Case Study

Improved Thyroid Function Following Chiropractic Care to Reduce Vertebral Subluxation: A Case Study & Review of the Literature

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Abstract

Objective: The purpose of this case study is to report on improvement of hypothyroidism in a 50-year-old male patient who decreased his need for synthetic thyroid hormone following chiropractic care.

Clinical Features: A 49-year-old man presented to a private practice for chiropractic care due to neck, back, and shoulder pain. Three years previously, he was diagnosed with hypothyroidism and prescribed Synthroid®.

Interventions and Outcomes: Subluxations-based chiropractic care was delivered using Diversified and Torque Release Techniques™. There were no changes in his lifestyle, diet, or exercise levels. Blood tests revealed his TSH blood levels remained in the normal range and his need for synthetic thyroid hormone decreased. His cervical curve additionally improved.

Conclusion: This paper appears to be the fourth to link the decreased need for synthetic thyroid medication while under chiropractic care. Further study is warranted due to the side effects, drug interactions, and costs associated with the use of synthetic thyroid medications.

Key Words: *Chiropractic, vertebral subluxation, Torque Release Technique™, Diversified technique, adjustment, cervical curve, hypothyroidism, Synthroid.*

Introduction

History

Hypothyroidism is defined as the failure of the thyroid gland to produce sufficient thyroid hormone to meet the metabolic demands of the body.[1] In the 19th century, cretinism and myxedema were attributed to the dysfunction of the thyroid gland and were treated by grafting animal thyroid to human thyroid.[2] This practice was disbanded later in the 19th century when injections replaced surgery, and later still, oral administration of animal extract was determined to be as effective.[2]

20th century studies focused on goiter and iodine deficiency. In 1924, iodized salt was introduced to the US markets and eliminated iodine deficiencies.[3] Advancements in this century started with the development of purified thyroxine crystals, which were quickly replaced by synthetic thyroxine and later liothyronine. Today, levothyroxine is the generic synthetic thyroid in common use and is registered under various names, such as Synthroid, Triosint, and Unithroid.[2]

Function

The thyroid is an endocrine gland that sits at the base of the anterior cervical spine below the larynx and is important for regulating metabolism in the body.[4] It secretes hormones Triiodothyonine (T_3) and Thyroxine (T_4), which are made up of iodine and the derivatives of the amino acid tyrosine. The thyroid hormones are stored in the thyroid gland in macromolecules of the protein thyroglobulin. When the hormones are secreted, they split from thyroglobulin, and release into the blood stream as free hormones. After entering the blood, most of the thyroid hormones combine with plasma proteins, such as thyroxine-binding globulin, which then are slowly released into the needed tissue.[4]

In order to produce proper amounts of thyroid hormones, ingestion of about 50 milligrams of iodine in the form of iodides are required each year along with proper stimulation by the anterior pituitary gland and hypothalamus.[4] The anterior pituitary gland produces thyroid-stimulating hormone (TSH), and the hypothalamus produces thyrotropin-stimulating hormone.[4] Regulation of the release of thyroid hormone is controlled by a negative feedback loop, starting with the hypothalamus. The hypothalamus helps regulate metabolism in the body. When it senses a decrease in metabolism it releases thyrotropin-releasing hormone, signaling the anterior pituitary gland to release TSH, which in turn stimulates the release of thyroid hormone by the thyroid gland.[4]

Epidemiology

The Wickham Study was conducted in 1972-1974 and a follow up was conducted in 1994, published in 1995, to determine general population statistics and the follow up to see if over twenty years the outcomes had changed.[5] On average, incidences of hypothyroidism range from 3.5-5.4 per 1,000 in other countries around the world. A 5% increase in the incidences of hypothyroid was reported in this study. However, studies from other locations in the world did not support their findings. Whether or not there is a local problem has not been determined.[5]

The Colorado Study captured data on over 25 thousand people at a 1995 health fair, revealing issues that relate to this case study.[6]

- Nearly 10% of those tested had not been diagnosed as having hypothyroidism and did not know they had it. Extrapolated nationwide, 13 million people might have undiagnosed thyroid gland failure
- Of those on medication, most were taking dosages that were not in the therapeutic range
- Even modest increases in TSH levels changed lipid and cholesterol levels associated with cardiovascular disease
- Symptoms, which are used to screen for hypothyroidism, were nonspecific and were of limited value. Those without symptoms might still have the disease.

A study done by the National Health and Nutrition Examination Survey (NHANES III) looked at the amount of hypothyroidism in the United States using an upper limit number of TSH at 4.5 mIU/ml. The NHANES III studied over 17 thousand people for whom TSH, T4, and thyroid antibodies data were available.[7] The incidence of hypothyroidism was found to be 4.6% of the U. S. population. They discovered subclinical hypothyroidism was 4.3% and overt hypothyroidism was .3%. The prevalence of subclinical hypothyroidism for women by race was 5.8% white, 1.2% black, and 5.3% Mexican-American. For men it was 3.4% white, 1.8% black, and 2.4% among Mexican-American.[7] The findings documented and supported the Wickham and Colorado studies, but, whereas the Colorado study found those on medication taking dosages that were not in the therapeutic range, this study quantified that to approximately 67% of those on medications were not appropriately treated. It also nearly replicated the number of people not diagnosed as having clinically significant thyroid disease at 9.2% opposed to 10% in the Colorado Study.

After iodize salt was introduced in 1924, the U.S. thyroid failure was attributed to autoimmune deficiencies.[8] In other parts of the world, iodine deficiency remains the primary cause of thyroid dysfunction.[8] The most common cause in the U.S. is autoimmune thyroiditis, also known as Hashimotos Disease.[2] Thyroidectomy, radioiodine therapy, and drug treatments, such as, lithium, interferon and thalidomide, are causes of hypothyroidism.[2]

Congenital hypothyroidism affects about 1 in 4,000 newborns.[3] Hypothyroidism is one of the most common endocrine disorders in the world and has the most prevalence in women and the elderly.[6] There may be as many as 13 million people with undiagnosed hypothyroidism in the United States.[9]

Symptoms

Common symptoms of this disease include fatigue, dry skin, cold sensitivity, muscle cramps, constipation, and voice changes. Other symptoms that are less common but occur with severe hypothyroidism are carpal tunnel syndrome, sleep apnea, pituitary hyperplasia, and hypernatremia.[10] Many rating scales have been used to determine the severity of hypothyroidism and the restoration to a normal thyroid state but have low sensitivity and specificity. They use subjective and objective indicators such as thyroid function tests, cholesterol levels, resting heart rate, anxiety level, disruption menstrual cycle, and sleep patterns.[10] Along with these symptoms and indicators, the diagnosis of hypothyroidism is made by measuring TSH. If an initial measurement of TSH is elevated, a measurement of Free T_4 is made to determine the classification.[10]

Diagnostics

Hypothyroidism is classified as subclinical, central, or overt. Subclinical hypothyroidism occurs when the serum TSH tests above the upper reference limit in combination with a normal free T4. In order for this to be an official reading, thyroid function must be stable for weeks or more, the hypothalamic-pituitary-thyroid axis is normal, and there is no recent or ongoing severe illness. Overt hypothyroidism is characterized by an elevated TSH, usually above 10 mIU/L, in combination with a lowered free T4.[10] Central hypothyroidism is caused by lowered TSH causing a lack of stimulation to the thyroid gland. The thyroid gland is often normal in this situation and is capable of producing thyroid hormone.[11] The lack of TSH production is due to a problem with the hypothalamus or pituitary gland.[11] Hypothyroidism may be due to primary gland failure of the thyroid, or insufficient stimulation by the hypothalamus or the pituitary gland. Failure of the thyroid to function properly could be caused by a congenital abnormality, iodine deficiency, autoimmune destruction (Hashimotos disease), or another type of disease.[10]

Costs

The figure of 4.3 billion dollars has been quoted as the annual cost of hypothyroidism. The fact is that number is associated with only women's costs.[12] The total cost including men is obviously greater, but there is no data in the available literature to quantify the total cost of hypothyroidism for all those diagnosed with the disease. Ambulatory visits accounted for over half the amount. Of the remainder, about one third were the costs of prescriptions. Private insurance and out-of-pocket expenses were paid by 58% of women, whereas those over 65, the remaining 42%, out-of-pocket expenses were offset by Medicare insurance.[12]

Case Report

Patient History

A 49-year-old male patient presented to a private chiropractic clinic with complaints of neck, back, and shoulder pain of no specific onset or injury, as well as a 4-year history of hypothyroidism. 5 years previously, he started experiencing low energy, fatigue and slurred speech. His general practitioner ordered a TSA panel (see Figure 1), and he was diagnosed with hypothyroidism. The panel showed an increase in TSH, which was measured at 87.45 UIL/ml. The general practitioner prescribed 100mg of Synthroid® per day, which is an artificial thyroid hormone replacement. 5 months after the Synthroid® was prescribed, the general practitioner re-tested TSH and ordered a free T_4 test. The TSH panel and T_4 level returned to normal. His symptoms of low energy, fatigue, and slurred speech resolved with the addition of the Synthroid®. During the beginning of his chiropractic care he was still using the prescribed Synthroid®.

Chiropractic Examination

The chiropractic examination consisted of new patient health history forms, functional rating index, orthopedic and neurologic testing, static and motion palpation, thermography, Torque Release Technique™ (TRT) analysis and plain film radiographic assessment consisting of lateral and anteroposterior views of the cervical, thoracic, lumbar spine and pelvis. The lateral cervical radiograph showed a 9-degree cervical lordosis (see Figure 5) when comparing segments C2 through C5. The normal value for this region is 20.1 degrees.[13] The patient was diagnosed with cervical and lumbar degenerative joint disease. Subluxation was assessed using TRT analysis, which discovered subluxation at levels of C1, C5, T6, L5, sacrum, pelvis, and coccyx/sphenoid.

Torque Release Technique®

TRT is a tonal, neurologically based chiropractic model, which focuses on locating the primary subluxation or alteration of the frequency or tone of the nervous system.[14,15] Primary subluxation is caused by the abnormal tension in the Cranio-Spinal-Meningeal Functional Unit (CSMFU), which in turn can cause alteration in the normal piezoelectric properties and neuropeptide release of the spinal cord.[16] Throughout chiropractic history, both segmental and cord tension subluxations have been described in texts such as the Chiropractic Textbook by Stevenson.[14,17,18] Cord tension subluxation is most likely caused by the pull of an attachment such as dura, connective tissue, or vertebrae, at a specific level, changing the tension in the entire CSMFU, thus changing the tone of the spinal cord causing global neurologic insult. Most common sites of attachment are at the levels of occiput, C1 (indirect), C2, C5, sacrum, and coccyx/ sphenoid.[14,19]

The Council on Chiropractic Practice acknowledges in their 2013 updated guide, that the subluxation is a neurologic distortion that can cause pathologic and structural changes.[20] TRT is said to be tonal because tonal techniques use a non-linear, neurological approach to analyze the nervous system and spine as a functional unit in order to locate the primary subluxation.[14,18,21] TRT uses functional measures to determine abnormal tone of the nervous system and apply an adjustive force by the use of the Integrator™, or by hand, at this specific location along the three-dimensional axes to allow for reestablishment of normal tone to the CSMFU, spinal cord and nervous system.[14,21]

TRT was developed out of randomized placebo-controlled research done by Dr. Jay Holder, who is the founder of Holder Research Institute, along with Robert Duncan, PhD, a biostatistician from the University of Miami School of Medicine.[14,22,23] The study observed the benefit of chiropractic care and increased retention rates of addicts suffering from reward deficiency syndrome (RDS).[24] In order for the study to have intra-examiner reproducibility and reliability, Dr. Holder created the Integrator™. It is a toggle recoil adjustment instrument and was the first to be 510k registered by the FDA for the adjustment of subluxation. It holds CE clearances that allow it to be marketed internationally as well as in the US. It fires at 1/10,000th of a second at 64 Hz with the option of clockwise or counterclockwise torque for the three-dimensional listings along with true adjustable force. The Integrator™ works by incorporating a pre-cocking mechanism that fires the instrument only if a predetermined amount of pressure has been reached. The TRT model incorporates 15 indicators of subluxation and includes evaluation of the Functional Leg Length Reflex (FLLR).[14] These indicators come from seven original chiropractic pioneers, Dr. Thomson (Terminal Point), Dr. Van Rumpt (D.N.F.T), Dr. DeJarnette (S.O.T), Dr. Logan (Logan Basic), Dr. Toftness (Toftness Technique), Dr. B.J. Palmer (Palmer Upper Cervical) and Dr. Epstein (Network Spinal Analysis), along with additions from Dr. Holder, to develop a non-linear tonal analysis or model.[14]

By using these indicators along with the FLLR and light pressure test to the specific vertebral levels of direct or indirect dural attachment, this neurological approach views primary subluxations and differentiates secondary subluxations, which are the compensations to the primary subluxation. There have been many other studies showing how TRT can help improve certain health problems and symptoms such as, infertility, ADHD, depression, and anxiety.[23-26]

Interventions and Outcomes

The patient was put on a care plan of three visits per week for the first six months and two visits per week for the last six months. Adjustments were given by hand at levels of C1 and C5 in the seated position. Adjustments given at T6 were done by hand with the patient in the prone position. The Integrator™ adjusting instrument was used at levels L5, Sacrum, pelvis and coccyx/sphenoid. The patient was also instructed to perform two-way seated cervical traction to help facilitate the adjustment to improve the cervical lordotic curve.[27] The initial functional outcome questionnaire given on the first visit was graded at 5 out of 40 (see Figure 4), with 40 being the most dysfunctional. Retesting occurred after eight months using the questionnaire, resulting in 1.25 out of 40 (see Figure 5). X-rays were also retaken at the eighth-month period of care. The cervical lordotic curve improved from 9 degrees (see Figure 6) to 19 degrees (see Figure 7), a 111% improvement. The patient had blood work 2 months into care and showed normal results (see Figure 2). After 8 months of care the patient reported he no longer needed to take the Synthroid®, which lasted for 8 months. At this time due to personal reasons he needed to reduce his weekly visits to one per week on average. He then noticed the fatigue starting to return. He started back on the Synthroid®, this time only needing one dose per week. Blood work was taken again 14 months into care, which would have been during the time he was not taking the medication and showed normal levels (see Figure 3). The patient has been able to maintain using one dose of Synthroid® per week while being under chiropractic care of one visit per week through the date of this paper being written. He has reported the adjustment giving similar results as the Synthroid®.

Discussion

A literature search of chiropractic care and hypothyroidism revealed three case studies. One case was a pilot study. Three other studies showed pertinence to this case study and the main focus was on hypothyroidism.

Two of the studies were done by Bablis and Pollard; the first in 2003 and the second in 2009.[28,29] Both studies used Neuro Emotional Technique (NET) to improve TSH levels in patients. A third 2015 case study conducted by Bak and Engelhardt used Chiropractic Biophysics to assess chiropractic care on a woman with pain resulting from an auto accident, who had also been diagnosed with hypothyroidism.[30] Using adjustments and traction devices, which helped the patients complaints, and thyroid function returned.[30]

In the 2003 study by Bablis and Pollard, two patients sought chiropractic care for pain, but also complained of tiredness and lethargy.[28] Manual chiropractic treatment resolved all pain complaints, but for the tiredness and lethargy, blood tests were sought revealing one to have hyperthyroidism with an initial TSH result of .07 mIU/L. The second woman's TSH level was 8.1mIU/L. Treatment using the Neuro Emotional Technique resulted in increasing the first woman's TSH to .09 mIU/L, but after six months, a third test revealed her TSH levels had increased to .33 mIU/L, within the normal range, which is .3—5.1 mIU/L. The second woman's level post NET treatment was lowered into the normal range of 3.7 mIU/L and eight months after that result, her level dropped further to 3.0 mIU/L.

The 2009 Bablis and Pollard study also brought TSH levels down in two women who were determined through blood tests to have hypothyroidism.[30] The first patient came in with lower back pain and received manual chiropractic treatment, which made her symptoms disappear, but she complained of tiredness and was tested to have a TSH level of 13.99 mIU/L. After eight weeks of NET treatment, her TSH levels dropped to 5.81mIU/L. A subsequent test revealed her TSH level had dropped to 1.45 mIU/L. The second patient presented to the chiropractic clinic complaining of thyroid problems. Although she had been prescribed Oroxine®, she stopped taking it because her symptoms returned. Her pre-NET test resulted in a 14.8 mIU/L. Post-NET testing revealed her TSH level had dropped to 5.81 mIU/L. A follow up test showed it had dropped to .82 mIU/L, which is in the normal range.[29]

In the third case study by Bak and Engelhardt, a patient presented complaints of upper trapezius and inter-scapular pain from an auto accident.[30] Four years prior, she had been diagnosed with hypothyroidism and put on medication. The second two years, she was switched to Amour Thyroid, a natural porcine-derived thyroid hormone by her endocrinologist. At the chiropractic clinic, she was assessed for her injuries using Chiropractic Biophysics (CBP). Adjustments were made using Mirror-Image® and Post Mirror Image®. TargetForce®, a traction device was used to address a deficient cervical curve. The patient used Denneroll®, an at-home traction device to ensure the correction. After a month of treatment, the patient complained of tremors. The chiropractor referred her to the endocrinologist. Her blood TSH level had dropped to hyperthyroid level (<.3 mIU/L). The endocrinologist dropped the prescribed levels of Amour Thyroid relieving her symptoms. Bak and Engelhardt did not present the patient's TSH levels. They documented the change in her symptoms via chiropractic care and the hypothyroid and hyperthyroid symptoms that occurred during simultaneous treatment.[30]

Treatment

Treatments other than levothyroxine are rarely used although one reference stated a patient was prescribed Armour Thyroid.[8,30] The literature revealed screening and treatment issues of hypothyroidism, but none could recommend changing how patients are screened for hypothyroidism nor found an alternative to synthetic thyroid hormone.

