

Reliability of the Pettibon Patient Positioning System for Radiographic Production

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Abstract — The research reported here investigated the reliability of the patient positioning procedure used to evaluate the upper cervical region by practitioners of the Pettibon Technique and sought to establish the range of error of measurement for mensuration. Thirty-eight subjects completed the study which included taking two series of both an anterior to posterior nasium as well as lateral cervical radiographs. The second series of x-rays were taken from one-half to 4 hours after the initial radiographs. While there were no intermediate chiropractic adjustments provided, the use of a simulated adjustment was performed. The collected data indicates that the reliability, as represented by the standard error measurement, is approximately one-half a degree for the upper angle measurement and two-thirds of a degree for the lower angle measurement. In both cases, the measurement error estimate is less than the one degree claimed by the author of the method tested.

Key Words: X-ray, Radiography, Mensuration, Reliability, Patient Positioning, Spinal Biomechanics, Chiropractic, Vertebral Subluxation

Introduction

The use of plain film radiography in the assessment of chiropractic patients is a well-established practice in chiropractic care.¹⁻² Many different chiropractic techniques encourage the use of radiographs to detect subluxations or axial skeleton misalignments.³⁻⁹ Radiographs have usefulness in characterizing the biomechanical components of subluxation.¹⁰⁻²¹ Studies examining changes in atlas misalignment have been documented following chiropractic adjustments²²⁻²⁹ and changes in the lateral curvature of the cervical spine following chiropractic intervention have been noted.³⁰⁻⁴⁴

Though the detection and accurate measurement of minute skeletal misalignments has been challenged⁴⁵ the preponderance

of evidence supports the reliability of these procedures when properly performed.⁴⁶⁻¹¹¹ Proper performance of conventional radiographic techniques used by chiropractors and other health professionals is important. Failure to be aware and solve several important problems in the production of radiographs will render them unreliable for use in mensuration and vector-based chiropractic adjustive procedures. For instance, variations in patient positioning can cause significant changes in the structural configuration seen on the x-ray film.¹¹²⁻¹¹⁴ Therefore, the doctor cannot be certain that the pre-adjustment radiographs show an accurate representation of spinal configuration, or that successive x-rays show actual changes due to therapeutic intervention rather than changes due to positioning alone.

A second problem is conventional x-ray production methods fail to overcome the inherent problem of alignment. The alignment or relation between the x-ray beam and the film must be precisely known before accurate measurement of spinal configuration can be made.¹¹⁵⁻¹¹⁸ A third problem is distortion of the image. Carroll states that distortion can be defined as unevenly distributed magnification, and that an object with a true long axis will not be distorted by beam angles as long as it lays parallel to the film.¹¹⁹

However, distortion will exist if the object to be filmed is not precisely centered between the x-ray beam and the film.¹²⁰ Doi

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and Rossman demonstrated experimentally that the apparent displacement of an object increases from the actual displacement by the square of the magnification factor.¹²¹ There is no radiographic magnification when an object is exactly aligned with the central ray, but magnification increases by a factor of +2 as the object is moved 90 degrees from the central ray.¹²²

The reproducibility of radiographs has been the subject of several studies. Benson and his associates found that they could measure the spatial orientation of a single vertebrae to within a maximum of 3.5% of its actual spatial orientation.¹²³ In a separate study, Kirkpatrick and his associates found a 38.8% improvement in the reproducibility of x-ray films when a precise positioning procedure was employed.¹²⁴ In studies which used aligned equipment, precise object positioning, and measurement from an absolute origin or reference point, the error reported in the literature was quite small.

Stereoradiograph techniques, which involve the use of two x-ray tubes making simultaneous exposures obliquely or perpendicularly to one another, have been used to determine spinal configuration.¹²⁵⁻¹²⁸ By a process of triangulation with known reference points, the position of the structure to be evaluated can be determined accurately.¹²⁹⁻¹³⁰ This method also eliminates the possibility of patient movement between exposures. However, the method has certain disadvantages. First, the cost of the necessary equipment is prohibitive to most clinical practitioners.¹³¹⁻¹³³ Second, the quality of the radiographic image is poor due to radiation from the separate tubes fogging the opposite films.¹³⁴⁻¹³⁵ This makes identification of points to be used for measurement difficult and offsets the advantage, if any, of increased accuracy.¹³⁶

Hindmarsh states that the equipment is unnecessary for routine clinical use, and that the single tube method does not significantly reduce accuracy as long as other criteria (alignment and positioning) are met.¹³⁷ Research has not validated the claim that the stereoradiographic method is superior to the single tube method.¹³⁸

Several methods have been proposed to increase the accuracy and reproducibility of radiographs for assessing structural deformities and monitoring their progress under care. These methods have several features in common:

1. Precisely known alignment of the x-ray beam to the film.¹³⁹⁻¹⁴³
2. Precise and consistently reproducible patient positioning procedures.¹⁴⁴⁻¹⁵⁰
3. At least two perpendicular views used to construct a three-dimensional image.
4. A graphic representation of spinal configuration constructed from radiographic measurements.¹⁵¹⁻¹⁵⁸

