CASE STUDY

The Clinical Application of Differential Compliance Methodology to Joint Fixation Identification and Resolution Using the PulStarFRAS™

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Abstract — This paper describes a single subject case study designed to evaluate the clinical usefulness of Differential Compliance Methodology employing the PulStarFRAS instrumentation. The results of the study illustrate the effectiveness of multiple impulse percussive force application in the release of fixations of spinal joints, where fixations were identified by compliance readings obtained with the PulStarFRAS. Over a progression of three weeks, the patient experienced a change in cervical curvature from a radius of 150 cm to 15 cm, as well as resolution of presenting symptoms. Moreover, a restoration of normal cervical hard tissue compliance was recorded. Based on the results of the study, Differential Compliance Methodology including multiple impulse force application using the PulStarFRAS can be considered to have been an effective intervention in the care of the patient studied, who exhibited signs of spinal fixation with accompanying musculoskeletal dysfunction and other symptoms.

Key words: Differential Compliance Methodology, PulStarFRAS, tissue compliance, joint fixation, musculoskeletal dysfunction.

Introduction

As reviewed by Leach,[1] The earliest model of chiropractic practice, formulated in the early part of this century by D.D. and B.J. Palmer, was to normalize the nervous system and restore homeostasis by 'removing nerve interference" through spinal adjustments. It was proposed that vertebral subluxations involved occlusion of the spinal nerves at the inter-vertebral foramen.

Following this model, the practice of chiropractic has focused to a large extent on the detection and correction of vertebral subluxations. Methods were developed for x-ray analysis that measured small displacements of vertebrae for the purpose of identifying the most efficacious segment at which to administer the chiropractic adjustment . Various adjustive techniques, ranging in the intensity and duration of force application, have been developed to promote normal alignment of the spine.

Other approaches to chiropractic care are concerned with mobilization of the bony segments of the spine which exhibit "fixation." In 1973, Gillet and Liekens,[2] introduced the concept of restricted joint mobility due to joint 'fixation.' In this concept, joint dysfunction is caused by:

- *Muscular fixation* where joint motion is restricted by muscle spasm or hypertonicity;
- *Ligamentous fixation* where joint mobility is caused by shortened or thickened ligaments;
- *Osseous fixation* where joint mobility is caused by ankylosis or congenital deformity.

The Gillet and Liekens model, addressed joint dysfunction by a manipulative thrust to re-establish normal motion (by moving the joint through the restricted range of motion). This concept has also appeared in another text[3] as an accepted rationale for mobilization.

Another model, 'receptor tonus,' first advanced in 1957 by Nimmo[4] focused attention on the role of sensory receptors as an explanation of neuromuscular dysfunction. Practitioners of Nimmoís technique have advocated stretching or compressing the involved musculature to relieve musculoskeletal dysfunction. Thus, both the 'fixation' model and the 'receptor tonus' models serve to demonstrate the clinical significance of mobilization of fixated joints.

The three approaches to chiropractic care described herein, as well as other approaches,[5] present a common theme suggesting that the identification of areas of spinal fixation, or low compliance, is an integral part of the general chiropractic practice protocol.[6] In this regard, within the past four years, sensitive instrumentation has been developed by Sense Technology[7]

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which allows the clinician to measure differences in compliance which reveal the location of even small areas of fixation. In parallel, methods for releasing fixations using multiple impulse percussive forces have also been developed by Sense Technology.[8,9] Included in these methods is the use of the PulStarFRAS which applies impulses at a rate that varies between 2 and 12 Hertz. This instrument and associated computer software, support a methodology conducive to testing the validity of clinical practice theories as well as the effectiveness of specific techniques which consider change in spinal curvature and enhanced musculoskeletal function as outcome measures.

To demonstrate, this single subject case study presents clinical findings regarding tissue compliance and accompanying changes in cervical curvature obtained with the Sense Technology Function Recording and Analysis System (PulStarFRAS) in conjunction with Differential Compliance Methodology.[7] This approach involved challenging each spinal or joint segment of interest with a small constant energy mechanical impulse and recording the response to generate compliance readings. Fixated segments were identified from the compliance readings. Resolution, or release of fixations following the application of multiple percussive forces was evaluated by repeating the challenge to each joint segment with the same low energy mechanical impulse. The compliance readings taken before and after multiple force application were recorded and graphically displayed for comparison.