Helfand's "Screening for Subclinical Thyroid Dysfunction in Nonpregnant Adults: A Summary of the Evidence for the U.S. Preventive Services Task Force" purpose was to determine if screening should be done on patients without history or symptoms of thyroid dysfunction.[9] Early detection benefits were to prevent development of atrial fibrillation, osteoporotic fractures, and complicated overt hypothyroidism. Those benefits were countered by adverse effects of overtreatment and those of L-thyroxine including, nervousness, palpitations, atrial fibrillation, and exacerbation of angina pectoris. Above or below normal levels of TSH are associated with an increase in osteoporosis, which can happen with either a false positive result to screening or untherapeutic levels of L-thyroxine dosage.

In "Treatment for primary hypothyroidism: current approaches and future possibilities," the authors acknowledged that levothyroxine therapy was problematic in that patient symptoms and feeling of wellbeing were not satisfied by the drug.[3] They documented the numerous other prescriptive drugs that could affect the absorption and action of levothyroxine, and discussed three alternative drugs that they recommended for further study.[3]

"Hypothyroidism: An Update" reiterated much of the first article, saying screening of asymptomatic patients was not recommended for the same reasons, but did caution that older people, pregnant women, patients with suspected ischemic heart disease, those being treated for hypothyroidism with persistent symptoms, those diagnosed as subclinical hypothyroid, and those suspected of having myxedema coma were special cases deserving of extra screening.[1] Physicians were cautioned to double-check all medications patients were taking due to drug interaction. This article as well as others stated that hypothyroidism require life-long thyroid hormone therapy.

"Hypothyroid Investigation and Management" gives additional lists of symptoms that should be checked beyond those commonly reported by patients. It cautions that trying to determine the cause of the symptoms is important if case the hypothyroidism is transient due to a temporary drug prescribed or an illness. When symptoms persist, it is recommended that a dosage adjustment should be made.[8]

Correction Mechanism

When the body is stressed beyond what it can withstand, it adapts to each specific stressor in order to continue functioning. These adaptions are changes in the way the body organizes the neurologic system by creating new neuronal pathways. Due to re-organization of these neuronal pathways, they operate at a different frequency or tone than the original normal pathway and are facilitated.[31] Each and every stress on the body is memorized as well as any adaptations that are needed at that instant in time.[32] The adaptation can manifest as a change of signal to postural muscles that connect to specific vertebrae causing subluxation, or a change in signal to any other part of the body.[18,31,33]

The importance of chiropractic care is in the direct affect it has upon the central nervous system (CNS) where the interference manifests. Wherever a bone may have shifted out of place due to the change in signal to the muscle, it is called subluxation and can be located in the spine.[21] Chiropractic techniques may focus on applying a force to the bone-muscle component of subluxation causing the bone to shift into normal alignment. TRT is a technique that acknowledges the neurologic adaptation and attempts to counteract it at a location along the CNS that has connection through the CSMFU, which is where it is best able to accept corrective neurological stimulus for that particular neurologic adaptation.[14,18,33] This location along the CNS as well as the CSMFU is very important in this process due to the cord tension produced, as well as the transfer of neurologic signal by the meninges.[34] In an article explaining new research on meningeal composition and function, it was found that the meninges are a source of important growth factors and can relay neural signals in addition to protecting the CNS.[34] Because the cord tension model of subluxation shows how the tone of the cord can be altered, it will prevent further neurologic signal to the rest of the body. Lack of neurologic signal may produce more subluxations as well as postural distortions and spinal curve changes such as loss of cervical lordotic curve, which have been shown to have negative health consequences.[27,35,13] This cycle will then keep repeating itself causing degeneration and is termed the vertebral subluxation complex.[21]

Research has shown there is a direct connection among the endocrine, immune, and limbic systems through a network of neuropeptides and neurotransmitters and hormones.[16] TRT has been shown to have positive effects on the brain reward cascade, reward deficiency syndrome, and improving wellbeing in patients.[23,24,36] This may be partly due to the limbic system extending into the dorsal horns of the spinal column.[16] If the spinal cord receives tension or pressure from the pull of a dural attachment, this could in turn alter the production of proper neuropeptides necessary for limbic, endocrine, and immune system function.[4,16,37] Pressure has been shown to decrease enzymatic activity, in which the slightest change may alter proper hormone production.[4,37] There are several reasons hypothyroidism may occur. Autoimmune reaction causes T lymphocytes to attack the thyroid gland through the release of lymphokines, which are involved in the feedback loop of the limbic system. TSH uses a secondary messenger system to activate the thyroid cells. The secondary messenger system may be decreased by activation of a specific dopamine gene in the brain reward cascade.[38] The hypothalamic-pituitary-adrenal axis is also incorporated into the brain reward cascade through the hypothalamus and locus coeruleus and is an important factor in hypothyroidism.[39] The hypothalamus is very important to the brain reward cascade due to having receptors for nearly all neuropeptides.[16] If the brain reward cascade improperly stimulates the hypothalamus, it may release improper amounts of corticotropin-releasing hormone, which can decrease thyroid function. By correctly stimulating the CNS at the point of neurologic adaptation, tension is released from the spinal cord and natural tone is returned to the nervous system. Chiropractic adjustments may improve the release of neuropeptides in the limbic system, which may further improve many biological processes in the body such as hypothyroidism.[14,16,18]

Limitations

There are limitations within the study due to patient self-reporting, which is not an objective measure, and frequency of treatment, which also was dependent on the patient. Other environmental and personal factors need to be accounted for to eliminate their possible affect on TSH levels during chiropractic care. Possible factors may include the patient's change in diet, exercise, sleep, other medications, and other treatment the patient may not have reported. Due to the nature of a case study the data cannot be extrapolated to the general population.

Conclusion

Because synthetic thyroid hormone is now the only current treatment for hypothyroidism, it would be beneficial to have an alternative treatment such as chiropractic care. Those currently receiving synthetic thyroid medication risk its side effects, drug interactions, and associated costs. The Colorado Study showed that about 10% of individuals are undiagnosed supporting a need for chiropractic care as a preventative healthcare model because it may provide incidental relief. This case study as well as the three others demonstrates the possibility of chiropractic adjustments improving thyroid function.[28-30] Further studies are needed such as randomized, controlled trials to investigate possible chiropractic alternatives.

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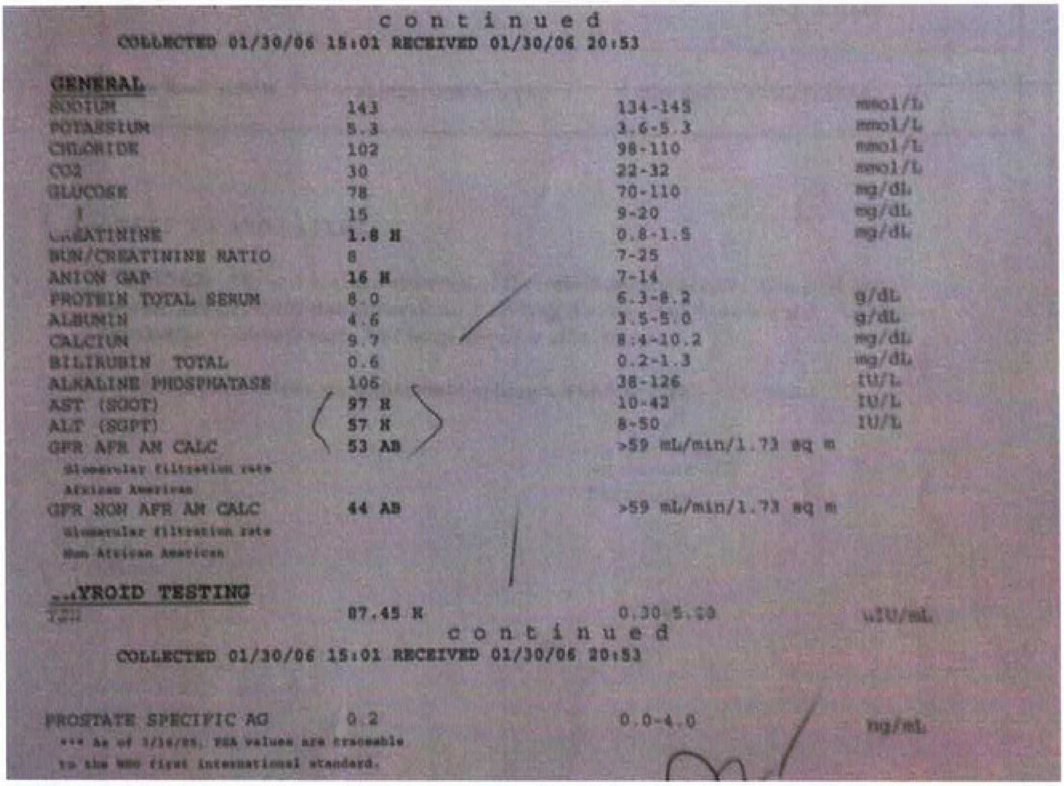

continued

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GENERAL

SODIUM	143	134-145	mmol/L
POTASSIUM	5.3	3.6-5.3	mmol/L
CHLORIDE	102	98-110	mmol/L
CO2	30	22-32	mmol/L
GLUCOSE	78	70-110	mg/dL
[illegible]	15	9-20	mg/dL
CREATININE	1.8 H	0.8-1.5	mg/dL
BUN/CREATININE RATIO	8	7-25	
ANION GAP	16 H	7-14	
PROTEIN TOTAL SERUM	8.0	6.3-8.2	g/dL
ALBUMIN	4.6	3.5-5.0	g/dL
CALCIUM	9.7	8.4-10.2	mg/dL
BILIRUBIN TOTAL	0.6	0.2-1.3	mg/dL
ALKALINE PHOSPHATASE	106	38-126	IU/L
AST (SGOT)	97 H	10-42	IU/L
ALT (SGPT)	57 H	8-50	IU/L
GFR AFR AM CALC Glomerular filtration rate African American	53 AB	>59 mL/min/1.73 sq m	
GFR NON AFR AM CALC Glomerular filtration rate Non African American	44 AB	>59 mL/min/1.73 sq m	

...YROID TESTING

TSH	87.45 H	0.30-5.00	uIU/mL

continued

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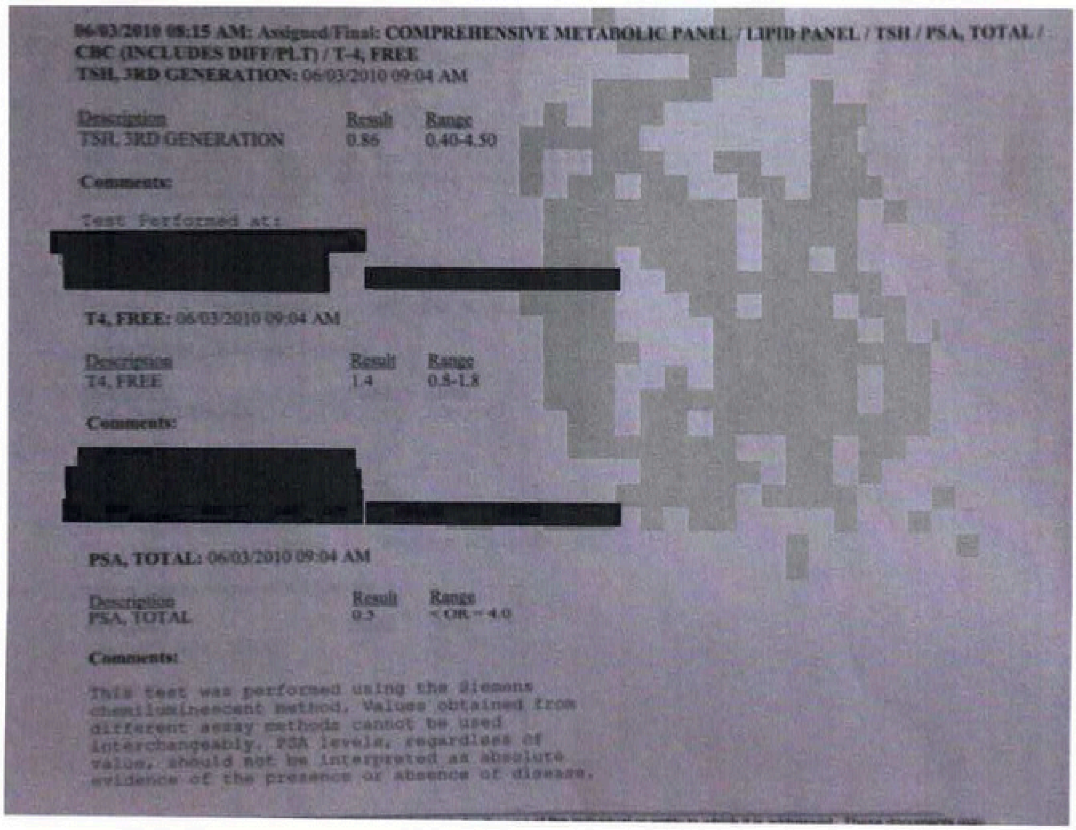
PROSTATE SPECIFIC AG	0.2	0.0-4.0	ng/mL

*** As of 3/16/05, PSA values are traceable to the WHO first international standard.

Figure 1



06/03/2010 08:15 AM: Assigned/Final: COMPREHENSIVE METABOLIC PANEL / LIPID PANEL / TSH / PSA, TOTAL / CBC (INCLUDES DIFF/PLT) / T-4, FREE

TSH, 3RD GENERATION: 06/03/2010 09:04 AM

Description	Result	Range
TSH, 3RD GENERATION	0.86	0.40-4.50

Comments:

Test Performed at:

[redacted]

T4, FREE: 06/03/2010 09:04 AM

Description	Result	Range
T4, FREE	1.4	0.8-1.8

Comments:

[redacted]

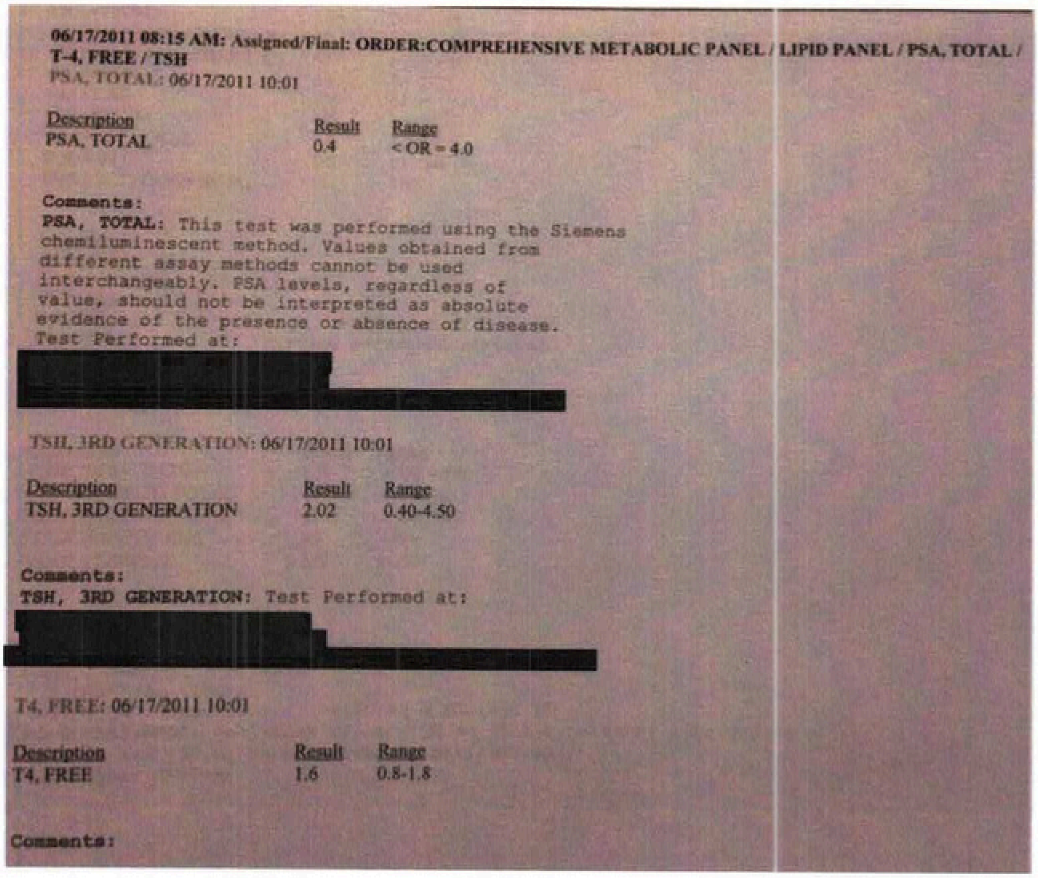
PSA, TOTAL: 06/03/2010 09:04 AM

Description	Result	Range
PSA, TOTAL	0.3	<OR=4.0

Comments:

This test was performed using the Siemens chemiluminescent method. Values obtained from different assay methods cannot be used interchangeably. PSA levels, regardless of value, should not be interpreted as absolute evidence of the presence or absence of disease.

