CASE STUDY

Resolution of Headaches in a 13 Year-Old Following Restoration of Cervical Curvature Utilizing Chiropractic Biophysics: A Case Report

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Abstract

Objective: To report on the chiropractic care of a patient with upper cervical subluxations, a decreased cervical curve and headaches.

Clinical Features: A 13 year-old male presented with daily cervicogenic headaches for a period of 4 years. Lateral flexion of the cervical spine was limited. There was a loss of the normal cervical curve. Motion palpation revealed hypertonicity at C1 to C3 and T1 to T6, with painful palpation bilaterally from C1 to C7 and from T1 to T8.

Intervention and Outcome: Radiographs and surface electromyography were initially taken in preparation for the development of an appropriate care plan. The patient was cared for using Chiropractic Biophysics (CBP) technique to include segmental adjustments, mirror-image adjustments, 2-way traction, and therapeutic exercises. Upon completion of the care plan, post radiographs were taken and a radiological comparative report was generated. Restoration of the cervical curve was achieved while the headaches were eliminated.

Conclusion: The patient presenting with a loss of cervical curve and associated cervicogenic headaches received chiropractic care under the standard protocol of Chiropractic Biophysics technique. Post radiographs demonstrated a restoration of the cervical curve while a complete resolution of the headaches was achieved. Chiropractic Biophysics technique appears in this case to have been effective in the treatment of cervicogenic headache by way of restoring the cervical spine to its proper lordotic configuration. Further research is encouraged.

Key Indexing Terms: *Cervical lordosis, Cervicogenic headache, Chiropractic Biophysics (CBP), Chiropractic, Subluxations*

Introduction

Headaches are common yet complicated pain disorders affecting 66% of the global population, creating medical and socioeconomic problems throughout the world.[1,2] To date, The International Headache Society documents 14 distinct types of headaches.[1] The mechanism, pathophysiology, and corresponding treatment plan for headaches varies greatly depending on the mechanism of the headache, therefore, it is imperative that the clinician be astute and thorough during the patient examination. Headaches can arise for a variety of reasons, including mechanical deformation of arteries, reflex autonomic effects, direct mechanical irritation to cervical

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sympathetic ganglia, myofascial effects, and direct relationship to joint functions. These direct relationships to joint functions can create a scleratogenous referral of headache pain from joint structures of the cervical spine, manifesting in the cervicogenic headache.[3]

The term "cervicogenic headache" was first coined by Sjaastad in 1983, who also proposed certain criteria for diagnosis.[2,4] Although there is still some debate over even the existence of cervicogenic headaches, a clear distinction has been established between headaches of cervicogenic origin and the ever-popular diagnosis of tension-type headaches.[5] With the increasing evidence for headaches of cervicogenic origin, others argue that today they are a major player in the headache population representing between 13.8% to 35.4% of all headache presentations.[2,4]

Over time, the characteristics initially proposed by Sjaastad of cervicogenic headache have evolved to include recurrent, moderate to severe headaches arising from the neck which are mostly unilateral in nature but can present bilaterally. The cervical spine usually has reduced range of motion accompanied with provocation of the pain with specific movements of the head and neck. Other criteria established by the International Headache Society and the International Cervicogenic Headache Study Group include precipitation of headache with external pressure over the upper cervical or occipital region, episodes of varying intensity and duration, frequent occurrence of head or indirect neck trauma, fixations of the upper cervical spine, and abnormal posture (loss or reverse of lordotic curve of the cervical spine).[1,2,4,6-8]

Like many mechanisms of head pain, the exact pathophysiology of cervicogenic headaches is not yet fully understood. There are, however, several postulations involving the trigeminal nucleus which resides just anterior to the cervical spine at the level of the brainstem. It is believed the pain generators include the zygapophyseal joints of the cervical spine, the atlanto-occipital joint, the atlanto-axial joint, adjacent soft tissue (muscle, ligaments, tendons, and fascia), dura mater, nerve sheath, intervertebral discs, and vasculature.[7,9]

In a phenomenon known as convergence, the nociceptive afferent input received from the pain generators in the trigeminal nucleus may converge with the nerve roots of C1, C2, and C3 in the trigeminocervical nucleus, enabling a pain-pattern referral to the head.[1,2,4] In addition, the convergence of the sensorimotor fibers of the spinal accessory nerve with the nerve roots of C1, C2, and C3 also enables a referral of cervical pain into the head.[6]