The present study was designed to evaluate the efficacy of the Differential Compliance Methodology as a sensitive analysis and low force approach to detecting and resolving fixation, with a measurable restoration of cervical curvature as the outcome. Although the study was restricted to the cervical spine and first thoracic vertebrae, the methodology described could be applied to any spinal region.

Methods

Identification of Fixated Segments

For the purpose of this study, an area of fixation was identified when there was a discontinuity in the smooth variation of compliance readings from one joint segment to the next, recording from the T1 segment upward. When a given segment showed a 20% or greater difference in compliance from the segment above, it was considered fixated. Generally the force application was applied at the first segment. However, the forces may also be applied to closely related areas, based on other clinical findings derived from the chiropractic assessment. The choice of a 20% difference was based on the error of measurement of the PulStarFRAS being approximately 6.0%.[7] Thus, an estimated difference of greater than three times the measurement error was considered likely to reflect a true difference in compliance.

Identification of fixations in this manner represents an instrument palpation performed by the clinician, which is analogous to manual palpation. To locate a fixation by manual palpation, the clinician detects differences in response to changes in joint compliance via sensory stimulation through the digits. In the absence of fixations, the response from segment to segment reveals no significant differences. When performing the palpation, the clinician inherently compensates for differences in compliance due to differences in structure. For example, the clinician would expect to observe a decrease in compliance progressing from C5 to T1, because of the additional support provided T1 by the ribs. The same is true of compliance readings obtained with the PulStarFRAS; large differences (20 % or greater) in compliance are interpreted as fixations, whereas smooth variation in compliance along the spine is interpreted as a reflection of normal compliance change due to anatomy.

Instrumentation

The compliance measurements utilized as part of this case study were obtained with the Sense Technology PulStarFRAS. This instrument applies a fixed low energy mechanical impulse to the underlying tissue and measures the response of the tissue and underlying bony structure to the impulse. A site of low stiffness (high compliance) exhibits a lower response when compared to areas of high stiffness (low compliance). The theory of operation and repeatability of the instrument have been described in detail elsewhere.[7] The compliance measures are made by the clinician using the impulse head of the instrument. Pressing the instrument against the patient at the site of measurement creates a preload between the instrument and the patient. When the preload reaches a preset value, the mechanical impulse is generated. Establishing the same preload at each site of measurement and using the same excitation energy for each measurement enables the instrument to obtain a precise, repeatable measurement of the underlying compliance. If the automatic frequency mode is chosen by the clinician, the impulse frequency is set based on the compliance reading obtained at each impulse. A low compliance segment will cause the impulse frequency to be at the upper range. As the compliance of the segment changes, the frequency of the impulses will also change; as the compliance increases, the frequency will decrease.

Study design

This study was conducted in the private office setting between August 26, 1995 and September 15, 1995. The patient was a female, aged 19, presenting with signs of bony fixation and complaints of muscle spasm in the upper quadrant of the left trapezius muscle, as well as frequent headaches emanating from the base of the neck radiating to the top of the head. After obtaining Informed consent from the patient to serve as a subject for the study, a study protocol employing Differential Compliance Methodology was followed.

Clinical Protocol

Clinical Assessment and Differential Compliance Methodology

Following a standard clinical assessment of the patient,[5] a standard lateral cervical x-ray of the patient was obtained. Based on the presenting status of the patient, the present study focused primarily on the cervical spine.

Prior to commencing the Differential Compliance Methodology, the patient was seated in an erect position with the head placed in flexion with the chin toward the chest. This

position placed the patient's cervical area at the limit of passive motion. This position also served to emphasize flexion fixations for easier detection by the instrumentation.

A 30 mm. dual probe attachment was used to perform the analysis of compliance in the cervical spine, and T1. The probe of the impulse head was placed at the level of each of the cervical vertebrae with the major axis of the impulse head parallel to the joint facets and the dual tips at an equal distance from the centerline of the spine. The analysis was started at the junction of C1-C2. The contact point for the cervical vertebra (C1-T1) is the lamina pedicle junction with the angle of the impulse head parallel to the joint facets.