Figure 2



06/17/2011 08:15 AM: Assigned/Final: ORDER:COMPREHENSIVE METABOLIC PANEL / LIPID PANEL / PSA, TOTAL / T-4, FREE / TSH

PSA, TOTAL: 06/17/2011 10:01

Description	Result	Range
PSA, TOTAL	0.4	< OR = 4.0

Comments:

PSA, TOTAL: This test was performed using the Siemens chemiluminescent method. Values obtained from different assay methods cannot be used interchangeably. PSA levels, regardless of value, should not be interpreted as absolute evidence of the presence or absence of disease.
Test Performed at:
[redacted]

TSH, 3RD GENERATION: 06/17/2011 10:01

Description	Result	Range
TSH, 3RD GENERATION	2.02	0.40-4.50

Comments:

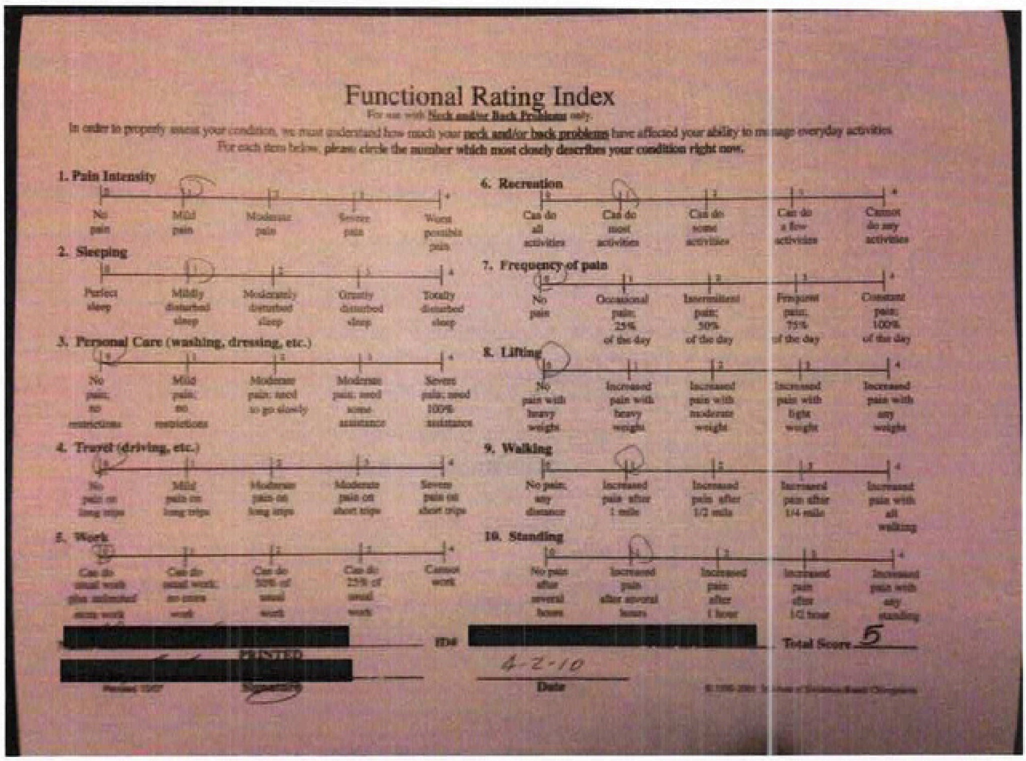
TSH, 3RD GENERATION: Test Performed at:
[redacted]

T4, FREE: 06/17/2011 10:01

Description	Result	Range
T4, FREE	1.6	0.8-1.8

Comments:

Figure 3



Functional Rating Index

For use with Neck and/or Back Problems only.

In order to properly assess your condition, we must understand how much your neck and/or back problems have affected your ability to manage everyday activities.
For each item below, please circle the number which most closely describes your condition right now.

1. Pain Intensity
0 No pain — 1 Mild pain — 2 Moderate pain — 3 Severe pain — 4 Worst possible pain

2. Sleeping
0 Perfect sleep — 1 Mildly disturbed sleep — 2 Moderately disturbed sleep — 3 Greatly disturbed sleep — 4 Totally disturbed sleep

3. Personal Care (washing, dressing, etc.)
0 No pain; no restrictions — 1 Mild pain; no restrictions — 2 Moderate pain; need to go slowly — 3 Moderate pain; need some assistance — 4 Severe pain; need 100% assistance

4. Travel (driving, etc.)
0 No pain on long trips — 1 Mild pain on long trips — 2 Moderate pain on long trips — 3 Moderate pain on short trips — 4 Severe pain on short trips

5. Work
0 Can do usual work plus unlimited extra work — 1 Can do usual work; no extra work — 2 Can do 50% of usual work — 3 Can do 25% of usual work — 4 Cannot work

6. Recreation
0 Can do all activities — 1 Can do most activities — 2 Can do some activities — 3 Can do a few activities — 4 Cannot do any activities

7. Frequency of pain
0 No pain — 1 Occasional pain; 25% of the day — 2 Intermittent pain; 50% of the day — 3 Frequent pain; 75% of the day — 4 Constant pain; 100% of the day

8. Lifting
0 No pain with heavy weight — 1 Increased pain with heavy weight — 2 Increased pain with moderate weight — 3 Increased pain with light weight — 4 Increased pain with any weight

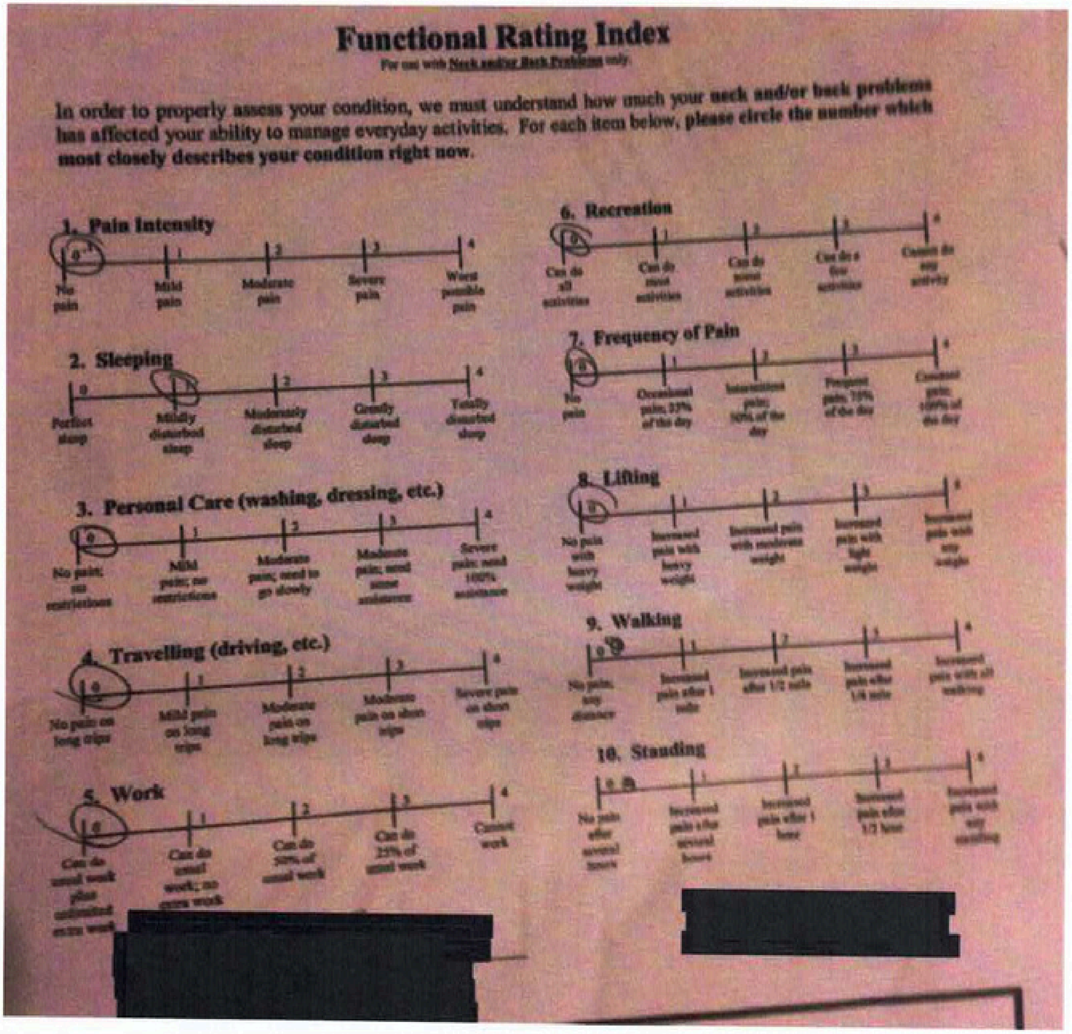
9. Walking
0 No pain; any distance — 1 Increased pain after 1 mile — 2 Increased pain after 1/2 mile — 3 Increased pain after 1/4 mile — 4 Increased pain with all walking

10. Standing
0 No pain after several hours — 1 Increased pain after several hours — 2 Increased pain after 1 hour — 3 Increased pain after 1/2 hour — 4 Increased pain with any standing

[redacted] PRINTED [redacted] Signature ID# [redacted] Total Score 5

4-2-10
Date

Figure 4



Functional Rating Index

For use with Neck and/or Back Problems only.

In order to properly assess your condition, we must understand how much your neck and/or back problems has affected your ability to manage everyday activities. For each item below, please circle the number which most closely describes your condition right now.

1. Pain Intensity
0 No pain — 1 Mild pain — 2 Moderate pain — 3 Severe pain — 4 Worst possible pain

2. Sleeping
0 Perfect sleep — 1 Mildly disturbed sleep — 2 Moderately disturbed sleep — 3 Greatly disturbed sleep — 4 Totally disturbed sleep

3. Personal Care (washing, dressing, etc.)
0 No pain; no restrictions — 1 Mild pain; no restrictions — 2 Moderate pain; need to go slowly — 3 Moderate pain; need some assistance — 4 Severe pain; need 100% assistance

4. Travelling (driving, etc.)
0 No pain on long trips — 1 Mild pain on long trips — 2 Moderate pain on long trips — 3 Moderate pain on short trips — 4 Severe pain on short trips

5. Work
0 Can do usual work plus unlimited extra work — 1 Can do usual work; no extra work — 2 Can do 50% of usual work — 3 Can do 25% of usual work — 4 Cannot work

6. Recreation
0 Can do all activities — 1 Can do most activities — 2 Can do some activities — 3 Can do a few activities — 4 Cannot do any activity

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0 No pain — 1 Occasional pain; 25% of the day — 2 Intermittent pain; 50% of the day — 3 Frequent pain; 75% of the day — 4 Constant pain; 100% of the day

8. Lifting
0 No pain with heavy weight — 1 Increased pain with heavy weight — 2 Increased pain with moderate weight — 3 Increased pain with light weight — 4 Increased pain with any weight

9. Walking
0 No pain; any distance — 1 Increased pain after 1 mile — 2 Increased pain after 1/2 mile — 3 Increased pain after 1/4 mile — 4 Increased pain with all walking

10. Standing
0 No pain after several hours — 1 Increased pain after several hours — 2 Increased pain after 1 hour — 3 Increased pain after 1/2 hour — 4 Increased pain with any standing

[redacted]

[redacted]

Figure 5

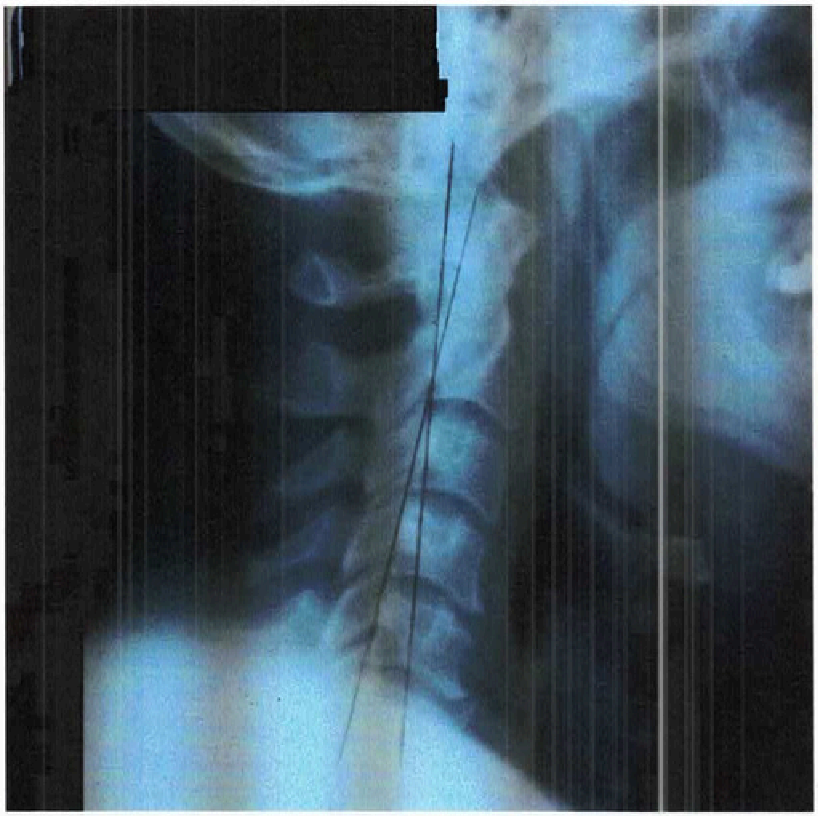

Figure 6 Pre Lateral Cervical Radiograph: 04/02/2010 Cervical Lordosis: 9 degrees

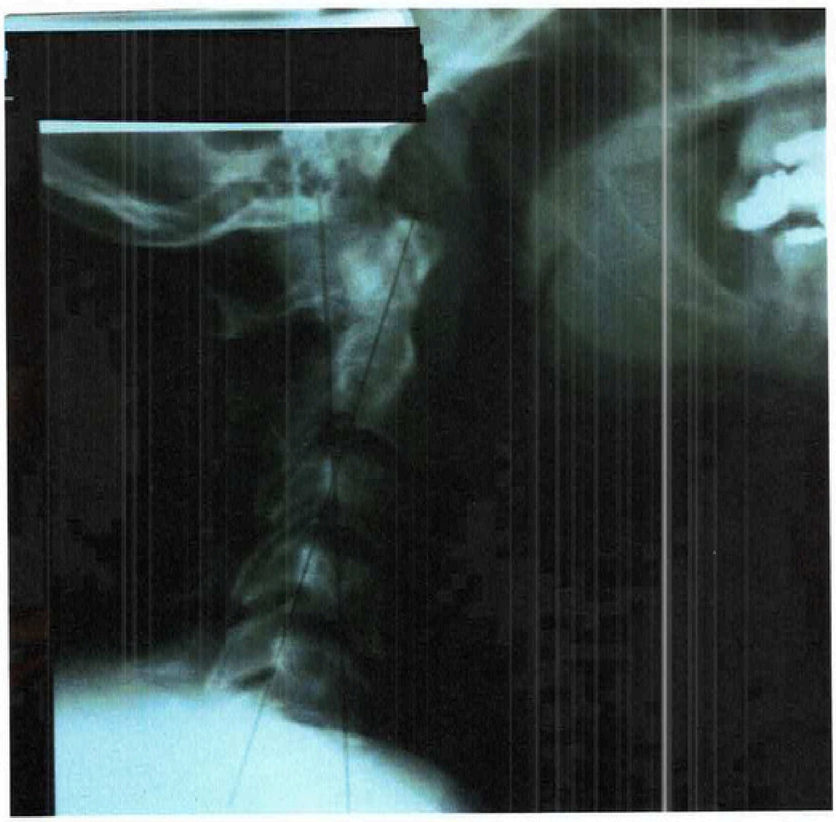

Figure 7 Post Lateral Cervical Radiograph: 01/08/11 Cervical Lordosis: 19 degrees

Hindawi Publishing Corporation
Evidence-Based Complementary and Alternative Medicine
Volume 2017, Article ID 4345703, 9 pages
http://dx.doi.org/10.1155/2017/4345703

Research Article

Glucose Metabolic Changes in the Brain and Muscles of Patients with Nonspecific Neck Pain Treated by Spinal Manipulation Therapy: A [^{18}F]FDG PET Study

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Received 2 August 2016; Revised 24 November 2016; Accepted 15 December 2016; Published 12 January 2017

Academic Editor: Jeng-Ren Duann

Objective. The aim of this study was to investigate changes in brain and muscle glucose metabolism that are not yet known, using positron emission tomography with [^{18}F]fluorodeoxyglucose ([^{18}F]FDG PET). *Methods.* Twenty-one male volunteers were recruited for the present study. [^{18}F]FDG PET scanning was performed twice on each subject: once after the spinal manipulation therapy (SMT) intervention (treatment condition) and once after resting (control condition). We performed the SMT intervention using an adjustment device. Glucose metabolism of the brain and skeletal muscles was measured and compared between the two conditions. In addition, we measured salivary amylase level as an index of autonomic nervous system (ANS) activity, as well as muscle tension and subjective pain intensity in each subject. *Results.* Changes in brain activity after SMT included activation of the dorsal anterior cingulate cortex, cerebellar vermis, and somatosensory association cortex and deactivation of the prefrontal cortex and temporal sites. Glucose uptake in skeletal muscles showed a trend toward decreased metabolism after SMT, although the difference was not significant. Other measurements indicated relaxation of cervical muscle tension, decrease in salivary amylase level (suppression of sympathetic nerve activity), and pain relief after SMT. *Conclusion.* Brain processing after SMT may lead to physiological relaxation via a decrease in sympathetic nerve activity.

1. Introduction

Spinal manipulation therapy (SMT), which is performed by healthcare practitioners such as chiropractors, osteopathic physicians, and physiotherapists, has been applied mainly to musculoskeletal problems such as neck pain or low back pain. Many investigators have performed various experiments to elucidate the mechanism underlying the clinical effects of SMT. The earliest studies analyzed the magnitude of the force applied to the vertebrae and the movement of vertebrae during SMT, with the forces exerted by the practitioner quantified using a flexible pressure mat [1, 2]. The rotation and relative movement of vertebrae after treatment using a mechanical adjusting device (activator adjusting instrument, AAI) [3] have also been reported [4–8]. Previous studies have suggested that SMT has beneficial clinical effects, including pain relief [9] and reduction of blood pressure [10, 11]. It is thought that biomechanical input by SMT could generate a physical response or reflex [12]; however, the mechanism of these clinical effects induced by SMT is still unknown.

In recent years, the findings of brain activation studies using imaging modalities such as functional magnetic resonance imaging, near-infrared spectroscopy, and positron emission tomography (PET) have contributed to advances in brain science [13]. Such studies are able to enhance our understanding of the neurophysiological effects of specific physical/psychological tasks by detecting associated activation and deactivation of brain regions. PET has also been used to elucidate the metabolic changes that alternative therapies induce in living tissues; for example, an ^{18}F-labeled glucose analog has been used to study cerebral metabolic changes after acupuncture [14] and aromatherapy [15], and $[^{15}O]H_2O$ has been used to assess changes in cerebral blood flow during massage [16]. Lystad and Pollard have noted the usefulness of neuroimaging techniques for gaining a better understanding of the neurophysiological effects of SMT [17].