Another postulation indicates the rectus capitis posterior minor muscle as an additional factor in the referral of neck pain to the head. Within this muscle, fibers connect the atlanto-occipital junction to the dorsal spinal dura, potentially creating an additional pathway that allows pain originating from the pain generators of the anatomic structures of the cervical spine to manifest in the head.[8] Other, simpler propositions include entrapment or irritation of the greater and lesser occipital nerves due to tight musculature and other soft tissue compromise at the base of the skull, possibly facilitated by postural deviations such as anterior head carriage.[2]

Case Report

Clinical Features

A 13-year-old patient presented to the clinic suffering daily headaches over a period of 4 years. They were described as both sharp and aching in quality. According to the subjective pain scale the intensity of his headaches would range from 4 to 9 out of 10, however, at some point during the day the pain would always escalate to at least 8/10. The patient estimated that his headaches would occur for a minimum of 5 hours per day. Nothing alleviated the pain, while school and playing soccer were provocative factors. The patient never took medication for the condition but, after 4 years of suffering headaches, presented to the clinic for care.

Chiropractic Examination

Lateral cervical radiographs were taken which revealed a marked loss of cervical curve. (See Figure 1) Measurements were drawn revealing an anterior head carriage of 29.6 mm and a cervical curve of -3.8 degrees (-42 degrees being ideal). Ranges of motion were normal in flexion, extension, and rotation bilaterally, but were limited by 20 % in lateral flexion bilaterally. Motion palpation revealed hypertonicity at C1 to C3 and T1 to T6, with painful palpation bilaterally from C1 to C7 and from T1 to T8. In addition, we noted "severe" fixation in the upper cervical area. Initial Surface EMG readings revealed abnormalities. (See Figures 2 & 3) Orthopedic and neurological examinations were within normal limits.

Based on the patient history, radiographs, and examination findings, a diagnosis was made of loss of cervical curve, kyphosis, cephalgia, poor posture, and cervical and thoracic subluxations.

Intervention and Outcomes

In caring for this patient, we utilized Chiropractic Biophysics (CBP) technique. This technique was developed by Donald D. Harrison, D.C. after growing frustrated with the lack of scientific evidence supporting chiropractic techniques. Chiropractic Biophysics was founded on the idea that structural anomalies of the spinal column, including postural abnormalities, result in imbalances of the homeostatic mechanisms of the body.

By way of faulty homeostasis, the structural anomalies can result in pathological manifestations. One goal of CBP practitioners is to globally restore spinal curvature and to normalize postural imbalances, thereby improving the musculoskeletal structure and overall health of the patient.[9,10]

Pre and post radiographs are often utilized for mensuration to monitor progress of spinal curve restorations. Mirror-image adjusting procedures are used, along with mirror-image exercise techniques and cervical extension traction. Ancillary procedures may also be utilized in the event that additional modalities are necessary, especially in pain control cases. These procedures include ice packs, massage, and isometric relaxation techniques. Outcome assessments are generated using pre and post radiographs along with standard chiropractic outcome assessment methods such as pain scales

and visual analog scale forms.[9,10]

Research demonstrates the efficacy of Chiropractic Biophysics technique. It has been shown that postural abnormalities such as anterior head carriage or loss of cervical curve results in excessive loading to adjacent structures. These excess forces have been shown to have a causal relationship with degenerative disc disease, entrapment syndromes such as thoracic outlet syndrome, overuse syndromes, and myofascial pain syndromes, among others.[9,10] It is suggested that restoring spinal curves to normalcy can result in improved health outcomes.

Contraindications to care are generally limited to extension traction, which include stroke history or predisposition, hypertension, posterior osteophytes, canal stenosis, and diabetes. A patient with radicular patterns of pain during cervical distraction orthopedic testing would also be contraindicated.[9,10]

The patient was compliant and adhered to the recommendations of the doctor. For the first 5 visits, the patient only received mirror-image adjustments with a drop table in both the supine and prone positions, coupled with supine cervical chiropractic adjustments. Beginning on the 6th visit the patient began mechanical traction therapy (cervical extension traction), in addition to his adjustments. When traction therapy was utilized the patient also received a modality of either ice or heat. Just over one month after initiating care post radiographs were taken and a radiology comparative report was generated.