Application of Impulse Forces

Although the present study focused on Differential Compliance Methodology, the selection of a segment(s) or closely related area, for force application was made utilizing multiple aspects of the patient's assessment including patient history, presenting complaints, manual palpation, thermography, x-ray analysis, leg length checks, and orthopedic tests. The criteria for force application in regard to Differential Compliance Methodology required that the segment, counting upward from T1, exhibit at least a 20% or greater difference in compliance reading relative to the next higher segment.

The force application involved a series of rapid, controlled mechanical thrusts (impulses) delivered with the PulStarFRAS at the point and line of drive derived from the patient assessment. The instrument provided options of a preload of low, medium or high, impulse force levels of 10, 15, 20, 25, 30 or 35 lbf., an impulse rate of , 2, 4, 6, 8, 10, 12 or AUTO, and a maximum number of impulses that may be administered of 100, 150 or 200. In regard to the subject of this study, based on clinical findings, the instrument parameters were set on a preload of medium, an impulse level of 25lbf., and a maximum number of impulses of 150. The impulses were continued until the compliance of the segment ceased to change, or the preset limit of maximum impulses was reached.

Post Intervention and Duration of Study

Directly after the application of low impulse forces applied to the fixated segment, with the instrument set to the same parameters, a second set of compliance readings was obtained in the

Table 1. Difference in Relative Compliance of Vertebral Segments Before and After Percussive Impulse Force Application.*

		Cervical Segment							
		C1	C2	C3	C4	C5	C6	C7	T1
Visit									
1	pre	100	78	62	70	85	92	**76**	**99**
	diff.								**(23)**
	post	82	79	76	76	90	100	**100**	**100**
	diff.								**(0)**
2	pre	76	68	64	75	**80**	**100**	84	86
	diff.						**(20)**		
	post	76	64	55	65	**82**	**88**	84	76
	diff.						**(6)**		
3	pre	73	66	54	50	57	**64**	**90**	96
	diff.							**(34)**	
	post	66	64	48	46	54	**72**	**74**	76
	diff.							**(2)**	
4	pre	65	75	66	**60**	**97**	95	97	100
	diff.					**(37)**			
	post	55	60	55	**56**	**74**	76	78	82
	diff.					**(18)**			
5	pre	58	62	48	55	74	85	**100**	**80**
	diff.								**(20)**
	post	55	48	45	56	59	66	**74**	**65**
	diff.								**(9)**

* Only differences between segments of 20% or greater were considered areas of fixation,as described in Methods. Occ. represents the occiput, diff. is difference. Numbers are expressed as percent compliance relative to the area of greatest compliance. Numbers in bold represent those segments which showed a 20% or greater difference in compliance before and after Differential Compliance Methodology.

same area of the spine as the first set. The second set of compliance readings, and all subsequent readings, were compared against the highest response in the first set of readings to evaluate the change in compliance following force application.

Force applications continued until three consecutive sessions, representing different visits, produced post compliance analyses that exhibited less than 20% difference in the relative compliance readings between any two adjacent spinal segments of the cervical spine. When patient analysis reached this status, a second standard lateral cervical x-ray of the patient was taken to evaluate change in curvature.

Results

Compliance Readings

The progressive changes in compliance of the cervical vertebrae are shown in Figure 1a-e, and Table 1. Compliance readings of 20% or greater were recorded during the first visit between T1, and C7 (forces applied at T1). The second visit showed fixation between C6 and C5 (forces applied at C6). A compliance difference indicating fixation was observed between C7 and C6 on the third visit (forces applied at C7). Compliance varied greater than 20% between C5 and C4 at the fourth visit (forces applied at C5). During the fifth visit, the same compliance pattern as the third visit was apparent, with a compliance of 20% between T1 and C7 (forces applied at C7).

In each instance, following impulse force application to the first segment exhibiting a 20% or greater relative compliance with an adjacent segment, the compliance readings decreased. The drop was from 23% to zero on the first visit, 20% to 6% on the second, 34% to 2% on the third, 37% to 18% on the fourth, and 20% to 9% on the fifth visit (Table 1). The Sixth through eight visits revealed no segments showing greater than a 20% difference in compliance.

Cervical Curve Change

The pre-intervention lateral x-ray of the patient revealed a loss of the cervical lordotic curve. The spine appeared nearly straight, with a + 150 cm radius, following the method of Pierce[10] (Figure 2).