The [^{18}F]-labeled glucose analog, fluorodeoxyglucose ([^{18}F]FDG), is thought to be able to visualize the energy metabolism of various tissues such as brain and muscles in vivo. One of important advantages of [^{18}F]FDG PET is that we can simultaneously measure the energy metabolism of brain and muscles. We have hypothesized that clinical effects such as muscle tension relaxation and pain relief are mediated by the regional brain activity induced by SMT. We have also expected any changes in muscular energy consumption in treatment condition. In addition, we have also expected significant correlation between the regional brain activity and the muscular energy consumption.

Previously, we reported preliminary results of our study to examine our initial hypothesis that a [^{18}F]FDG PET can visualize brain metabolic changes induced by SMT [18]. In this paper, we report our conclusive results on this issue. In addition, the present work tries to examine our additional hypothesis that the [^{18}F]FDG PET can visualize muscular metabolic changes induced by SMT, as well as their association with the regional brain metabolism.

2. Subjects and Methods

We recruited 21 male subjects (mean age ± SD: 26.4 ± 5.9 years) with cervical pain and shoulder stiffness but without abnormalities in neck-to-shoulder MR images and without history of any treatments prior to the present study. We performed MRI examination of the neck to the shoulder area on all participants; the resulting MR images were used as a reference for the anatomical locations of cervical muscles in PET images. Female subjects were not included in this study because of physiological fluctuations due to the menstrual cycle [19–23].

SMT was applied using an AAI, Activator II (Activator Methods International, Ltd., Phoenix, USA), in accordance with the Activator Methods (AM) basic scan protocol [24, 25]. We utilized the AAI to apply impulses to specific vertebrae or joints (Figure 1). SMT was performed on the subject in a prone position without movements such as cervical rotation, lateral flexion, and extension, in order to prevent the muscular [^{18}F]FDG uptake due to muscle contractions during the therapeutic procedure. SMT was carried out on the whole spine, the scapulae, the ilium, and the sacrum,

FIGURE 1: The location of cervical adjustment by the activator adjusting instrument (AAI) in the treatment condition. Spinal manipulation therapy (SMT) by AAI was performed by contact on the joints and did not include muscle massage. SMT on all subjects was performed by the same chiropractor, who was an advanced practitioner of Activator Methods.

as necessary for each subject. The mean number of SMT-adjusted sites was 8 per subject.

PET scanning was performed twice on each subject according to the protocol given in Figure 2. The interval between the two scans ranged from 7 to 70 days (mean interval ± SD: 23 ± 15 days). The subjects received SMT intervention which lasted for approximately 20 minutes including a diagnostic procedure. Soon after the treatment, [^{18}F]FDG-containing saline solution was injected to the subject through the left cubital vein (mean ± SD: 47.0 ± 8.9 MBq) in quiet room with a dim light next door to the treatment room in the same building. On the other scan day, [^{18}F]FDG was injected to the subject after a 20-minute-long resting phase instead of SMT intervention. The subjects in both conditions were asked to sit in a relaxed position with their eyes closed for 30 minutes before PET scanning. The brain scan and the scan on the neck to the shoulder area of the subject were initiated after 30 minutes of [^{18}F]FDG injection, utilizing a PET scanner, SET2400W (Shimadzu, Inc., Kyoto, Japan). The PET scanning covered the entire brain in one scan, taking 10 minutes for the emission scan and another 5 minutes for the transmission scan for tissue attenuation correction. Scanning from the neck to the shoulder area in one scan took 5 minutes for the emission scan and another 5 minutes for the transmission scan for tissue attenuation correction. Images were acquired with a 128 × 128 matrix and reconstructed using Fourier rebinning and Ordered Subset Expectation Maximization Algorithm [18]. The intensity of subjective pain was evaluated using a 0–10 visual analog scale (VAS) before and after SMT in the treatment condition. VAS evaluation was not done in the resting condition except for in 9 subjects. Cervical muscle tension was measured bilaterally at the superior part of the trapezius muscle using a tissue hardness meter (Muscle Meter PEK-1, Imoto Inc., Kyoto, Japan); the mean value of three measurements was recorded. Additionally, salivary amylase levels were measured for each subject using an amylase monitor (Nipro Inc., Osaka, Japan) to evaluate changes in autonomic nervous system (ANS) function. Figure 2 shows the measurement points.

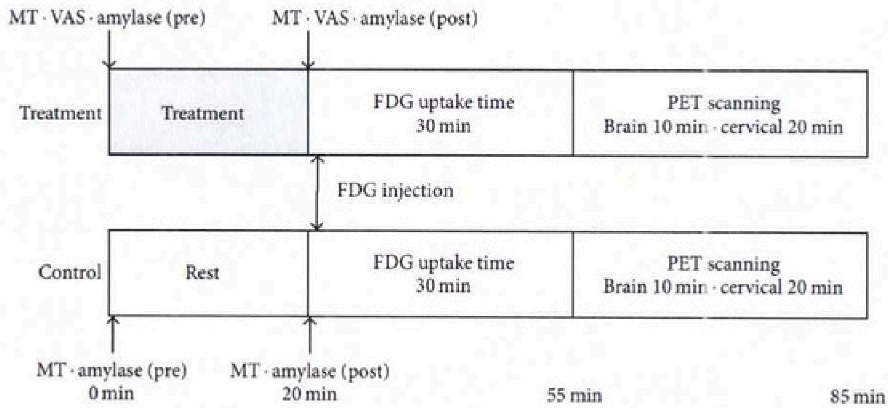

FIGURE 2: Diagram of the study protocol. Half of the subjects were randomly assigned to be scanned first in the resting condition and then in the treatment condition; the other half were scanned in the reverse order. The intensity of subjective pain was evaluated before and after spinal manipulation therapy only in the treatment condition. Muscle stiffness and salivary amylase were measured before and after the treatment or resting period. MT = muscle tension, VAS = visual analog scale.

Further details of the study protocol are described in our previous report [18]. The whole protocol was approved by the Ethics Committee of Tohoku University Graduate School of Medicine, Sendai, Japan (number 2008-115).

For data analysis, differences in values before and after treatment and between the control and treatment conditions were compared using paired t-tests for all measurements except for PET data. Brain PET images were analyzed using the voxel-wise statistical analysis software package Statistical Parametric Mapping 8 (SPM8; Functional Imaging Laboratory, London, UK) in order to identify regional glucose metabolic changes [26, 27]. An FDG brain template distributed by Montreal Neurological Institute (McGill University, Montreal, Canada) [28] was used for anatomical standardization (spatial normalization) of the PET images. Each voxel had dimensions of $2 \times 2 \times 2$ mm in the normalized image. The normalized data were smoothed using an isotropic Gaussian kernel of 12 mm (for the x-, y-, and z-axes) to increase the signal-to-noise ratio by suppressing high-frequency noise. The threshold for the statistical significance of the voxel value height in the present study was set at $p < 0.05$ with correction for multiple comparisons (family-wise error correction), while our previous study applied the compromised threshold of $p < 0.001$ without correction. Voxel values of the PET images were compared between the resting and treatment conditions using a paired t-test.

PET images of the neck and shoulder regions were coregistered to the MR images of the same subject; regions of interest (ROIs) for cervical muscles were then manually drawn on the PET images using Dr. View software (Version 2.0, AJS, Tokyo, Japan), using the MR images as references. ROIs were drawn on the trapezius muscle at C7-T1 levels bilaterally, the splenius muscles, the semispinalis muscles, the elevator scapular muscles, and the trapezius muscles at C6-C7 levels bilaterally. The standardized uptake value (SUV) for each muscle was calculated using the following formula:

$$\text{SUV} = \text{tissue radioactivity concentration (Bq/g)} \times \frac{\text{body weight (g)}}{\text{injected activity (Bq)}}. \tag{1}$$

SUVs were statistically examined using a paired t-test to compare muscle metabolism after SMT and after resting. In addition, the authors searched for specific brain regions associated with muscular energy consumption by applying linear correlation analysis using SUV of each muscle studied here as a parameter in SPM8.

3. Results

The SMT-associated regional brain metabolic changes (activation and deactivation) detected by the SPM8 analysis are shown in Table 1. Statistically significant areas were overlaid on the standard MRI brain template images (Figure 3). PET analysis of the cervical muscles showed a trend toward reduced metabolism (SUV) after SMT compared with the control condition; however, these changes were not statistically significant (Figure 4). In addition, no meaningful correlation was detected between muscular SUV and regional brain activity.

In contrast, cervical muscle tension was significantly reduced bilaterally after SMT ($p < 0.0001$ for both sides, Figure 5). Salivary amylase level decreased significantly after SMT ($p = 0.022$) but increased significantly in the control condition ($p = 0.011$, Figure 6). Comparisons of VAS pain scores in the treatment condition revealed a significant decrease after SMT ($p < 0.0001$, Figure 7), while the comparison in the control condition showed nonsignificant difference ($n = 9$).

4. Discussion

The findings of the present study demonstrate how stimuli to the mechanoreceptors of the joints and skin during SMT are processed in the brain. Injected [^{18}F]FDG was absorbed into

TABLE 1: Brain metabolic changes associated with the spinal manipulation therapy intervention.

Anatomical region	Coordinates x, y, and z (mm)	Brodmann area	Cluster equiv.	Voxel Z score
Activation				
Broca's area	−34, 6, 28	44	110	5.84
ACC	2, 8, 40	32	228	5.72
SSAC	16, −26, 48	5	114	5.65
Wernicke's area	46, −48, 20	22	30	5.52
VAC	−6, −88, 38	19	31	5.32
CV	6, −62, −4	—	14	5.28
VC (V2)	24, −80, 6	18	17	5.24
Deactivation				
IPL	−40, −40, 34	39/40	286	6.74
FP	−2, 68, −8	10	160	6.66
IFG PT	40, 28, 16	45	117	6.53
PSMA	30, 14, 44	6	348	6.34
PMC (M1)	−28, −18, 56	4	45	6.12
FEF/dl-PFC	−30, 12, 44	8/9	157	5.93
dl-PFC	−38, 26, 24	46	309	5.70
AG/FG	−40, −60, 8	39/37	177	5.58
ITG	−70, −22, −20	20	20	5.66
TP	40, 22, −44	38	12	5.64
CV (V1)	−14, −66, 24	17	46	5.29

Brain metabolic changes detected by SPM8 are presented (voxel height threshold $p < 0.05$ with corrections for multiple comparisons, extent threshold 10 voxels minimum). The statistical significance of regional metabolic changes is given as Z scores $[(\text{Mean}_{\text{treatment}} - \text{Mean}_{\text{control}})/\text{SD}_{\text{control}}]$.
ACC, anterior cingulate cortex; SSAC, somatosensory association cortex; VAC, visual association cortex; CV, cerebellar vermis; VC, visual cortex; IPL, inferior parietal lobule; FP, frontal pole; IFG, inferior frontal gyrus; PT, pars triangularis; PSMA, premotor area/supplementary motor area; PMC, primary motor cortex; FEF, frontal eye field; dl-PFC, dorsolateral prefrontal cortex; AG, angular gyrus; FC, fusiform gyrus; ITG, inferior temporal gyrus; TP, temporal pole.

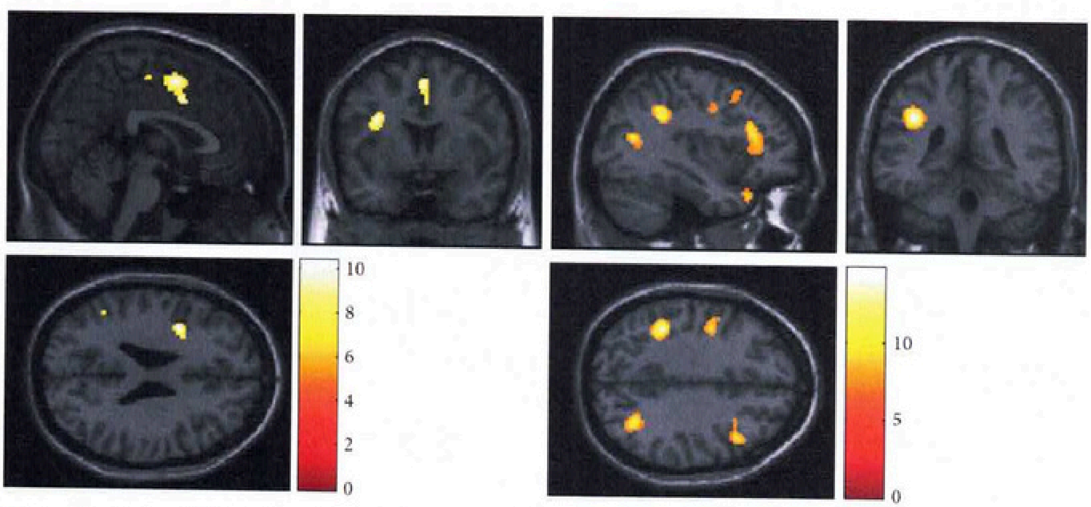

FIGURE 3: Regional activation (left) and deactivation (right) after spinal manipulation therapy (SMT) using an activator adjusting instrument. Glucose metabolism is increased in regions including the anterior cingulate cortex and cerebellar vermis but is relatively reduced in many sites, including the prefrontal cortex, after SMT. The voxel height threshold is $p < 0.05$, corrected for multiple comparisons; the extent threshold is 10 voxels minimum.

activated brain regions and visualized by PET. We observed multiple changes in brain activity after SMT.

SPM8 analyzes approximately half a million voxels of brain volume data simultaneously. Correction for multiple comparisons is therefore indispensable, making the statistical threshold extremely high. Since many studies have failed to detect significant differences in voxels after correction for multiple comparisons, the SPM8 development team proposed the use of a compromised threshold for voxel height ($p < 0.001$) combined with a voxel extent threshold for

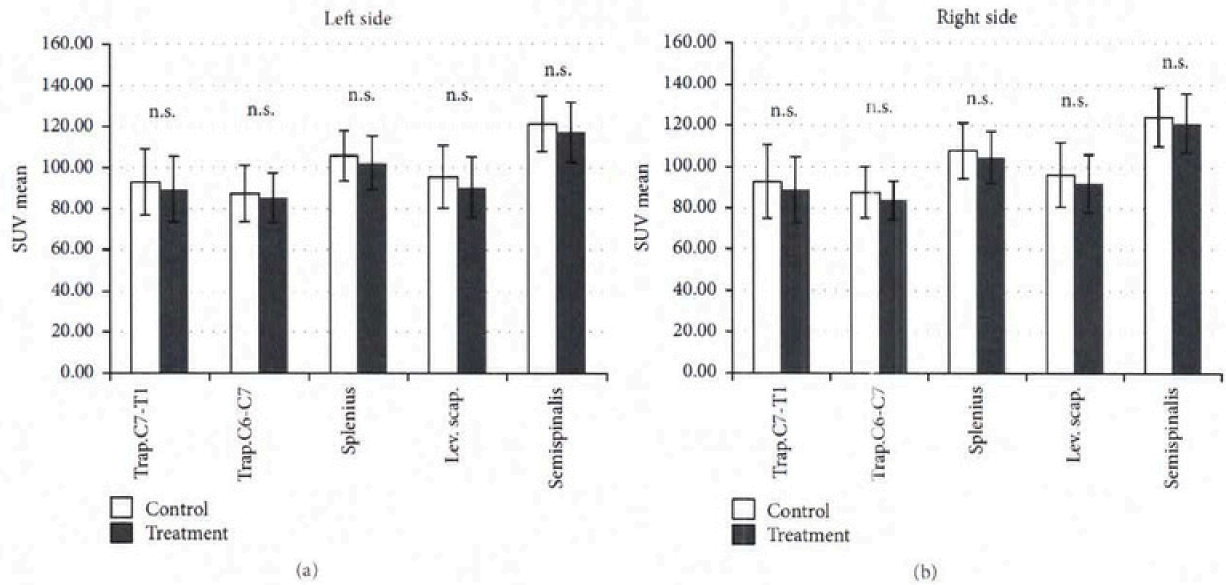

FIGURE 4: Results of positron emission tomography analysis of cervical muscles (paired t-test). The error bars represent standard deviations. The results indicate a trend toward reduction of mean standardized uptake value (SUV) after SMT; however, the difference is not statistically significant. Trap., trapezius muscle; Splenius, splenius muscles; Lev. Scap., levator scapulae; Semispinalis, semispinalis muscles; C7-T1, between the seventh cervical spine and the first thoracic spine; C6-C7, between the sixth cervical spine and the seventh cervical spine.