The comparative radiographs demonstrated a restoration of cervical curve in only 6 weeks. (Figure 4) Anterior head tilt was initially measured at 29.6 mm and was reduced to 17.6 mm in this time, equaling a change of 40.5%. Using Chiropractic Biophysics mensuration and measurements, the absolute rotational angle of measurement, a measurement of the curvature of the cervical spine between C2 and C7, was initially measured at -3.8 degrees (91% from normal). On post radiographs, the absolute rotational angle of measurement equaled -43.4 degrees (3.3% from normal). "Normal" values used by Chiropractic Biophysics practitioners were derived from the orthogonal nomenclature system developed by White and Panjabi.[10] (See Table 1)

The overall percentage change from the first radiograph to the second totaled 1,042.1%. Post SEMG readings demonstrated improvement in asymmetry and overall hypertonicity. (See Figures 5 & 6) In addition to the positive changes in the radiographic measurements of the patient, the headaches he suffered from for 4 years subsided until, by the end of the care plan, they were completely eliminated.

Discussion

The importance of maintaining a proper cervical lordosis cannot be overstated. Loss of cervical spine lordosis has been attributed to health concerns ranging from a propensity for degenerative changes, neck pain, and an irritation or facilitation of the pain generators of the spine leading to cervicogenic headache, airway obstruction, and a compromise of the development of dento-facial structures.[11,12,13] However, studies have shown that a decreased cervical curve is not definitively indicative of neck pain or muscle spasm.[12,13] Even though these studies were unable to determine a causal relationship between loss of cervical curve and neck pain, research in one study did show that 17% of a sample group with chronic neck pain and 36% of a sample group of acute neck pain demonstrated loss of cervical curve on radiograph.

The studies stress that practitioners should take special caution in positioning technique while collecting data on this topic, stating that data can be easily skewed if technique and mensuration are even slightly flawed.[13] Although this data suggests that no causal relationship can be determined, it is a reasonable assumption that neck pain and facilitation of pain generators in the neck that refer to the head (cervicogenic headache) is due to a cascade of events that occur in the cervical spine with decreased cervical curve just one component to that equation.

Loss of cervical curve may impact the development and structural capabilities of cranio-facial features. A study conducted by two dentists in Denmark noted a correlation between adolescent patients with various orthodontic problems, airway obstruction, and cranio-facial development with "markedly backward-curved upper cervical spine." The authors hypothesize that the loss of cervical curve and anterior head carriage that accompanies it causes the surrounding soft tissue of the face, head, and neck to exert excessive pressure on the developing bones and joints of the face, resulting in structural compromise. The authors also found "remarkable associations" between dysfunction of the temporomandibular joint and anterior head carriage which is usually preceded by loss of cervical lordosis. This study suggests that cooperation with physiotherapists should be considered when treating patients with temporomandibular joint dysfunction. They conclude that "The importance of good body posture and function of the airway is of considerable importance in orthodontics and the concept of 'functional and postural competency' in dentofacial development cannot be overlooked…"[11]

Medical Treatment

Standard medical care in treating headaches is often unsuccessful due to the complicated nature of headaches, and proper medical management is largely dependant upon a proper diagnosis.[2] This paper previously discussed the challenges headaches present to both the patient and practitioner. If a misdiagnosis is made, the allopathic approach of medicine may target the wrong pain generator. For example, if a misdiagnosis of migraine headache is made, the patient might receive medications affecting the vasculature of the head as opposed to drugs targeting the specific cervicogenic pain generator such as nociceptors of cervical zygapophyseal joints.

The initial medical care plan in treating cervicogenic headaches includes pharmacological treatments. The conservative medical approach includes tricyclic antidepressants, anti-epilectic drugs, muscle relaxants, non-steroidal anti-inflammatory drugs, and morphine-based medications. Other, more conservative treatments have been

attempted including nitroglycerin, oxygen, and ergotamines, however, these therapies have been shown to have little to no clinical efficacy in the treatment of headaches that are cervicogenic in nature.[2,4,6]

More invasive medical procedures include botulism toxin A injections, cortiocosteroid injections, anesthetic blockades of the suspected nerve(s), intracutaneous sterile water injections, occipital nerve stimulators, and radiofrequency thermal neurolysis.[2,4,6,14-17] Surgical options in the treatment of cervicogenic headache include ganglionectomy or neuroectomy, ventral or dorsal decompressive operations, occipital nerve liberation, and joint fusion.[4,6] As with all medical procedures, these carry inherent and sometimes ominous risks which should be taken into consideration by both the practitioner and the patient when considering these treatment options.