The post cervical lateral taken at the end of the fifth visit (third week of the study), revealed restoration of a more typical cervical curve with a radius of approximately +15 cm (Figure 3).

Patient Assessments and Symptomatic Changes

Chiropractic assessments over the study period showed gradual improvement in musculoskeletal function, as evidenced through improved range of motion and palpation findings, concomitant with change in tissue compliance. The patient reported that just prior to the fourth visit, all presenting symptoms had disappeared.

Figure 1a. First Visit. Percussive Forces Applied at T1 Segment.

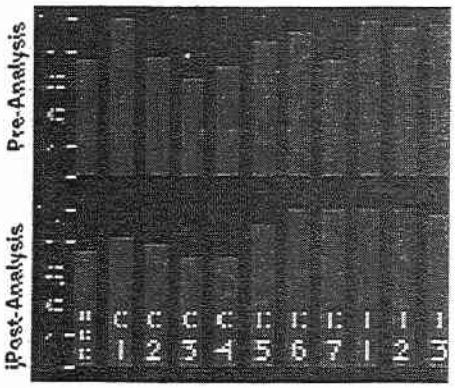


Figure 1b. Second Visit. Percussive Forces Applied at C6 Segment

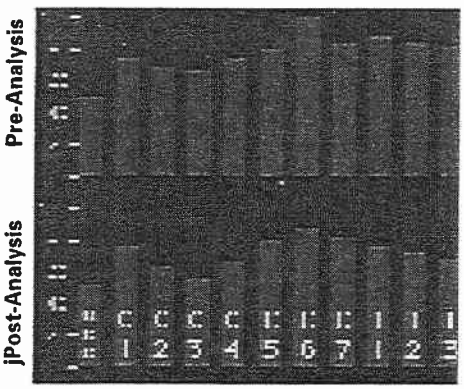


Figure 1c. Third Visit. Percussive Forces Applied at C7 Segment

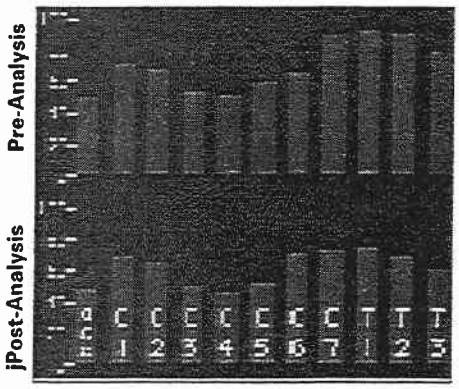


Figure 1d. Fourth Visit. Percussive Forces Applied at C5 Segment

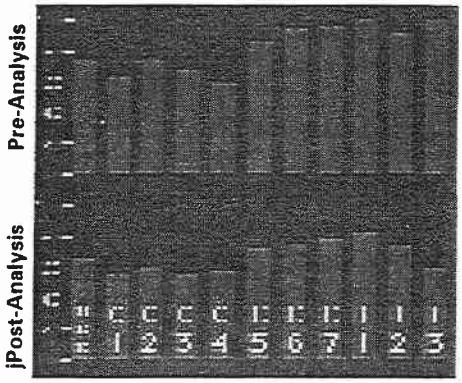


Figure 1e. Fifth Visit. Percussive Forces Applied at C7 Segment

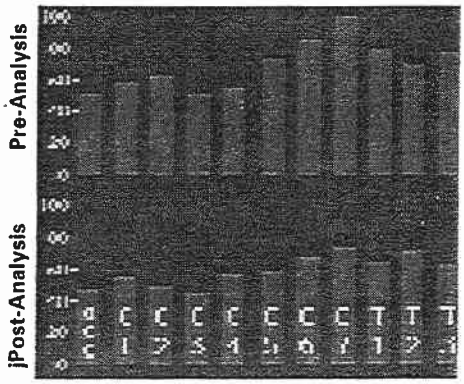
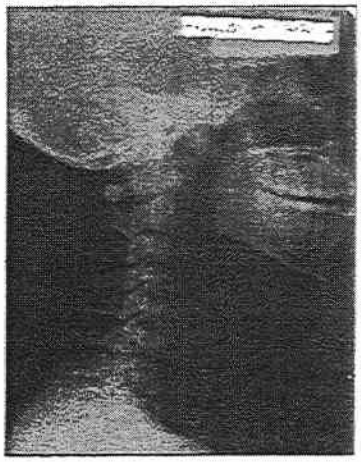