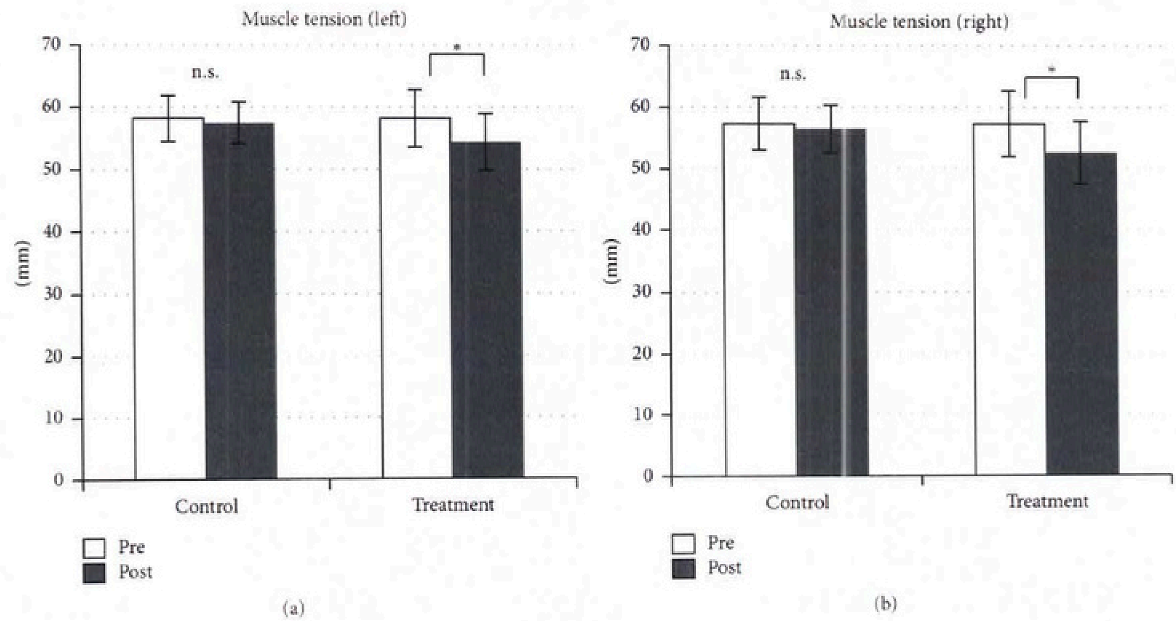

FIGURE 5: Muscle tension is significantly reduced after spinal manipulation therapy. $^{*}p < 0.0001$.

the size of each voxel cluster (e.g., 10 voxels minimum), as used in our previous report [26, 27]. This technique has been useful for practical purposes but is prone to Type-1 errors. The significant voxel clusters that survived correction for multiple comparisons in the present work may therefore indicate more robust and reliable findings than those in our preliminary report [18]; we believe these results are worthy of reporting as conclusive findings, despite the fact that the intensity of the observed brain responses to SMT intervention was initially estimated to be much weaker.

As for regional brain metabolic changes after the SMT intervention, activation (increased metabolism) was detected in the dACC (Brodmann area [BA] 32), cerebellar vermis (CV), and somatosensory association cortex, and regional

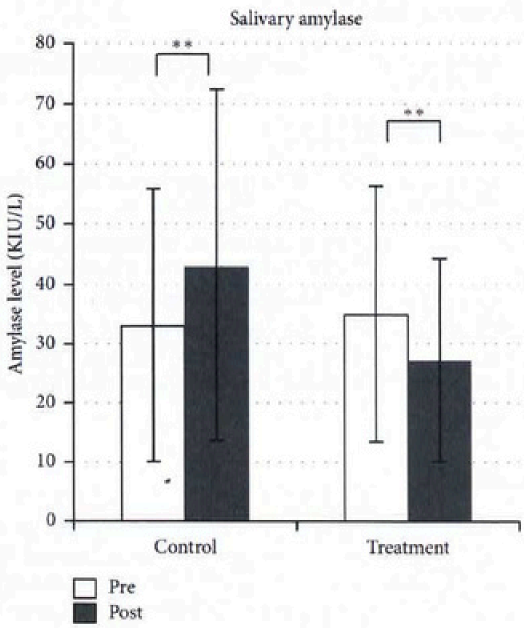

FIGURE 6: Changes in salivary amylase level. Salivary amylase level is reduced after spinal manipulation therapy but increased in the control condition. $^{**}p < 0.05$.

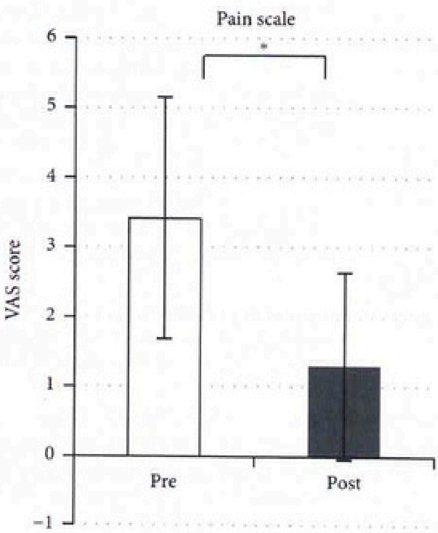

FIGURE 7: Changes in subjective pain in the treatment condition. The pain scale score is significantly decreased after spinal manipulation therapy. $^{*}p < 0.0001$.

deactivation (decreased metabolism) was detected in regions including the prefrontal cortex (PFC) and temporal sites. Involvement of the ACC in cognitive and emotional processes has been recognized since Papez mentioned the idea in 1937 [29–31], and this area is also involved in placebo and opioid analgesia [32]. Some brain activation studies have also demonstrated activation of the ACC in response to pleasant or unpleasant stimuli such as massages or the olfactory stimulus of isovaleric acid, respectively [33–35]. The ACC is part of network that carries out cognitive processing based on individual factors such as experiences or emotions while making contact with the other regions in the network, such as the limbic system and cortex [32, 36]. Recently, specific features of the dACC functions and their connectivity to other brain regions are not fully elucidated yet, though they have been revealed little by little. For example, dACC is involved in cognitive functions, motivation, and reward-based decision-making as a part of the network including the CV and prefrontal cortex [37]. The neuronal activity changes in dACC and CV were detected in the present study.

The CV receives somatic sensory information from the spinal cord and via the vestibulospinal tract or reticular nuclei of the brainstem through the spinal cord, connecting indirectly or directly with motor cells on the ventral horn. These systems control involuntary muscular tension and reflexes. Our results suggest that stimulation of joints during SMT induced relaxation of reflexive muscle tension. The cerebellum is also thought to have a functional role as an integrator of multiple effector systems, including affective processing, pain modulation, and sensorimotor processing [38]. Recently, many studies have reported roles for the cerebellum in nonmotor functions [39, 40]. A study by Sacchetti et al. showed that the CV is activated during mental recall of emotional personal episodes in humans [39]. Lou et al. also reported that the CV, ACC, and some regions of the PFC are activated during relaxation mediation in yoga [41]. However, it is important to note that the PFC was deactivated after SMT in our study. Interestingly, Critchley et al. found that the ACC/dACC (BA24/32) and CV are specifically activated during biofeedback therapy [42], a technique for controlling one's tension to generate a state of relaxation. The activated areas in the present study are similar to those activated during biofeedback relaxation, indicating that the state of the brain after SMT may be similar to that induced by biofeedback therapy. Furthermore, our assessment of body responses in this study showed relaxation of muscle tension and decreased salivary amylase levels—phenomena that are associated with reduced sympathetic nerve activity. Salivary α-amylase levels correspond to plasma norepinephrine levels and are utilized as an accessible measure of sympathetic nervous reactivity in stress research, with lower levels indicating lower activity [43–45].

Ouchi et al. suggested that the comfortable sensation generated by back massage may be related to increased regional cerebral blood flow in the posterior brain—specifically, in the precuneus [16]. SMT stimuli to the joints may be processed differently from those of muscle massage, resulting in decreased sympathetic nerve activity. On the other hand, certain cervical muscles showed a tendency toward decreased glucose metabolism after SMT, although the difference was not statistically significant (Figure 4). Increasing the number of study subjects may increase the significance of this finding. The underlying mechanism of reduced muscular glucose uptake is not yet understood; however, an animal study suggests the involvement of sympathetic nerve activity [46]. Glucose uptake in skeletal muscles may thus be influenced directly or indirectly by the ANS.

Although the mechanism of muscle relaxation is still unknown, we hypothesize the involvement of (a) autonomic nervous activity and (b) improvement of the range of joint movement [47]. In the present study, we observed that SMT stimulus induced physical responses such as muscle tension relaxation, pain relief, and reduced amylase secretion. These changes may be associated with neural processing in the dACC and CV. Neural inputs evoked by SMT stimuli via various receptors in muscles, tendons, and joints may ascend to the somatosensory areas of the brain through the medial lemniscal system. The response signal descending from the brain may then adjust the postural muscles accordingly.

Muscular SUV, an index of energy consumption of skeletal muscles, did not show significant difference between the control and treatment conditions, while muscle tension did show significant difference. In addition, we could not detect meaningful correlation between the SUV of muscular glucose consumption and the regional brain glucose consumption.

As is the case with every study, our methodology is not without limitations. Ideally, the present subjects would have undergone PET scanning before and after the SMT intervention in both the control and treatment conditions. However, this protocol would have assigned 4 PET scans to each subject, resulting in unreasonably high radiation exposure for this kind of study. Furthermore, it is hard to perform serial PET scans within 1 or 2 hours of each other because of the relatively long physical half-life of the [^{18}F] nuclide (110 minutes). In addition, the number of subjects ($n = 21$) was still relatively small for a clinical study; however, we define the present results as conclusive ones in order to minimize radiation exposure of the subjects, who were healthy other than their neck and shoulder symptoms and who are considered to be part of the general public. Previously, we reported preliminary findings with a sample size of 12; however, the study results were only at threshold level [18], and these results seemed to be prone to Type-1 errors because they were based on a compromised statistical examination without correction for multiple comparisons. On the other hand, no voxels survived with a standard statistical examination including correction for multiple comparisons, suggesting that these negative results may be prone to Type-2 errors. By raising the sample size to 21, now we are able to obtain robust results that survived even after correction for multiple comparisons. Thus, the authors believe the present results are more reliable as an evidence for further discussion on clinical effects of SMT interventions while our preliminary report was useful as a "proof of concept" study.

5. Conclusion

In summary, we observed metabolic changes in the brain and skeletal muscles, as well as reductions in subjective pain, muscle tension, and salivary amylase, after SMT intervention. These results may be associated with reduced sympathetic nerve activity, suggesting that SMT induces a kind of relaxation similar to that achieved by biofeedback. The brain response to SMT may reflect the psychophysiological relaxation that accompanies reduced sympathetic nerve activity.

Competing Interests

The authors declare that they have no competing interests.

Acknowledgments

The authors thank the staff of the Division of Cyclotron and Radioisotope Center, Tohoku University, for their technical support. They thank Japan Chiropractic Doctor College for funding this study. This work was also supported in part by a Grant-in-Aid for Scientific Research (no. 21590754 to Manabu Tashiro) from the Japan Society of Promotion of Sciences (JSPS) and by a grant from the Japan Society of Technology (JST) for research and education in molecular imaging.

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CASE STUDY

Chiropractic Care of a Pregnant Patient Presenting With a History of Migraine Headaches, Hypothyroidism, and Tachycardia

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Abstract

Objective: To describe the care of a pregnant patient presenting with a history of migraine headaches, hypothyroidism, and tachycardia.

Clinical Features: A 28-year-old woman presented for chiropractic care at 14 weeks gestation with a history of prior Caesarean section. She sought chiropractic care to improve her chances of a trial of labor and vaginal delivery for her current pregnancy. History revealed the patient as diagnosed with migraine headaches, hypothyroidism and tachycardia. During care, the patient experienced visual field disturbances and neurological deficits in the face and upper extremities.

Intervention and Outcome: The patient was cared for with diversified technique consisting of the Gonstead Technique, Thompson Drop, and Webster Technique. She attended care for a total of 33 visits of 7 months duration. The result was a successful trial of labor at 40 weeks plus 4 days and delivery of a healthy baby girl.

Conclusion: This case report provides supporting evidence on the effectiveness of chiropractic as described in the care of a pregnant woman.

Key Words: *Chiropractic, pregnancy, migraines, hypothyroidism, tachycardia, vertebral subluxation, adjustment*

Introduction

In a secondary analysis of the 2007 National Health Interview Survey, an analysis for women between the ages of 18 and 49 years who were pregnant or had children less than 1 year old found that 37% of pregnant women and 28% of postpartum women reported using CAM in the last 12 months compared with 40% of nonpregnant/non-postpartum women.[1] Given the multitude of changes, both physiologically and biomechanically during pregnancy a number of pregnancy-related health concerns arise (i.e., low back and/or pelvic pain, headaches, morning sickness, gestational diabetes), and the use of complementary and alternative medicine (CAM) among pregnant women has been established to address a specific complaint and/or promote their health and wellbeing.[2-3] For chronic pain - pelvic pain for example, the medical approach/perspective is to provide opioids due to their potency despite associated risks for adverse effects, abuse, diversion, and addiction.[4] Concerns regarding these side effects for both the mother and fetus motivates expectant mothers to use CAM.[5] Of the practitioner-based CAM therapies, chiropractic remains a popular choice of care[6], given its popularity among adults for neck pain and low back pain.[7] Chiropractic therefore is also popular among pregnant women to address both pregnancy-related MSK complains and for wellness care.[8-9] For pregnant patients presenting to chiropractors, it is not uncommon for them to present with comorbidities. In this era of collaborative care[10], an understanding of the implications of these comorbidities to chiropractic care is of the utmost importance. To inform evidence-based practice (EBP), we present the care of a pregnant patient presenting for care with comorbidities of migraine headaches, hypothyroidism and tachycardia.

Case Report

History

A 28-year-old woman presented for chiropractic consultation and possible care at 14 weeks gestation with a history of prior Caesarean delivery. She sought chiropractic care because she felt that it would help improve her chances of a trial of labor and vaginal delivery for her current pregnancy. A review of systems and history examination revealed the patient received a medical diagnosis of hypothyroidism with mild tachycardia and occasional migraine-type headaches.

Examination

A spinal postural analysis demonstrated a mild head and pelvic tilt with a moderate lateral ribcage shift and forward head carriage (see Figures 1A and 1B). In addition to inspection, chiropractic examination of the patient utilized the Webster sacral analysis[11-12] along with range of motion and static and dynamic palpation. Vertebral subluxations[13] were identified in the upper cervical, pelvic, and upper thoracic spine. The patient was scheduled for care and adjusted utilizing the Gonstead cervical chair, Thompson drop and the Webster Technique.

Intervention & Outcomes

The patient was cared for throughout her pregnancy for a total of 33 visits of seven months duration. Throughout the course of treatment, the patient's most common complaints were mild headaches and sacral pain. At her 26th week of gestation while away visiting family, the patient experienced "floaters" in the visual field of both eyes, which improved with rest. Immediately following this, she reported losing the inferior aspect of her peripheral vision.

She described a numb, tingling sensation in her left hand and loss of sensation on the left side of her face. Her family took her to the local hospital, where a complete examination was performed, including ultrasound imaging of the carotid and vertebral arteries, cranium and cervical spine magnetic resonance imaging (MRI) and competed tomography (CT). All were negative for any pathology. Shortly thereafter, the aforementioned symptoms spontaneously remitted, and she was released from the hospital.

The patient resumed chiropractic care upon returning home and scheduled a follow-up visit with a local neurologist, who reported finding no abnormalities. At her 30th week of gestation, the patient fell at home and her obstetrician's palpation found her fetus had moved from vertex to a transverse lie.

After two chiropractic appointments and performing a set of recommended inversion exercises at home, the patient reported feeling the baby had shifted back to vertex. This was confirmed two weeks later by her obstetrician's internal pelvic examination. During her 38th week of gestation, the patient reported a visual field disturbance in her right eye which limited her peripheral vision. She said her head had become "cloudy" and she felt disoriented. She then reported experiencing tingling in her right hand which wouldn't go away with movement.

The patient reported feeling the same feeling in her face as if it had fallen asleep, and then she felt a headache. The patient said this was the same pattern of symptoms as the previous episode, but on other side. George's maneuver for vertebrobasilar artery insufficiency and auscultation for carotid bruits were negative. The patient was adjusted in the cervical spine based on findings of spinal subluxations. Two days after her visit, the patient reported complete resolution of her symptoms.

The patient was able to successfully attempt a trial of labor at 40 weeks plus 4 days and delivered a baby girl weighing 8 lbs. 9 oz. and measuring 21 inches long. She reported not feeling the urge to push until the very end of the delivery, and said her arms and legs were sore from attempting various birthing positions. The patient elected to continue chiropractic care post-partum for 13 visits over 14 weeks before being released to a maintenance program of bimonthly visits.

Discussion

Given the clinical presentation of the patient presented, a number of issues are ripe for discussion and reflects the complexity of chiropractic care beyond the mere application of SMT. Foremost are the patient's reported visual disturbances and paresthesia during her second trimester. During pregnancy, a number of neurologic disorders such as eclampsia, pseudotumor cerebri, obstetric nerve palsies, subarachnoid hemorrhage, pituitary tumors, and choriocarcinoma can develop.[14]

Of interest in the case reported is the possibility of stroke in this patient given her neurological complaints. Secondly, we have a patient presenting for care motivated by the need to have a vaginal birth. Despite evidence that VBAC is a reasonable and safe choice for the majority of women with prior cesarean[15], the attending clinician must still be cognizant for the possibility of a uterine rupture resulting in maternal and perinatal morbidity and mortality.[16] Third, the patient presented with a history of migraine headaches, hypothyroidism and tachycardia. The co-morbidities have implications to chiropractic care.

Stuber and colleagues[17] noted that pregnancy and the postpartum period places the pregnant woman at increased risk for thrombophilia and that thromboembolism or pulmonary embolism has been identified as the leading cause of maternal death in the United States. Medical conditions associated with stroke in pregnancy include hypertension, diabetes, sickle cell disease, systemic lupus erythematosus, thrombophilia, smoking and heart disease and migraine headaches.

Risk factors for stroke during pregnancy include age over 35 years or older, alcohol and recreational drug abuse (particularly cocaine) as well as a lupus anticoagulant or anticardiolipin antibody and multiple gestation and greater parity.[18] Complications of pregnancy that are significant risk factors include postpartum hemorrhage, preeclampsia and gestational hypertension, transfusion and postpartum infection.[18-19]

The clinical history or physical examination is not sufficiently sensitive to address the patient suffering from stroke. Brain imaging in the form of CT or MRI is recommended as quickly as possible after symptom onset or the suspicion of stroke arises. Concerns have been raised regarding the potential teratogenic effects of MRI exposure in early pregnancy. However, MRI remains the preferred imaging option in pregnancy. CT scanning does expose the fetus to radiation. However, if MRI is not available, the benefits of CT scanning greatly outweigh the risks in this situation and should be performed.