Therapies growing in popularity amongst the medical community in the treatment of cervicogenic headache include spinal manipulative therapy (chiropractic adjustments), osteopathic manipulations, and other physiotherapy techniques and modalities.[2,4,6]

Chiropractic Care

The chiropractic subluxation is composed of a multitude of delicate components. Faye's original component model of subluxation included 5 components; kinesiopathology, neuropathology, myopathology, histopathology, and biochemical changes.[18] It is important for the chiropractor to understand that each of these components as described by Faye are intricately laced within the criteria and/or the pathophysiological mechanisms of cervicogenic headache as proposed by Sjaastad, the International Headache Society, and the International Cervicogenic Headache Study Group.[2,4]

They have established that one component to the cervicogenic headache is restriction of range of motion fitting within the subluxation component of kinesiopathology. The neuropathology component of Faye's model of subluxation is seen within the involvement of the trigeminal and trigeminocervical nuclei in cervicogenic headaches. Myopathology relates to the possible involvement of the rectus posterior capitis minor muscle. Histopathology is woven within the idea that irritation of the occipital nerves can result in head pain, while the last component of biochemical changes is evident within the hypothesis that structural abnormalities of the cervical spine (loss of cervical curve) may facilitate the nociceptors of the zygapophyseal joints.

High velocity, low amplitude manipulations of the cervical spine have been shown by chiropractors and physical therapists as an effective method in treating cervicogenic headaches, especially when coupled with other modalities such as traction, stretching, and soft-tissue therapy.[3,19-25] Bronfort states that non-pharmacological and non-invasive therapeutic techniques such as spinal manipulation in the case of cervicogenic headache has similar pain relief effects of prescription drugs, but without the side-effects of medication.[23]

Nilsson compared two groups with cervicogenic headache, one receiving only soft-tissue therapy and the other receiving only spinal manipulations. His results determined that of the 25 people receiving only soft-tissue therapy, 12 (48%) had an overall decrease in pain, 5 remain unchanged, while 8 had an increase in pain. The other group consisting of 28 subjects who received only spinal manipulation resulted in an overall decrease in pain in 20 (71.4%) of the subjects, no change in 6 of the subjects, and an increase in pain in 2 of the subjects. This data supports his conclusion that spinal manipulation can produce significant results in those suffering with cervicogenic headaches.[25]

Of particular interest to the Chiropractic Biophysics practitioner is the fact that studies have specifically shown the clinical efficacy of Chiropractic Biophysics technique in the restoration of decreased or kyphotic cervical curves.[26,27] But in order to make this claim, it first must be concluded that radiographic mensuration used in pre and post radiographs is valid and reliable. One such study concluded that the mensuration techniques and spinal configurations used by Chiropractic Biophysics practitioners is, in fact, repeatable, reliable, and valid.[28]

A pilot study conducted by Harrison used 3 groups in a study of restoration of cervical lordosis. Lateral cervical radiographs were taken of all the groups, in particular to assess the absolute rotation angle between C2 and C7, a main outcome measure used in Chiropractic Biophysics. The first group consisted of 30 control subjects receiving no care over a period of 10 to 14 weeks. The second group consisted of 35 subjects receiving diversified spinal manipulation, drop-table adjustments, and cervical extension-compression traction (the same care plan used by the doctor in this case study). The third group consisted of 30 subjects who received diversified spinal manipulation and drop-table adjustments, but no cervical extension-compression traction.[27]

Neither the control group nor Group 3 reported any statistically significant changes to either the absolute rotation angle or the degree of anterior head carriage. However, the treatment received in Group 2 yielded significant changes on post radiographs. Of the 35 subjects, 29 had a cervical lordosis following treatment as opposed to only 11 before initiation of the care plan. The absolute rotation angle between C2 and C7 changed an average of 13.2 degrees while anterior head carriage was reduced an average of 6.8 mm.[27]