Figure 2. Before Force Application Radiograph.*



*** The Radiograph was taken August 20, 1995. Cervical curve exhibited a radius of 150 cm (see Results).**

Figure 3. Post Force Application Radiograph. *

*** The Radiograph was taken on September 15, 1995. Cervical curve exhibited a radius of 15 cm (see Results).**

Discussion

This single subject study was designed to illustrate the clinical usefulness of compliance readings and fixation resolution obtained with the PulStarFRAS. Based on the patient's presenting complaints and clinical assessment findings, the present study focused predominantly on the cervical spine. The methods described, however, are applicable to any region of the spine.

The clinical approach utilized in the case study was conservative in that (1) *only one vertebra was chosen* for force application during each patient visit and (2) *the second analysis of compliance was not used* to select additional vertebral segments for fixation resolution on the same patient visit. In addition to being conservative, the approach was very specific in that no other methods, many of which are non-specific mobilization techniques, were employed. This approach was chosen to evaluate the minimum application of force, and number of segments addressed, which could produce a change in the compliance of the spine. Moreover, the constraints of a single subject study precluded the introduction of any other confounding variables, such as the simultaneous use of other mobilization techniques. Thus, the results of the study can be more likely to be attributable to the effects of the percussive impulse forces applied through the PulStarFRAS, and its high order of specificity, resulting from the differential compliance analysis of the cervical segments and T1.

An important contribution of the Differential Compliance Methodology is found in its complement to manual palpation. That is, in essence serving as an objective instrument assisted palpation. During manual palpation, the clinician is testing for differences in response along the spine. Likewise, the instrument produces a graph of the relative compliance of the spine that highlights the differences in compliance from segment to segment, mimicking the manual palpation process but with much higher repeatability and reliability than manual palpation. In addition, the graphs permit the findings to be quantified.

The clinical results of the case study were obtained in five visits, over a period of three weeks. This is considered by these authors to be a relatively short period in which to achieve the level of positive patient response evidenced both in clinical findings, disappearance of symptoms, and restoration of the cervical curve. Based on the experience of the second author, the time to elicit patient progress as described, is less than half of what is observed with other clinical approaches used in his clinical setting. The patient was quite pleased and tolerated the force application with no indications of discomfort.

Multiple impulse therapy is thought by the authors to effect changes in segmental joint compliance and therefore to effect reversal of musculo-skeletal dysfunction by: (1) stimulating noci and mechano receptors within and around the joint musculature; (2) eliciting a relaxation response at the spinal cord level; (3) lengthening ligaments and; (4) disrupting unorganized fibrin growth within or between facets to reestablish normal joint movement. Future studies are planned to investigate this mechanism of action. Moreover, clinical observations and anecdotal reports of similar results to the present study justify further studies to evaluate outcomes over a range of instrument settings, tailored to the specific needs of the patient, as well as variation in the time (number of visits) required to achieve resolution of fixation.

The methodology described in this study is considered most beneficial to the patient when applied with appropriate attention to other clinical findings that may reinforce or contradict the clinician's interpretation of the differential compliance readings. As in the present study, the selection of any spinal segment(s) for force application should be routinely made utilizing a range of assessments, including but not limited to; palpation, thermography, surface EMG, x-ray analysis, leg length checks, patient history, and presenting complaints.

Summary and Conclusions

The results of this case study indicate that multiple impulse forces applied with the PulStarFRAS is effective in increasing the compliance of the vertebral segments following the appli-

cation of percussive forces. Resolution of aberrant clinical findings as well as patient symptoms, occurring within a period just prior to the fourth visit, accompanied the methodology. This response is, in the realm of the second author's clinical experience, considerably less than that obtained with other treatment protocols. Based on the results of this case study, the use of Differential Compliance Methodology employing the PulStarFRAS instrumentation was a positive asset to enhance this patient's care which resulted in the resolution of joint fixation, spinal curve restoration, and improved musculoskeletal function, including symptom relief. Future studies are planned to verify observations of similar results by other practitioners using this methodology in the clinical setting, with a larger number of subjects.

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