It is worth pointing out that migraine with an accompanying aura is still sufficiently common in pregnancy that it should be considered in the differential diagnosis, particularly if there is an evolving neurological deficit rather than an abrupt onset.[18] Neurological examination, augmented by imaging studies (i.e., MRI and CT) demonstrated no perceptible defect or neurological deficit in the patient reported. In addition, the patient was "cleared" by a maternal fetal medicine specialist. The attending chiropractor performed George's Test along with auscultation for possible bruits prior to adjusting the patient. Note that the patient's neurological symptoms and visual disturbances occurred prior to the patient being adjusted and 3 months after onset of these symptoms, similar symptoms occurred on the contralateral side. Two days after receiving chiropractic adjustments, including to the cervical spine, her visual and neurological symptoms resolved.

This case report is also unique in that patient reported on attempted a trial of labor after cesarean (TOLAC) with successful outcomes (i.e., VBAC - "successful" trial of labor resulting in a vaginal birth) despite a history of pelvic trauma that repositioned her fetus from vertex to transverse with legs down at 30 weeks. Following two chiropractic visits along with recommended home activities (i.e., inversion exercises), the patient's fetus reverted from transverse lie (i.e., fetus is lying sideways with the head in one flank and the buttocks in the other) to vertex position (i.e., the fetus presents by the head, with the best fit into the lower pelvis in the occipito˅anterior position). This temporal association with the patient's care via Webster Technique[12] further emphasizes the Webster Technique's role not as a breech turning technique, but a technique to balance the bony pelvis and soft tissue structures. It is our contention that trauma and the resultant mechanical deformation of the pelvis were related to a change in fetal position.

Chiropractic care to restore a normal physiological relationship within the pelvic bowl facilitated the fetus to regain the vertex position. While obviously important to every expecting mother, this may be especially important to a mother requesting a TOLAC, as it may address the original cause of her prior surgical delivery. Alcantara and Hamel[20] described the chiropractic care of a 29-year-old gravid female with complaints of low back pain. The patient had two surgical Caesarean deliveries for two previous births due to "failure to advance during labor and associated fetal distress." Similar to the case presented, this 29-year-old patient wanted to undergo a trial of chiropractic care to possibly enable her to have a natural childbirth. The patient was cared for primarily with the Webster Technique, employing a drop-piece mechanism for the sacral adjustments. The patient's low back complaints were ameliorated along with a successful vaginal birth.

Migraine Headaches

For the pregnant patient presenting for chiropractic care with headaches and migraines in particular, there is an urgent need to recognize the "red flags" that requires the need for urgent medical referral from those that are benign. It should be noted that there is an association between migraine and risk of vascular disease during pregnancy. In a systematic review of the literature by Wabnittz and Bushnell[21], the authors found an increased risk for gestational hypertension and preeclampsia among migraineurs (compared to nonmigraineurs) as well as thromboembolic events and increased risk of ischemic stroke, particularly with active migraine. We are aware of one study describing the chiropractic care of a pregnant patient with a primary complaint of migraine headaches. Alcantara and Cossette[22] presented a 24-year-old gravid female with chronic migraine headaches since age 12 years.

Previous unsuccessful care included osteopathy, physical therapy, massage and medication. Non-steroidal anti-inflammatory medication with codeine provided minor and temporary relief. Chiropractic care involving spinal manipulative therapy (SMT) and adjunctive therapies resulted in symptom improvement and independence from medication. The authors raised the possibility that chiropractic is a viable alternative to medication during pregnancy.

Borkhuis and Crowell[23] described the care of a 31-year-old female with a chief complaint of upper back and neck tension as well as tension and migraine headaches. The interest of the paper was that following one adjustment, the patient reported normal menstruation and following eight adjustments the patient reported she had conceived. The patient's headache complaints were also reported as abating.

Alcantara et al.[24] examined a stroke patient's preexisting conditions of pregnancy, migraine headaches and systemic lupus erythematosus as risk factors for stroke. The brothers Alcantara argued that the increased risks of vertebrobasilar artery (VBA) insufficiency or stroke associated with chiropractic care are more likely due to patients with headache and neck pain. The key to the attending chiropractor's decision tree in this case to adjust the patient was the "all-clear" signal based on imaging studies and from the neurologist's findings. According to the attending chiropractor, this case is a good example of when possible stroke symptoms are present but in reality may be related to the presence of spinal subluxations.

Hypothyroidism

The incidence of hypothyroidism in pregnant women has been estimated to be 0.3–0.7%.[25] The causes of hypothyroidism during pregnancy include Hashimoto disease, Post-thyroid ablation/removal, iodine deficiency, primary atrophic hypothyroidism, infiltrative disease (e.g., sarcoid, amyloidosis) and thyroid stimulating hormone-dependent hypothyroidism.[26-27] Autoimmune thyroid condition such as Hashimoto's thyroiditis and post-thyroid ablation therapy are the most common causes of hypothyroidism.[28] The clinical signs and symptoms of a patient with hypothyroidism include reports of having low energy, inappropriate weight gain for gestational age, constipation, goiter, cold intolerance, low pulse rate.[26]

Hypothyroidism (including subclinical hypothyroidism) may lead to obstetric and neonatal complications as well infertility. A number of studies within the last decade have underscored the critical importance of maintaining adequate fetal thyroid hormone levels during pregnancy to ensure normal central and peripheral nervous system maturation. Low maternal circulating thyroxine levels have been associated with a significant decrement in child IQ and development. In addition to risks for the fetus, hypothyroidism during pregnancy confers an increased risk for obstetrical complications such as intrauterine fetal death, gestational hypertension, placental abruption and poor perinatal outcomes.[29-31]

Hypothyroidism in pregnancy is treated with a larger dose of thyroxine compared to non-pregnant women. Commercially available thyroid dietary supplements are available.[32] However, keep in mind that the amounts of thyroid hormone in these easily accessible dietary supplements can potentially lead to iatrogenic thyrotoxicosis. Therefore, it is of the utmost importance to monitor the thyroxin levels of the patient during supplementation. During the postpartum period, thyroid dysfunction occurs in 50% of women found to have thyroid peroxidase antibodies in early pregnancy. The hypothyroid phase is symptomatic and also requires thyroxine therapy. A high incidence (i.e., 25-30% in those affected) of permanent hypothyroidism have been found in these women. Women with transient post-partum hypothyroidism should be monitored frequently, as there is a 50% chance of these patients developing hypothyroidism during the next 7 years.[33]

To the best of our knowledge, this is the first reporting of a pregnant patient presenting for chiropractic care with a comorbidity of hypothyroidism. A number of publications have addressed the topic of hypothyroidism but never in the context of pregnancy care.[34-43]

With respect to the patient's tachycardia, hemodynamic changes during pregnancy such as increased blood volume and cardiac output, decreased arterial blood pressure and decreased systemic vascular resistance have been observed along with an increase in maternal heart rate (tachycardia). Most of these changes are almost fully reversible and occurs within weeks and months after delivery.[44]

In closing, we caution the reader on the lack of generalizability the case reported. The lack of a control group, spontaneous remission, self-limiting course and natural history of the disorder, subjective validation, and expectations for clinical resolution on the part of the patient make cause and effect inferences difficult. Nonetheless, the purpose of this case report was to share the clinical experience of caring for a pregnant patient with a multiple symptom complex. Arguably, it is from such clinical observations that form the basis for generalizations in clinical practice.

Conclusion

We described the care of a pregnant patient presenting for care with multiple symptom complex in addition to successful VBAC. We described the patient's presenting co-morbidities as they are relevant to chiropractic care. We support further documentation in the chiropractic care of such patients in the interest of evidence-informed practice.

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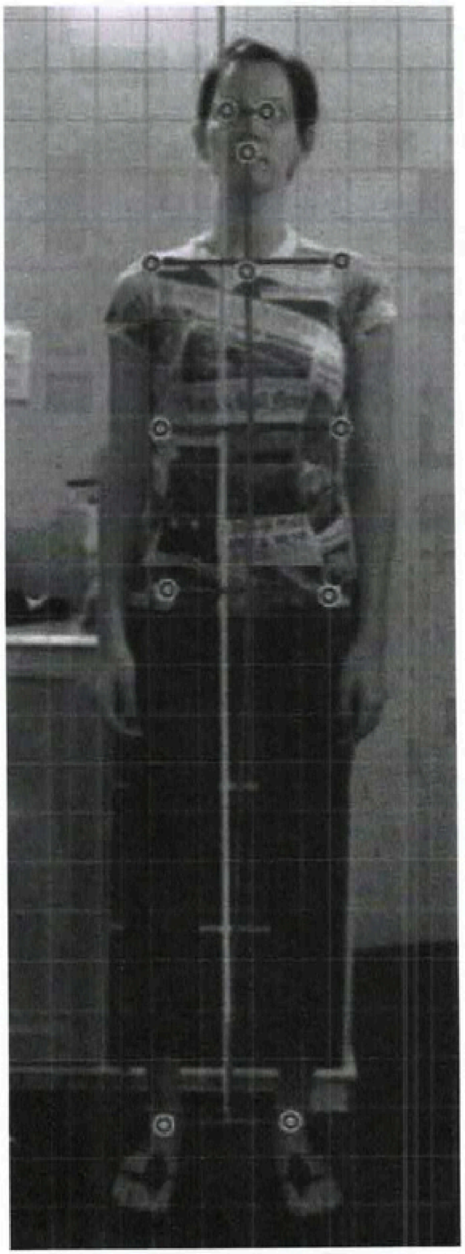

Figure 1A. Antetroposterior view of the patient's posture.

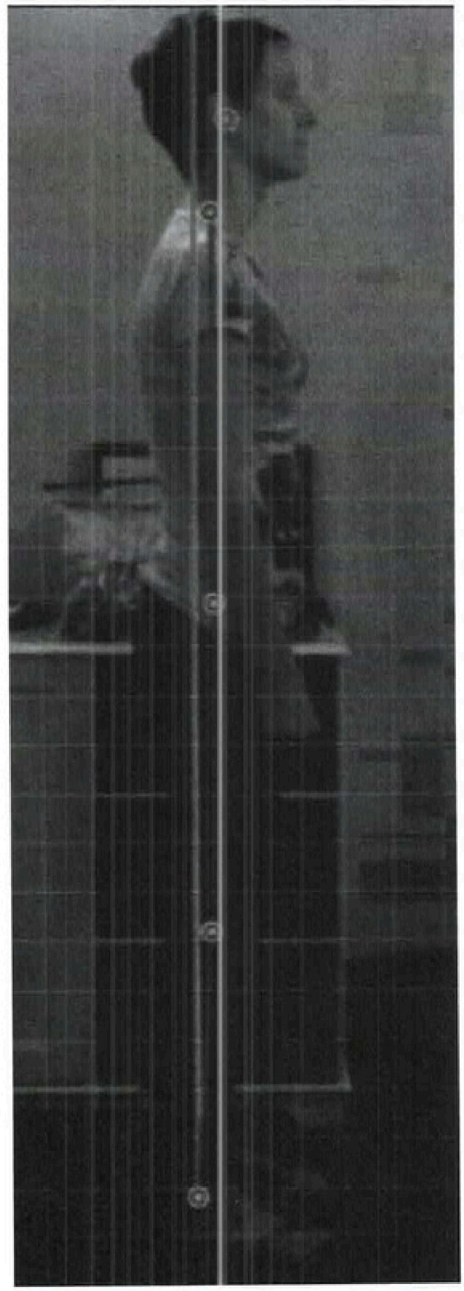

Figure 1B. Lateral view of the patient's posture.

Case Study

Resolution of Hypothyroidism & Irritable Bowel Syndrome in a 34-Year-Old Female Following Chiropractic Care to Reduce Vertebral Subluxation: A Case Study & Review of the Literature

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Abstract

Objective: To report on the case of a 34 year old female with secondary hypothyroidism and irritable bowel syndrome (IBS) experiencing improvement following chiropractic care.

Clinical Features: A 34-year-old female presented to a chiropractic office complaining of low back, hip, and upper back pain. She also reported that she was medically diagnosed with irritable bowel syndrome and secondary hypothyroidism.

Intervention and Outcome: Rolling paraspinal thermography was used to localize and quantify Dysautonomia secondary to subluxation. Torque Release Technique (TRT) was utilized to address areas of vertebral subluxation. After two months of care, the patient reported improvement in thyroid function determined by a thyroid function test and she was able to stop her medication. Additionally, the patient reported improvement in her irritable bowel syndrome, low back, hip and upper back pain.

Conclusion: This case study provides supporting evidence that chiropractic care may contribute to improvement in overall thyroid and gastrointestinal function. Additional research is advised to explore the benefits of chiropractic management in patients with hypothyroidism, IBS and dysautonomia.

Key Words: *Chiropractic, subluxation, vertebral subluxation, Torque Release Technique, TRT, hypothyroidism, secondary hypothyroidism, adjustment, irritable bowel syndrome, dysautonomia*

Introduction

The purpose of this paper is to report on the case of a 34 year old female with secondary hypothyroidism and irritable bowel syndrome experiencing improvement following chiropractic care. Hypothyroidism is a common endocrine disorder that is characterized by a deficiency in thyroid hormone.[1-3] In 2011, it was estimated that hypothyroidism affects approximately 10% of women and 6% of men under the age of 65 in the United States.[1] This is in comparison to the National Health and Nutrition Examination Survey (NHANES III) from 1999-2002, about 1 in 300 people, approximately 3.7% of the general population, are affected by hypothyroidism.[3-5] The prevalence of hypothyroidism is steadily increasing and remains a burden on the general population. It is found to be 2-8 times more common in women than men and has a higher incidence in Caucasian and Mexican-Americans compared to African Americans.[3]

Etiology

Hypothyroidism is classified as congenital or acquired and then categorized by primary or secondary types.[3] Primary hypothyroidism is defined as thyroid gland dysfunction.[1-3,6-8] This is characterized by increased levels of thyroid-stimulating hormone (TSH) and decreased levels of thyroid hormones T3 and T4.[1-3,6-8] Common causes of primary hypothyroidism are iodine deficiency, autoimmune disease also known as Hashimoto's Thyroiditis, surgical or radiation induced, or infection.[1,6] Secondary or central hypothyroidism is defined by dysfunction of the hypothalamus or anterior pituitary. This is characterized by low, normal, or mildly elevated TSH secretion and a decrease in thyroid hormones triiodothyronine (T3) and thyroxine (T4) production and secretion.[1-3,6-8] Common causes of secondary hypothyroidism includes pituitary or hypothalamus adenoma, as well as surgery and radiation used to treat the adenoma, gene mutation, and Sheehan Syndrome.[7,9]

Anatomy and Pathophysiology

The thyroid is a bilobulated gland that is found in the anterior portion of the neck and is situated anteriorly and around the trachea.[2,8] The thyroid gland consists of follicle cells that are filled with a secretory substance called colloid. Colloid contains thyroglobulin, a glycoprotein.[8] Thyroglobulin is involved in the synthesis and storage of thyroid hormones.[8] Thyroid hormones include tetraiodothyronine, also known as thyroxine or T4, and triiodothyronine, also known as T3. T3 and T4 play a major role in the metabolic rate of the body.[2,8] Additionally, the thyroid gland contains parafollicular cells, which secrete calcitonin. Calcitonin plays an important role in regulating plasma calcium levels.[2]

Synthesis of thyroid hormones is a complex mechanism of chemical reactions.[2,8] Production is largely dependent on the ingestion of iodine. It is suggested that 50 milligrams of iodine should be ingested per year.[2] To prevent iodine deficiency, the United States has fortified common table salt with sodium iodide.[2,3,8] The first step in production of thyroid hormones is called "iodide trapping."[2] This is the process of taking iodide from the blood into the follicular cells via an active pump mechanism. Through a series of chemical reactions, hormones T3 and T4 are formed.[2] The thyroid gland has the ability to synthesize and store molecules of T3 and T4.[2,8] It is estimated that 93% of active thyroid hormone secreted by the thyroid gland is in the form of T4.[2] The majority of T4 is converted into T3 once it reaches the target tissue such as the liver, kidneys, pituitary gland, various centers of the brain, and the thyroid gland itself.[8] T3 is four times more potent than T4, therefore it is found in lower quantities in the plasma in comparison to its target tissue.[2,8] Thyroid hormones are transported through the blood while bound to plasma proteins. Approximately 99% of thyroid hormone is bound to thyroxine-binding globulin (TBG), thyroxine-binding albumin (TBA), and thyroxine-binding prealbumin (TBPA). 1% of thyroid hormones are free, unbound hormone that is biologically active.[8]

Neuroendocrine regulation of the thyroid gland is controlled via the hypothalamic-pituitary-thyroid (HPT) axis.[2,8] Three structures regulate the production and secretion of thyroid hormones—the hypothalamus, the anterior pituitary, and the thyroid gland.[2,8] The hypothalamus secretes a hormone called thyrotrophin-releasing hormone (TRH). TRH is secreted by nerve endings from the hypothalamus and transported to the anterior pituitary via the hypothalamic-hypophysial portal system.[2] TRH then stimulates the anterior pituitary to secrete thyroid-stimulating hormone (TSH).[2,8] TSH therefore stimulates the thyroid gland to produce and secrete thyroid hormones in the form of T3 and T4. Regulation of thyroid hormone production is by a negative feedback mechanism where secretion of T3 and T4 inhibit the production of TSH and TRH (see figure 1).[2,8]

Thyroid hormones have an array of effects on the body. The main effect is to increase basal metabolic rate. This includes an increase in carbohydrate metabolism and synthesis, protein synthesis, and degradation of lipids.[2,8] In addition, thyroid hormones are necessary for myelination of nerve fibers and central nervous system (CNS) development, increased number and activity of mitochondria, assist in skeletal growth and normal muscle function. As a result of thyroid hormones control on metabolism, cardiac output, heart rate, blood flow, and respiration are also affected. Gastrointestinal mobility, sleep, sexual function, and control of other endocrine organs are all dependent on thyroid hormone production.[2,8]