A subsequent non-randomized, clinical control trial of subjects with neck pain and decreased cervical curvature conducted by Harrison yielded similar results in the manipulation plus traction group, but posted an even greater average change in absolute rotation angle of 17.9 degrees in 30 subjects versus no change in 33 control subjects. This study also included visual analog scales for neck pain and monitored the patients who improved under care for 14 months. The average visual analog scale in the manipulation plus traction group was reduced from 4.1 to 1.1. In addition, this group was reassessed in 14 months when it was concluded that the subjects maintained their cervical lordosis and decrease in pain.[26]

Conclusion

In conclusion, the clinical data collected in this case study supports previous postulations that spinal manipulation yields positive results in the treatment for headache, specifically, those of cervicogenic origin. Chiropractic Biophysics, an evidence-based technique using a protocol of pre and post radiographs, mirror-image and segmental adjusting, cervical extension-compression traction, therapeutic modalities such as ice and heat, and therapeutic exercise programs, has been shown to be a particularly effective chiropractic technique in the restoration of cervical curve. In the event that cervicogenic headaches stem from a reduced lordotic curve or a kyphotic curve of the cervical spine, one can deduce that Chiropractic Biophysics technique is an effective means in the treatment of cervicogenic headache by way of restoring the cervical spine to its proper lordotic configuration.

References

1. Hall T, Briffa K, Hopper D. Clinical evaluation of cervicogenic headache: a clinical perspective. J Man Manip Ther. 2008;16(2):73-80.
2. Chou LH, Lenrow DA. Cervicogenic headache. Pain Physician. 2002 Apr;5(2):215-225.
3. Shooker CM. Models of headache and their implications for treatment using manual therapies. J Chiropr Med. 2002 Jun;1(2):62-69.
4. Inan N, Ateş Y. Cervicogenic headache: pathophysiology, diagnostic criteria and treatment. Agri. 2005 Oct;17(4):23-30.
5. Nilsson N, Bove, G. Evidence that tension-type headache and cervicogenic headache are distinct disorders. J Manipulative Physiol Ther. 2000 May;23(4):288-289.
6. Biondi DM . Cervicogenic headache: a review of diagnostic and treatment strategies. J Am Osteopath Assoc. 2005 Apr;105(4 Suppl 2):16S-22S.
7. Tuchin P, Brookes MJ, Swaffer, T. A case study of chronic headaches. Australas Chiropr & Osteopat. 1996 Jul;5(2):47-52.
8. Alix ME, Bates DK. A proposed etiology of cervicogenic headache: the neurophysiologic basis and anatomic relationship between the dura mater and the rectus posterior capitis minor muscle. J Manipulative Physiol Ther. 1999 Oct;22(8):534-539.
9. Troyanovich SJ, Harrison DD. Chiropractic biophysics (CBP) technique. Chiropr Tech. 1996 Feb;8(1):30-35.
10. Cooperstein R. Chiropractic biophysics (CBP). Chiropr Tech. 1995 Nov;7(4):141-146.
11. Solow B, Sandham A. Cranio-cervical posture: a factor in the development and function of the dentofacial structures. Eur J Orthod. 2002 Oct;24(5):447-456.
