The Chiropractic Theories: A Synopsis of Scientific Research.* 2nd Edition. Baltimore, USA: Williams & Wilkins.

16) Letts, R.M. and Jawadi, A.H. 2004. Congenital Spinal Deformity. http://www.emedicine.com/orthoped/topic618.htm Accessed on: 8 January 2005

17) Magee, D.J. 2002. *Orthopedic Physical Assessment*. 4th Edition. Philadelphia, Pennsylvania, Saunders Company.

18) Malanga, G.A. 2004. Cervical Radiculopathy. http://www.emedicine.com//sports/topic21.htm Accessed on: 10 October 2005

19) Menezes, A.H. 2004. Evaluation and treatment of Congenital and Developmental Anomalies of the Cervical Spine. *Journal of Neurosurgery* (Spine 1) 2: 188-197.

20) Moore, K.L. and Dalley, A.F. 1999. *Clinically Orientated Anatomy.* 4th Edition, Baltimore, USA, Lippincott, Williams and Wilkins.

21) Nace, B.A. 1999-2005. *The Merck Manual of Diagnosis and Therapy*. 17th Edition. Internet Edition, Medical Services, USMEDSA, USHH.

22) Rasmussen, B.K.; Jensen, R.; Schroll, M. and Olesen, J. 1991. Epidemiology of headache in a general population- a prevalence study. *Journal of Clinical Epidemiology* 44(11): 1147-1157.

23) Ricchetti, E.T; States, L.; Hosalkar, H.S. ;Tamai, J.; Maisenbacher, M.; McDonald-McGinn, D.M.; Zackai, E.H. and Drummond, D.S. 2004.

Radiographic Study of the Upper Cervical Spine in the 22q11.2 Deletion Syndrome. *Journal of Bone and Joint Surgery* 86(8): 1751-1759.

24) Ross, M.J. and Dufel, S. 2005. Torticollis.
http://www.emedicine.com/emerg/topic597.htm
Accessed on: 10 October 2005

25) Sanders, T.B. 2004. Years Worth of Tinnitus Research.
http://www.audiologyonline.com/articles/arc_disp.asp?article_id=730
Accessed on: 10 October 2005

26) Scher, A.I. 1998. Daily or Near-Daily Headaches is Surprisingly Common in the General Population.
http://www.scienceblog.com/community/older/1998/B/199801495.html
Accessed on: 10 October 2005

27) Shaik, J. 2005. Verbal communication on 22 November. M. Tech: Chiropractic, Technikon Natal, Durban.

28) Sheth, K. 2005. Muscle Atrophy.
http://www.nlm.nih.gov/medlineplus/ency/article/003188.htm
Accessed on: 10 October 2005

29) Simons, D.G.; Travell, J.G. and Simons, L.S. 1999. *Myofascial Pain and Dysfunction: The Trigger Point Manual.* Volume 1: Upper Half of Body. 2nd Edition. Baltimore, USA, Lippincott, Williams and Wilkins.

30) Singh, M.K. and Patel, J. 2003. Thoracic Outlet Syndrome.
http://www.emedicne.com/neuro/topic369.htm
Accessed on: 15 October 2005

31) Standring, S. 2005. *Gray's Anatomy: The Anatomical Basis of Clinical Practice.* 39th Edition. Elsevier, Churchill Livingstone.

32) Sucher, B.M. 2005. Thoracic Outlet Syndrome.
http://www.emedicine.com//pmr/topic136.htm
Accessed on: 10 October 2005

33) Taylor, J.A.M. and Resnick, D. 2000. *Skeletal Imaging: Atlas of the Spine and Extremities.* 1st Edition. Philadelphia, Pennsylvania, W.B. Saunders Company: 46-75.

34) Vernon, H. and Mrozek, J. 2005. A revised definition of manipulation. *Journal of Manipulative and Physiologic Therapeutics* 28(1): 68-72.

35) Webner, D. 2003. Muscle Weakness.
http://www.nlm.nih.gov/medlineplus/ency/article/003174.htm
Accessed on: 15 October 2005

36) Yochum, T.R. and Rowe, L.J. 1996. *Essentials of Skeletal Radiology*. 2nd Edition. Volume One. Baltimore, USA: Williams and Wilkins: 197-222.

37) Zagaria, M.E. 2003. Dizziness and Vertigo in Seniors.
http://www.uspharmacist.com/index.asp?show=article&page=8_1141.htm
Accessed on: 2 October 2005

CODE	CONGENITAL ANOMALY	INITIAL PRESENTING COMPLAINT	CLINICAL FEATURES RELATED TO THE ANOMALY	MANAGEMENT OF THE PATIENT

DATA COLLECTION SHEET 1

Appendix 1

CODE	DATE	ANOMALY PRESENT(√) OR NOT(X)	LOCATION	DESCRIPTION	IDENTIFIED BY		
					RESEARCHER	RADIOLOGIST	BOTH

DATA COLLECTION SHEET 2

Appendix 2