Due to the extensive effects thyroid hormones have on basal metabolic rate, a hypoactive thyroid gland can produce a wide variety of symptoms. The thyroid gland can store T3 and T4 for up to four months creating a slow onset of signs and symptoms.[8] There is a decrease in heart rate, respiration rate, blood volume, and body temperature. Cold intolerance and decreased perspiration is often noted, as well as weight gain.[2,3,8] There is decreased neuronal function causing symptoms such as fatigue and loss of energy, inability to concentrate, forgetfulness, hyporeflexia, muscle fatigue, weakness, and joint pain.[3,8] Many people sleep on average for twelve to fourteen hours a day and begin to develop signs of depression.[2] There may be puffiness in the face, dry skin and hair loss. A hallmark trait of hypothyroidism is myxedema. Myxedema is a form of edema due to an accumulation of proteins, polysaccharides, and hyaluronic acid from decreased metabolism.[3,8] Hashimoto's Thyroiditis, a form of primary hypothyroidism, often has symptoms of fullness in the throat and deepening of the voice due to hyperplasia of the thyroid gland.[2,3] Hypoactivity of the thyroid gland also affects the functioning of other endocrine organs. Hypothyroidism can cause male and female infertility, menorrhagia or irregular menstrual cycles.[2,3,8]

Primary hypothyroidism is more common than secondary hypothyroidism.[2,3,7] There are two main causes of primary hypothyroidism. Worldwide, the most common cause of primary hypothyroidism is iodine deficiency.[2] Inadequate intake of iodine prevents the production of T3 and T4 by the thyroid gland. Consequently, the anterior pituitary continues to produce high levels of TSH. TSH stimulates the production of thyroglobulin in the follicular cells of the thyroid but without iodine, T3 and T4 cannot be synthesized.[2,8] In addition, there is no negative feedback cycle elicited from T3 and T4 on TSH production. The follicular cells continue to grow bigger due to over production of thyroglobulin, which in turn causes the thyroid gland to enlarge.[2,8] Enlargement of the thyroid gland is called a goiter and can grow ten to twenty times its normal size.[2]

An article by Vanderpump states that in areas of severe iodine deficiency such as South-East Asia, Latin America, and Central Africa, the prevalence of a goiter is 80%.[10] According to the Merck Manual, in areas with adequate iodine intake, the most common cause of primary hypothyroidism is autoimmune thyroiditis, also known as Hashimoto's Thyroiditis.[1] Hashimoto's thyroiditis is caused by a cell-mediated immune response that destroys the follicular cells of the thyroid.[2,8] Another possible mechanism results from the production of antithyroid antibodies that block the TSH receptor on the thyroid.[8] Vanderpump states that post-mortem studies of people with hypothyroidism showed 27% of women and 7% of men with signs of Hashimoto's Thyroiditis.[10]

Secondary hypothyroidism is a characterized by a defect in thyroid hormone production due to insufficient stimulation by TSH.[11-13,9] A pituitary ademona is the most common cause of secondary hypothyroidism.[9,13] The adenoma mechanically compresses the portal vessels of the pituitary stalk of the pituitary gland. This can result in ischemic necrosis of the anterior pituitary.[9,13] In this case, the anterior pituitary does not secrete a sufficient amount of TSH and therefore does not stimulate the thyroid gland to secrete T3 and T4. The adenoma can also create increased intrasellar pressure leading to compression of the portal veins of the pituitary, impairing the delivery of TRH from the hypothalamus.[9] Another proposed mechanism depicts a defect in the "secreted TSH isoforms that conserve immunoreactivity but display a severe impairment in intrinsic bioactivity and ability to stimulate the TSH receptors."[11] Glycosylation plays an important role in altering the biologic activity of molecules. An error in glycosylation of TSH results in varied forms of bioactivity of TSH.[11] The secretion of bioinactive TSH affects the hypothalamic function, which leads to normal or slightly elevated TSH levels upon testing.[11]

Diagnosis

Diagnosis of hypothyroidism is based on a thorough history, clinical findings and laboratory analysis.[14] If hypothyroidism is suspected, initial plasma screening is used to perform a third-generation TSH assay and thyroid function test.[3,15] The accepted reference range for normal TSH levels is 0.4-4.2 mIU/L.[3] The accepted reference range for free T4 is 10.0-21.0 pmol/L, and the normal range for free T3 is 2.2-5.3 pmol/L.[16] The American Thyroid Association states that free T4 analysis is important in determining overall thyroid function while free T3 is important in determining hyperthyroidism.[17] Plasma T4 is found in larger quantities and is eventually converted to T3 in the target tissue.[8] In the instance of primary hypothyroidism, TSH levels are elevated while there are low levels of T4. TSH levels are often found to be above 10 mIU/L in primary hypothyroidism.[5,15,17,18] In the case of secondary hypothyroidism, low TSH, free T3, and free T4 levels are observed. [5,15,17,18] This represents dysfunction of the pituitary gland, preventing adequate TSH secretion. Inadequate TSH secretion then creates inadequate T3 and T4 secretion from an otherwise normally functioning thyroid gland.[18]

Medical Treatment

The treatment for hypothyroidism follows a biomedical approach in which the gold standard treatment is supplementation of once daily synthetic thyroxine (T4).[5,15,18] The most common supplementation is with Levothyroxine for an indefinite period of time.[18] The goal is to improve the function of the patient and to restore appropriate TSH and T4 levels. However, there is evidence to suggest that this is an inadequate form of treatment. Saravanan, Chau, Roberts, Vedhara, Greenwood, and Dayan state that there are many people suffering from hypothyroidism that continue to experience symptoms despite synthetic thyroxine treatment.[19]

Case Report

Patient History

A 34-year-old female presented to a chiropractic office with chief complaints of low back and hip pain and additional an complaint of upper back pain. At the time of presentation, the patient reported that she was twenty-two weeks pregnant. The low back and hip pain started three months prior to seeking chiropractic care. When asked to locate her pain, the patient pointed to the midline of L2-S1 and described the pain shooting into her left leg. The patient self-managed the pain with aspirin and did not seek previous care for her complaints.

The patient's history included self-diagnosed chronic sinusitis, irritable bowel syndrome medically diagnosed in 2013, and secondary hypothyroidism medically diagnosed in 2014. The patient was prescribed Nature-Throid by her medical doctor in 2014. The patient stated that she exhibited symptoms such as fatigue, weight gain, dry skin, sleepiness, and constipation, which lead her to seek medical treatment. Her medical doctor performed a thyroid function test and diagnosed her with secondary hypothyroidism.

Areas of stress were also identified. The patient's job was a major area of stress due to excessive sitting and a busy schedule. At the time of the initial visit the patient was twenty-two weeks pregnant, which added additional physical, mental, and emotional stress.

Examination

Observations in the patient's posture revealed anterior head translation, superior elevation of the right shoulder and superior elevation of the left iliac crest. Cervical active range of motion revealed a decrease in right rotation without pain. All other cervical ranges of motion, both passive and active, were painless and within normal limits. Lumbar range of motion revealed a decrease in flexion and the patient verbally rated pain as 3/10 on a pain scale of 0-10. All other active and passive lumbar ranges of motion were painless and within normal limits.

Static palpatory findings revealed taut muscle fibers at C1, along the thoracic and lumbar paraspinal musculature, sacrum, and the left sacroiliac joint. Upon palpation, tenderness was noted at C1, T1-T2, T8, and L5 vertebral segments. Using motion palpation technique, a decreased end range of motion was felt at C1, T1, T2, T8, L5, and left sacroiliac joint.

At the time of initial visit, the patient was pregnant and no radiographs were taken. Four months after care and delivery of the baby, a cervical radiograph series was taken and revealed a kyphotic cervical curvature and a posterior ponticle. A lumbar radiograph series was also taken and revealed slight hyperlordosis in the lumbar curvature.

Rolling paraspinal thermography was utilized in the evaluation of the patient's nervous system. Thermography readings compare skin temperature variations relating to localization of blood flow.[20] Abnormal thermography readings directly correlate with dysfunction in the neuromusculoskeletal system in the form of dysautonomia.[20] In a healthy patient, the autonomic nervous system effectively controls temperature regulation through dilation and constriction of blood vessels. These changes of temperature within the body occur as the autonomic nervous system works with the circulatory system to dilate and constrict the blood vessels to keep the surface temperature within a manageable range.[20] When vertebral subluxations are present, the normally symmetrical temperature gradients develop an asymmetrical pattern.[20] rolling thermography is used to determine the amount of dysautonomia, the ability of the patient to adapt to the environment, and the response of the patient to the adjustment.[20,21] Rolling thermography is a reliable tool to assess the function of the autonomic nervous system and is shown to have excellent intra-examinar and inter-examiner reproducibility.[22-24]

At the initial visit, the patient's thermography scan was determined invalid due to the patient having just had coffee and taken medication. A new scan was taken seven days later and demonstrated a severe heat abnormality at C2 and mild heat abnormalities at T11 and T12. See figure 2A.

The Quadruple Visual Analog Scale (QVAS) was used as a subjective indicator to record and measure the progress of pain. The score is averaged to determine the percentage of pain the patient is in. The score is categorized into low intensity (pain <50) and high intensity (pain >50).[25] The patient's QVAS score on the initial visit was 43%.

According to physical exam findings and assessment of the rolling thermography scan, subluxations were found in the cervical, thoracic, lumbar spine, and pelvis. Reassessments were given after one, two, four, and eight months of care. A health questionnaire, QVAS, and thermography were used to monitor progress.

Interventions and Outcomes

Over the course of eight months, the patient was adjusted forty-eight times utilizing Torque Release Technique (TRT) with adjustments administered with the Integrator instrument. On the first visit, C1, T1, and sacrum were adjusted. Each visit two-three segments were adjusted. In particular, C1 was the most commonly adjusted segment; other commonly adjusted segments included C5, T1, L5, and sacrum. The segments that were adjusted varied based upon indicators of subluxation discussed below.

TRT utilizes a neurological non-linear tonal model to identify indicators of primary vertebral subluxations and classifies subluxations into testing priorities.[26] It was developed by Jay Holder, D.C from a randomized clinical trial conducted in Miami, FL. The clinical trial was designed to measure the outcomes of subluxation-based chiropractic on the quality of life.[27]

TRT uses the Integrator instrument to deliver a specific chiropractic adjustment. The Integrator was designed for Holder's clinical trial to "ensure consistency and reproducibility in the application of delivering the chiropractic adjustment and to measure its outcome" in the study.[28] The Integrator is designed to simulate a Toggle Recoil adjustment and "fires at the speed of 1/10,000 of a second while providing a three-dimensional impulse using straight axial, right or left torque."[26] There is a cocking mechanism that allows the practitioner to pre-load the instrument with a pre-determined force. Holder states he designed a "pressure sensitive pisiform tip with an automatic release mechanism for the purpose of delivering thrusts with true intraprofessional reproducibility at a constant Hertz frequency."[28] Additionally, the Integrator "is the first chiropractic adjusting instrument to receive an FDA 510K Class II medical device designation for the adjustment of vertebral subluxation."[26-28] It is the only instrument that is capable of delivering a three dimensional adjustment that fires independent of the practitioner.[26]

TRT is a non-linear tonal model that is organized according to the cranio-sacral meningeal functional unit (C-SMFU). The C-SMFU consists of "the brain, spinal cord, multilayered meningeal sheath, bones of the cranium, vertebral column, and pelvis" as they all function as one unit.[26] TRT uses fifteen indicators of subluxation in order to detect a primary subluxation. The indicators include: static, tissue, intersegmental and motion palpation, functional leg length reflex (FLLR), abductor tendency/adductor resistance, foot flare, foot supination/pronation, heel tension, abnormal breathing patterns, inappropriate sustained patterns of paraspinal contractions, congestive tissue tone, postural faults, Cervical Syndrome Test, Wrong-Un test, Bilateral Cervical Syndrome, Derifield test, and abnormal heat and energy radiation from the body.[26] Table 1 lists each indicator and what that indicator means.

TRT uses a functional leg length reflex (FLLR) and pressure tests in order to find the primary subluxation. While the patient is in the prone position, an abrupt bilateral foot dorsiflexion is used to generate a bilateral deep tendon Achilles reflex. This is used to analyze functional leg length inequality.[26,27,29,30] When testing leg length inequality with an FLLR, Nadler states that "an improvement in leg length is not sufficient, and actual leg length balancing (evening) is necessary for confirmation. In other words, improvement in leg length is meaningless; only complete leg length evening is acceptable."[29] Prone leg length analysis has shown good inter-examiner reliability upon testing and is used to analyze the condition of the nervous system.[31-33] In addition to the FLLR, pressure testing was utilized. Skin contact is made with the distal tuft of a phalange to the spinal segment of interest. Each pressure test applies a specific vector and torque on the spinal segment of interest in order to determine the line of correction.[26] The pressure test is used to "temporarily reflex the dynamic dyskinesia or dysponesis of the subluxation's line of correction."[27] The adjustment is then administered with the Integrator.

Primary subluxations are grouped into eight non-linear testing priorities in order for efficient analysis and is reference in table 2.[26] Holder recognizes there are two categories of vertebral subluxation: spinal cord pressure and spinal cord tension.[26] As described in R.W. Stephenson's Chiropractic

Textbook, spinal cord tension is a major component of vertebral subluxation.[34] Holder argues that spinal cord tension is the most severe category of vertebral subluxation. Tensile forces on the spinal cord from the dura mater affect the neuroskeleton as a whole and therefore have the greatest insult on the system.[30] Areas of direct dural attachment to bone are the sphenoid, occiput located at the foramen magnum, C2, C5, S2, S3, S4, and coccyx.[26] Holder states that these areas of direct dural attachment are the most commonly subluxated.[26] The protocol states that there can only be one appropriate primary vertebral subluxation present at any given moment. In addition, there may be up to nine secondary or tertiary vertebral subluxations.[26] Adjusting one primary vertebral subluxation can therefore clear up to ten potential subluxations. Due to this principle, "one, two, but never more than three segments" are adjusted per visit and there are never more than three adjustments given in the same order per segment.[26]

The patient remained compliant with the recommended care plan and received regular reassessments. After two months of care, the patient reported much improvement in all of her complaints including irritable bowel syndrome. Her QVAS score reduced to 38% and her thermography scans demonstrated that she was responding to the adjustments. It was at this time that the patient reported she had just seen her medical doctor for a yearly physical and a follow up thyroid function test was performed. Her TSH and T4 levels were in the normal range and her T3 levels were found to be elevated. Her medical doctor stated that her "thyroid is over-replaced" and took her off Nature-Throid. Table 3 depicts the patient's thyroid function tests before and after chiropractic care. After eight months of care the patient's paraspinal thermography demonstrated moderate heat abnormality at T1 and a mild heat abnormality at T2 with the rest of the scan being clear. (See figure 2B).

Discussion

Chiropractic Literature

Hypothyroidism is a frequently encountered clinical condition and is historically medically treated. A thorough review of chiropractic literature regarding hypothyroidism revealed sparse results. These searches resulted in eight peer-reviewed articles and are discussed below. However, of the eight articles, only three discussed chiropractic management of hypothyroidism.

Bablis and Pollard have published two articles depicting two case series discussing the chiropractic management of hypothyroidism using Neuroemotional technique (NET). In 2004, Bablis and Pollard depicted two females diagnosed with hypothyroidism.[16] According to Bablis and Pollard, the normal range for free T4 is 10.0-21.0 pmol/L, normal range for free T3 is 2.2-5.3 pmol/L, and normal TSH is 0.30-4.00 mIU/L.[16] A 45-year-old Caucasian female reported low free T4 of 11.6 pmol/L, free T3 of 2.2 pmol/L, and low TSH level of 0.07 mIU/L shortly after starting chiropractic care. After six months of chiropractic care utilizing NET, the patient reported an increase in her free T4 level to 14.8 pmol/L and TSH level to 0.33 mIU/L.[16] The second case, a 30-year-old Caucasian female, started under chiropractic care for nervousness and depression. She was later diagnosed with primary hypothyroidism and demonstrated an elevated TSH level of 8.1 mU/L. The patient received one treatment using NET and a follow up thyroid function test, which showed a drastic decrease in TSH to 3.7 mU/L. Another follow up test was performed seven months later and showed the patient's TSH level lowered again to 3.0 mU/L.[16]

In 2009, Bablis and Pollard depicts different two females diagnosed with hypothyroidism.[35] A 41-year-old Caucasian female reported an elevated TSH level of 13.99mU/L and low free T4 levels of 8pmol/L and was diagnosed with primary hypothyroidism. The patient received chiropractic care utilizing NET for eight weeks. A follow up thyroid function test demonstrated a decrease in TSH to 5.81 mIU/L and an increase in free T4 to 12 pmol/L. With this improvement, the patient discontinued the use of her thyroid medication.[35]

The last case report from Bablis and Pollard depicts a 27-year-old Caucasian female who presented with a previously diagnosed hypothyroid condition. Her initial thyroid function test showed an elevated TSH level of 14.8 mIU/L which is consistent with hypothyroidism. After chiropractic care utilizing NET for two months, the patient received a follow up thyroid function test and it was determined her TSH level was 3.58 mIU/L and was in the normal range. A long term follow up with the patient reported discontinued use of thyroid medication and maintained improvement of thyroid function.[35]

In 2010, Brown, Graham, Bonello, and Pollard discussed a protocol for a pilot study to assess the chiropractic management of primary hypothyroidism utilizing NET.[36] They proposed a placebo-controlled, single blinded, randomized clinical pilot trial of 102 participants. These participants had to be over the age of 18, previously diagnosed with primary hypothyroidism, and on a stable dose of thyroid medication for six months prior to entering the trial. The treatment group would receive ten NET treatments over a six-week period. The placebo group would receive the NET protocol but would not receive the therapeutic components of the NET procedure. Both groups would be assessed at seven weeks and six months utilizing a depression questionnaire, thyroid function blood testing, SF-36 questionnaire, resting heart rate and temperature measurements.[36] In 2015, Brown, Graham, Bonello, and Pollard published the results of this trial.[37] Overall there were forty-four participants receiving NET and forty-six participants receiving the placebo. The conclusion of the study was found to show no clinical benefit in the management of primary hypothyroidism utilizing NET.[37]

Bak and Engelhardt discuss a case on improvement of hypothyroidism under chiropractic care.[38] The patient was medically diagnosed with Hashimoto's Thyroiditis after a thyroid function test indicated elevated TSH four years prior to seeking chiropractic care. After one month of chiropractic care utilizing Chiropractic Biophysics (CPB), the patient received a follow up thyroid function tests and it demonstrated her TSH level dropped into the hyperthyroid range. The patient was ordered by her medical doctor to decrease her thyroid medication as she demonstrated an improvement in thyroid function.[38]

Jacobs, Franks, and Gilman provided evidence on the use of

Applied Kinesiology (AK) in the diagnosis of hypothyroidism.[39] The article explained the mechanism behind AK testing and how it was used in conjunction with laboratory ratings to determine thyroid dysfunction. Jacobs, Franks, and Gilman clearly state that AK can be used as a screening protocol and not for the treatment or diagnosis of thyroid dysfunction.[39]

Echeveste reported a case on chiropractic care of a 9-year-old female diagnosed with Diabetes Mellitus Type 1 and hypothyroidism utilizing Diversified Technique.[40] Echeveste reported there was stabilization in the patient's glucose levels and there was an improvement in hypothyroidism symptomatology.[40] However, Echeveste failed to objectively report the overall thyroid function or if thyroid medication was discontinued.