12. Grob D, Frauenfelder H, Mannion AF. The association between cervical spine curvature and neck pain. Eur Spine J. 2007 May;16(5):669-78.
13. Helliwell PS, Evans PF, Wright V. The straight cervical spine: does it indicate muscle spasm? J Bone Joint Surg Br. 1994 Jan;76(1):103-106.
14. He MW , Ni JX, Guo YN, Wang Q, Yang LQ, Liu JJ. Continuous epidural block of the cervical vertebrae for cervicogenic headache. Chin Med J (Engl). 2009 Feb 20;122(4):427-430.
15. Goldberg ME, Schwartzman RJ, Domsky R, Sabia M , Torjman MC. Deep cervical plexus block for the treatment of cervicogenic headache. Pain Physician. 2008 Nov-Dec;11(6):849-854.
16. Jasper JF, Hayek SM . Implanted occipital nerve stimulators. Pain Physician. 2008 Mar-Apr;11(2):187-200.
17. Lee JB, Park JY, Park J, Lim DJ, Kim SD, Chung HS. Clinical efficacy of radiofrequency cervical zygapophyseal neurotomy in patients with chronic cervicogenic headache. J Korean Med Sci. 2007 Apr;22(2):326-329.
18. Kent C. Models of vertebral subluxation: a review. J Vert Sublux Res. 1996;1(1):11-17.
19. van Duijn J, van Duijn AJ, Nitsch W . Orthopaedic manual physical therapy including thrust manipulation and exercise in the management of a patient with cervicogenic headache: a case report. J Man Manip Ther. 2007;15(1):10-24.
20. Bronfort G, Assendelft WJJ, Evans R, Haas M, Bouter L. Efficacy of spinal manipulation for chronic headache: a systematic review. J Manipulative Physiol Ther. 2001 Sep;24(7):457-466.
21. Denny EM. Chiropractic intervention for a cervicogenic headache in a pediatric patient. J Clin Chiropr Pediatr. 2008 Mar;9(1):547-552.
22. Novicky SD. Chiropractic/rehabilitative management of chronic headaches: A retrospective case report. J Chiropr Med. 2003 Sep;2(3):96-101.
23. Bronfort G. Effectiveness of non-pharmacological treatments for headache. Eur J Chiropr. 2002 ;49(1):54-57.
24. Vernon H. Spinal manipulation in the management of tension-type migraine and cervicogenic headaches: the state of the evidence. Top Clin Chiropr. 2002 Mar;9(1):14-20.
25. Nilsson N, Christensen HW, Hartvigsen J. The effect of spinal manipulation in the treatment of cervicogenic headache. J Manipulative Physiol Ther. 1997 Jun;20(5):326-330.
26. Harrison DE, Harrison DD, Betz JJ, Janik TJ, Holland B, Colloca CJ, et al. Increasing the cervical lordosis with Chiropractic biophysics seated combined extension-compression and transverse load cervical traction with cervical manipulation: nonrandomized clinical control trial. J Manipulative Physiol Ther. 2003 Mar/Apr;26(3):138-151.
27. Harrison DD, Jackson BL, Troyanovich S, Robertson G, DeGeorge D, Barker WF. The efficacy of cervical extension-compression traction combined with diversified manipulation and drop table adjustments in the rehabilitation of cervical lordosis: a pilot study. J Manipulative Physiol Ther. 1994 Sep;17(7):454-464.
28. Troyanovich SJ, Harrison DD, Harrison DE. A review of the validity, reliablility, and clinical effectiveness of chiropractic methods employed to restore or rehabilitate cervical lordosis. Chiropr Tech. 1998 Feb;10(1):1-7.

Figure 1 – Pre Radiograph

Figure 4 – Post Radiograph

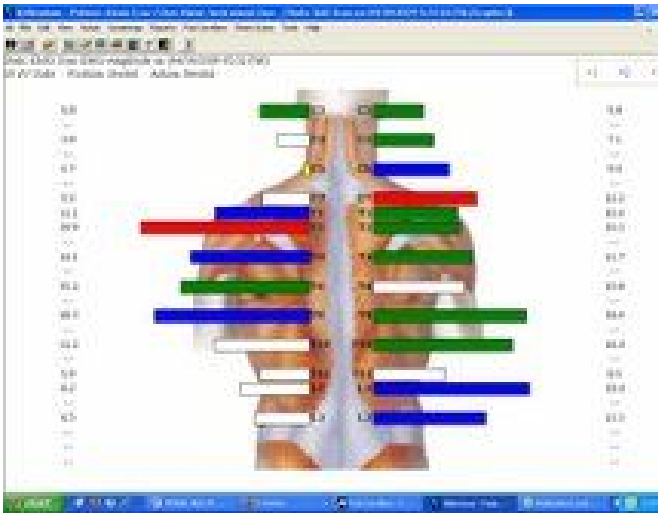

Figure 2 – Pre SEMG Amplitude Graph

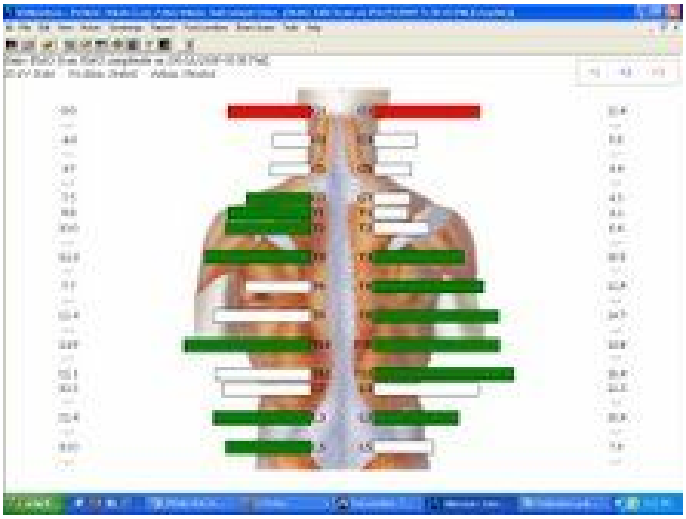

Figure 5 – Post SEMG Amplitude Graph

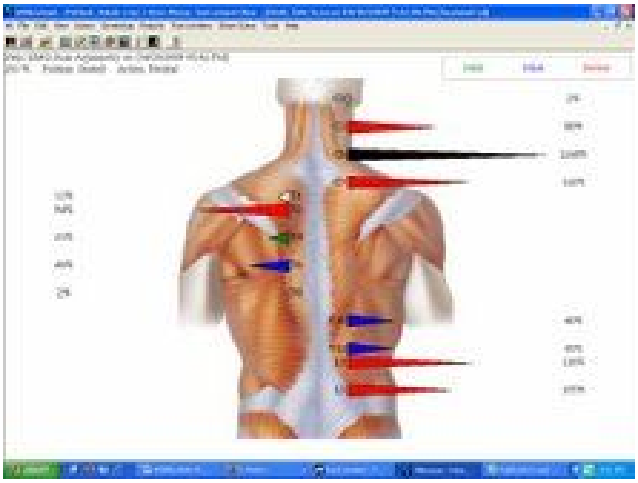

Figure 3 – Pre SEMG Symmetry Graph

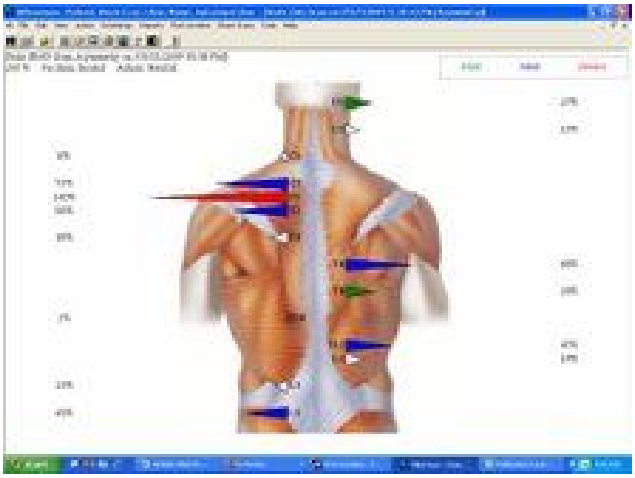

Figure 6 – Post SEMG Symmetry Graph

Cervical Spinal Level

RRA per Segment	Normal Values	Xray 1 Values	Versus Normal	Xray 2 Values	Versus Normal	% Change: Xray 1 to 2
C1 to Horiz.	-29°	-16.7°	42.4%	-35.5°	22.4%	112.6%
C2-C3	-10°	1.6°	116.0%	-14.0°	40.0%	975.0%
C3-C4	-8°	-5.4°	32.5%	-12.3°	53.8%	127.8%
C4-C5	-8°	-3.9°	51.3%	-6.2°	22.5%	59.0%
C5-C6	-8°	-1.2°	85.0%	-9.5°	18.8%	691.7%
C6-C7	-8°	5.1°	163.8%	-1.5°	81.3%	129.4%
C7-T1	-8°	-10.9°	36.3%			

RRA = Relative Rotational Angle of Measurement

Global Analysis	Normal Values	Xray 1 Values	Versus Normal	Xray 2 Values	Versus Normal	% Change: Xray 1 to 2
ARA C2-C7	-42°	-3.8°	91.0%	-43.4°	3.3%	1042.1%
Translation C2-C7	0 mm	29.6 mm	29.6 mm	17.6 mm	17.6 mm	40.5%

ARA = Absolute Rotational Angle of Measurement

Table 1 Radiographic Changes