Edwards and Alcantara performed a case study of a 28-year-old pregnant female who presented with migraine headaches, hypothyroidism and tachycardia.[41] The case focused visual field disturbances and chiropractic care during pregnancy. Edwards and Alcantara failed to discuss overall thyroid function of the patient and chiropractic management of hypothyroidism.[41]

Subluxation Model

Chiropractic literature describes multiple theories that demonstrate how nervous system dysfunction caused by malposition of vertebrae can affect somatic and visceral structures.[42] This phenomenon is termed *vertebral subluxation* and is the foundation of chiropractic theory and practice. In order to understand the mechanisms of this case, an examination of how vertebral subluxation affects proper visceral function, specifically the HPT axis will be discussed. According to the dysafferentation model of subluxation, proper input to the central nervous system (CNS) is needed proper nervous system function.[42] Kent states, "aberrant afferent input into the CNS may lead to dysponesis" resulting in inadequate efferent response to the body and consequently to visceral function.[42] The intervertebral motion segment is richly surrounded by nociceptors and mechanoreceptors. There is extensive nerve supply to the entire vertebral column. Specifically in the cervical spine, the sinuvertebral nerve supplies the intervertebral disc at the segment of entry and the segment above.[42,43] An article by McLain states, "the presence of mechanoreceptive and nociceptive nerve endings in cervical facet capsules proves that these tissues are monitored by the central nervous system and implies that neural input from the facets is important to proprioception and pain sensation in the cervical spine."[42,44] Therefore, biomechanical dysfunction such as hypomobility of the affected segments can alter mechanoreception and nociception. It is understood that decreased mechanoreception can cause an increase in nociception.[42,45] In addition, it is also proposed that altered mechanoreption elicits a physiological reflex activation which causes altered autonomic nervous system function and general peripheral nervous system dysfunction.[40,46,47]

Stress and increased nociception is shown to elicit a neuroendocrine response.[45-49] Bablis presents a proposed mechanism of how prolonged stress affects the neuroendocrine system including thyroid function.[35] Increased levels of epinephrine have been shown to elicit autonomic and neuroendocrine responses to stress. This includes the activation of the hypothalamic-pituitary-adrenal (HPA) axis.[35] The hypothalamus releases corticotrophin-releasing hormone (CRH), a neurotransmitter found in stress response.[50] CRH then stimulates the release of adrenocorticotropin (ACTH) from the pituitary and in turn, ACTH stimulates the release of cortisol from the adrenal cortex.[50] Through Bablis' research, ACTH, cortisol, and epinephrine are common indicators of prolonged stress.[35] An article by O'Connor, O'Halloran, and Shanahan states that prolonged stress causes a decrease in TRH release from the hypothalamus resulting in a decrease anterior pituitary release of TSH, and therefore inhibition the release of T3 and T4 from the thyroid gland.[51] Bablis also noted that inhibition of the HPT axis during prolonged stress can be mediated by the chronic release of CRH, somatostatin, and cytokines.[35] In conjunction of a chronic C1 subluxation and prolonged stress exhibited by the patient, it is proposed that autonomic nervous system dysfunction triggered dysfunction in the neuroendocrine system. The chiropractic adjustment is understood to restore proper motion and reestablish the normal balance between nociception and mechanoreception.[40,42,45] In addition, a cervical adjustment elicits a parasympathetic response from the autonomic nervous system and "in turn helps rectify HPA axis dysfunction" and thereby HPT axis dysfunction.[52]

Limitations

The limitations of this study include the outside effects, mainly the biomedical intervention, on the reduction of symptomatology. It is difficult to differentiate which treatment, chiropractic care or medical intervention, was responsible for improving the function of the pituitary and thyroid gland. Another area of limitation was the medical diagnosis of secondary hypothyroidism. The cause of pituitary dysfunction was not explored. It was stated only by the evaluation of the patient's thyroid function tests that she had secondary hypothyroidism.

Conclusion

Chiropractic is an art, science, and philosophy that is created on the vitalistic premise that the human body is a self-healing and self-regulating organism and observes that the cause of disease is from inside the body.[53] D.D. Palmer, the discoverer of chiropractic stated that living organisms are born with an innate intelligence that runs through the nervous system and allows the body to heal itself when given the right conditions. Interference with the nervous system would affect one's ability to heal and adapt to the environment, resulting in disease. This interference is termed "vertebral subluxation".[42,53,54]

This case presented a 34-year-old female diagnosed with secondary hypothyroidism, irritable bowel syndrome and neuromusculoskeletal complaints. Upon examination, the patient showed signs of nervous system dysfunction and vertebral subluxations. After two months of TRT care, the patient reported improvement in thyroid function determined by a thyroid function test and improvements in IBS and her back pain. This improvement caused her medical doctor to take her off of prescription thyroid medication. The evidence gathered from this case study suggests that chiropractic care may contribute to improvement in overall thyroid and gastrointestinal function through improvement in dysautonomia.

Additional research is needed to explore the benefits of chiropractic management in these types of cases. This is the first study to use TRT in the management of a patient with hypothyroidism and IBS. Future research should implement additional objective data in order to investigate the effects of chiropractic care on nervous system function. At a minimum, each study should provide specific, objective, and measurable data about the patient's nervous system and subluxations. Examples of this would include, but not limited to, rolling thermography, sEMG, and x-ray analysis. It is also crucial that plasma analysis of TSH and thyroid hormones is used to demonstrate thyroid function before and after chiropractic management.

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Tables

Indicator	Explanation
Palpation	Performed by hand using scanning palpation, tissue palpation, inter-segmental palpation, and motion palpation
Functional Leg Length Inequality	An Achilles deep tendon reflex is performed in order to view functional leg length and determine a differential diagnosis for the primary subluxation.
Abduction tendency / adductor resistance	If abductor tendency or adductor resistance is noted in the patient's legs while lying prone on the table this indicates a C2 subluxation on the side of resistance.
Foot flare	If inversion or eversion of the feet is noted while the patient lies prone on the table, this indicates a subluxation at a level of direct dural attachment.
Foot supination/pronation	If pronation or supination of the feet is noted while the patient lies prone on the table this indicates a subluxation at a level of direct dural attachment.
Heel tension	If unequal tension of the Achilles tendon is noted, this indicates a primary subluxation at a level of direct dural attachment.
Abnormal breathing patterns	This indicates compartmentalized breathing.
Inappropriate sustained patterns of paraspinal contractions	Performed by scanning by hand or an EMG and indicates the cause of the primary subluxation is likely mental or emotional.
Congestive tissue tone	Performed by tissue palpation of the anterior neck muscles and posterior kidney areas. This indicates the likely cause of the subluxation is chemical.
Postural faults	Abnormal postural positions are noted while standing, sitting, and laying prone.
Cervical Syndrome Test	The patient turns his/her head to the long leg side. If the legs balance, this indicates a posterior rotation of C1 or C5 with or without laterality subluxation.
Wrong-Un Test	The patient turns his/her head to the short leg side. If the legs balance, this indicates a lateral C1 subluxation.
Bilateral Cervical Syndrome Test	The patient turns his/her head to both sides and the leg length switches back and forth. This indicates a possible PI listing of the one following segments: Occiput, coccyx, C5, C1, and T6, or a lateral C1.
Derifield Test	A short leg in the prone extended position becomes the long leg in the 90 degree prone flexed position. This indicates one of following possible subluxations: AI sacral base, AS trochanter, PI ilium, or superior pubic rami.
Abnormal heat/energy radiation from the body	Performed by rolling thermography.

Table 1. 15 Indicators of Dis-ease and Subluxation Utilized in Torque Release Technique[26]

Priority	Possible Subluxation
1	Lateral occiput or lateral sacrum +/- *torque* Coccyx with sphenoid (compass vectors) *no torque*
2	**Cervical Syndrome Test:** C1 posterior rotated +/- *torque* **Wrong-Un Test:** C1 lateral +/- *torque* **Bilateral Cervical Syndrome Test:** Occiput posterior inferior +/- *torque* Coccyx posterior inferior with sphenoid *no torque* C5 posterior inferior +/- *torque* C1 posterior inferior +/- *torque* T6 posterior inferior +/- *torque* C1 lateral +/- *torque*
3	**Derifield Test:** AI sacral base *no torque* AS trochanter *no torque* PI ilium *no torque* Superior pubic rami *no torque*
4	C2 (C3) +/- *torque*
5	C7 +/- *torque*
6	L3 +/- *torque*
7	L5 +/- *torque*
8	Any other segment +/- *torque*

Table 2. Non-Linear Testing Priorities Utilized in Torque Release Technique[26]

	TSH	Total T4	Total T3
Normal Range	0.4-4.2 mIU/L	4.5-12.0 ug/dL	71-180 ng/dL
Pre-Chiropractic	2.30 mIU/L	6.2 mcg/dL	107 ng/dL
Post-Chiropractic	1.86 mIU/L	6.1 ug/dL	197 ng/dL

Table 3. Pre and Post Chiropractic Adjustment Thyroid Test Results

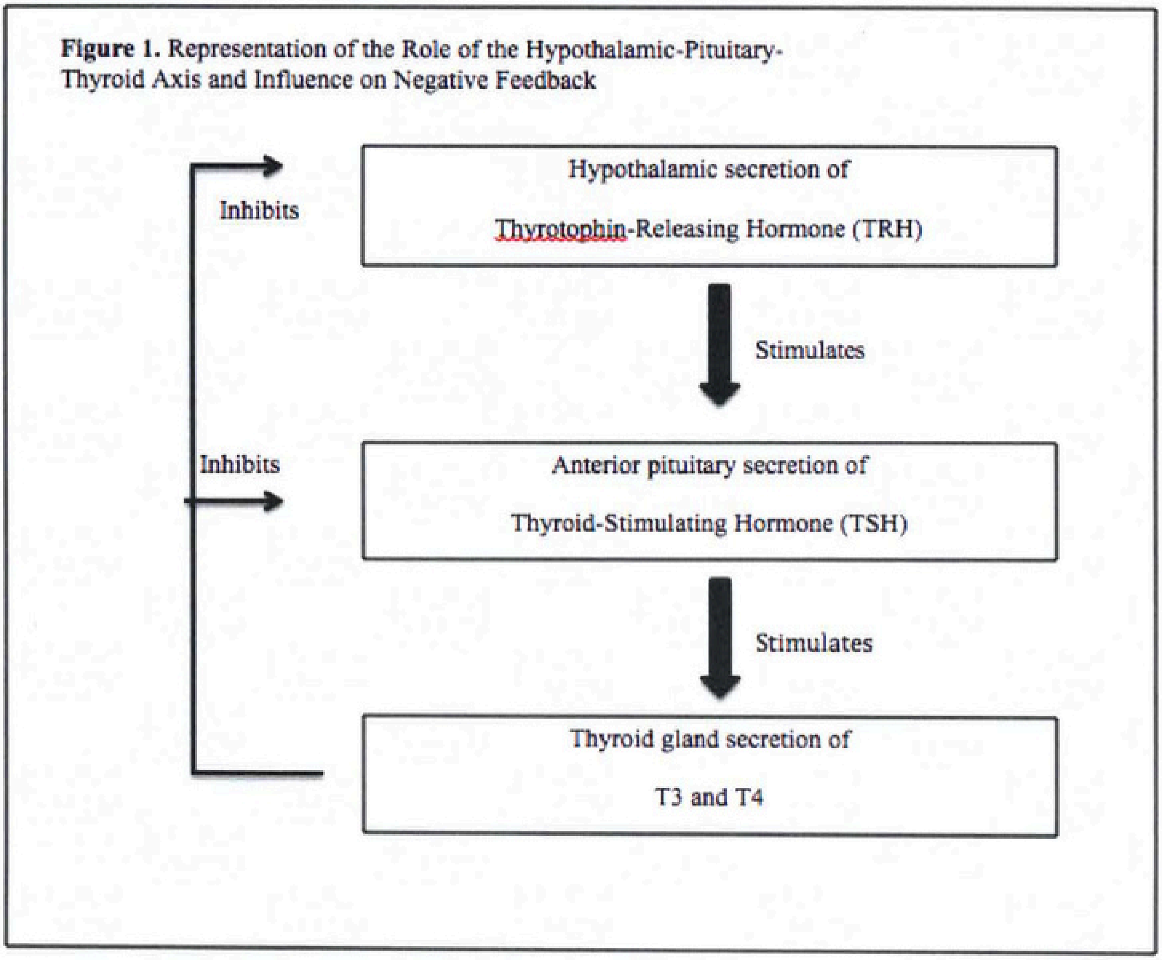

Figure 1. Representation of the Role of the Hypothalamic-Pituitary-Thyroid Axis and Influence on Negative Feedback Diagram courtesy of Kathleen Delander 2016. Used with permission

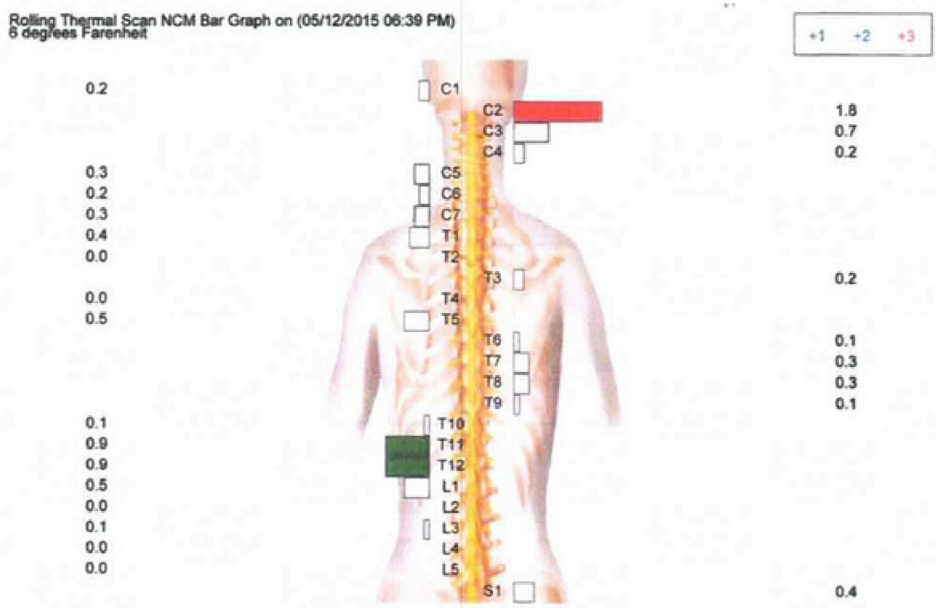

Figure 2A. Rolling Paraspinal Thermography Scan: Initial Visit

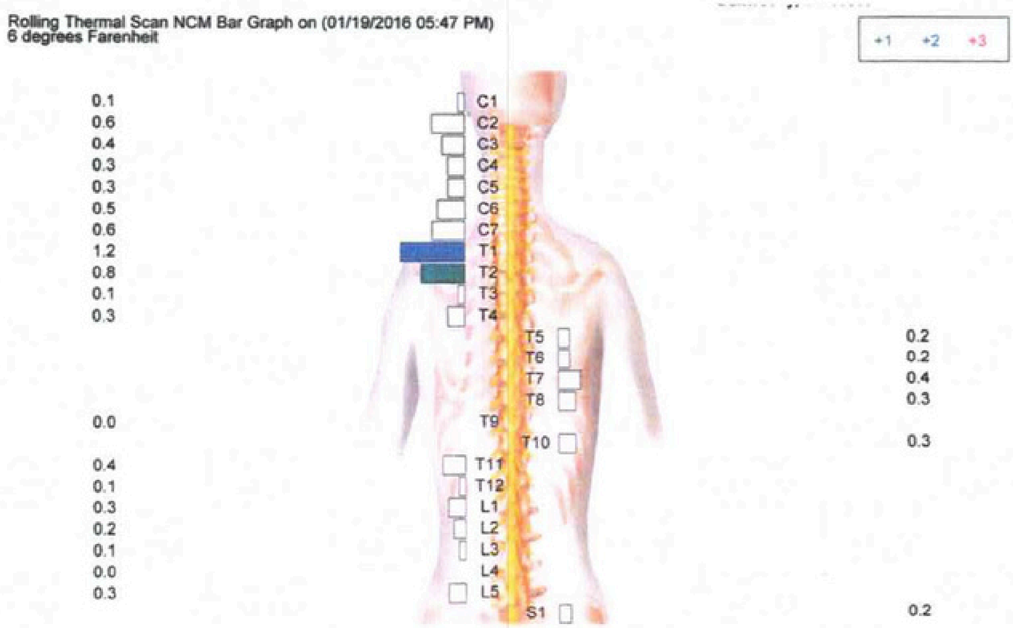

Figure 2B. Rolling Paraspinal Thermography Scan: Eight-Month Re-evaluation