In addition to these common features, much has been written about the advantage of high voltage radiography in clinical use. Using KV ranging from 80-120 offers the following advantages: short exposure time, reduced tube load, and reduced patient radiation dose. Improvement in film quality was also

observed if a grid was used to reduce "noise" on the film, so that it did not obscure image elements of low contrast. Using this method, several structures could be superimposed without any disturbing effect. The best screen film combination was found to be Kodak X-omatic Regular screens with Agfa-Cavaert Medichrome film.¹⁵⁹

A comprehensive review of chiropractic and cognate literature revealed several studies related to the reliability of the production and analysis of radiographs. One study which was of interest used the Grostic technique of upper cervical x-rays to evaluate their impression prior to and following adjustment.¹⁶⁰ The study found that the absolute values of both atlas rotation and laterality were significantly different after adjustment. The researchers concluded that some consistency might have occurred in the radiographic process. In a similar study, Aldis and Hill found results comparable to the Grostic and DeBoer study.¹⁶¹ Sigler and Howe point out that both of these studies may have been affected by examiner bias, because neither study used investigators who were blinded as to the purpose of the research.¹⁶² Sigler and Howe conducted a study to ascertain the reliability of inter- and intra-examiner analysis using the upper cervical x-ray marking system; and they concluded that the margin of error was so great that one must reject the system on the claim that it is both imprecise and unreliable.

Two other studies found the Pettibon upper cervical x-ray marking system reliable. The first study was a delayed test-retest design and involved six Pettibon practitioners.¹⁶³ Each practitioner marked 30 A to P nasium radiographs twice with at least one month between the first and second analysis. All identification was hidden from the examiners and an independent research consultant controlled the study to eliminate bias. Both inter- and intra-examiner reliability were found to exceed a correlation of .90. In a second study, Jackson again found a high degree of reliability in both the inter- and intra-examiner markings of x-ray films which were presented in blind conditions.¹⁶⁴

In order to establish whether the patient x-ray positioning procedures used by Pettibon technique practitioners is reliable, it was first necessary to establish the reliability of the x-ray marking system. If the x-ray marking system had proven unreliable, then the researchers would have lacked the means to test the x-ray positioning procedure.

The Jackson studies, in addition to the earlier studies by Grostic and DeBoer, and Aldis and Hill provide sufficient empirical evidence to support Pettibon's claim that his marking system is reliable and moreover, precise. The purpose of this study was to investigate the reliability of the patient x-ray positioning procedure used in the upper cervical technique by Pettibon practitioners, and to begin to establish the range of error.

If patient positioning and x-ray production procedures are reliable, then the research team would expect consistent markings from the radiograph examiners on the readings and re-readings of the radiographs produced.

Methods

Five experienced upper cervical Pettibon practitioners participated in this study. One practitioner was responsible for taking the x-ray films, while another served as a qualifier who was

responsible for eliminating radiographs which had identifying artifacts and/or head rotation. The additional three doctors served as film examiners.

Fifty-three volunteer subjects participated in this study. Each subject received the usual standard of care provided to a chiropractic patient undergoing the Pettibon procedures. Subject participation was limited to individuals who were 18 years of age or older, in good health and who had no history of severe musculoskeletal problems or concurrent disease. Pregnant females were not accepted as subjects for this study.

A-P nasium and lateral cervical radiographs were taken of each of the 53 subjects (See Figure #1 and #2). A second x-ray series was taken anywhere from approximately one half to four hours after the initial x-rays. A simulated standard Pettibon upper cervical adjustment (no actual adjustive treatment was provided) preceded the production of the second x-ray series. The use of a simulated adjustment was to control for possible changes in spinal configuration which might appear in radiography as a result of normal body movement during the Pettibon adjustment procedure independent of the actual effects of the adjustment on the spine. The simulated adjustment consisted of both active and passive stressing of the cervical spine in right and left lateral flexion at the end points of motion.

During the interim between the first and second x-ray series, a qualifier examined each film for identifying artifacts, which would bias blind examination by the three examiners who marked the films. (See Figure 3 for explanation of mensuration.) Fifteen of the fifty-three subjects were eliminated from the study after the first series of x-rays for various reasons including the production of poor x-rays, positional distortion, and artifacts. One patient played rugby between the first and second set of

radiographs and suffered an injury that rendered him unconscious. Another patient was involved in an automobile accident. All patients were instructed not to participate in any vigorous activities between films that might alter their biomechanical state and were asked to inform the researchers if they experienced any trauma between the exams. Thus, 38 subjects remained and their x-rays were marked by the examiners.

All patient identification of x-rays was removed by the qualifier prior to the time the examiners received them. Each of the three examiners marked both the first and second x-ray series in random order. An independent research consultant coordinated the random analysis of films and was present at both the marking and x-ray film production sites to ensure the integrity of the research.

The doctors responsible for taking the x-ray films were experienced Pettibon practitioners and were instructed to follow the standard Pettibon procedures for patient positioning and x-ray production. In order to ensure that the x-ray production process was not biased, the doctors responsible for taking the x-rays were not informed that the Pettibon patient positioning procedures were being tested. Instead, they were told that the marking system was being researched. All x-rays were taken at 100 MA, 2/10. The KV ranged from 76-100. Kodak high speed 14" x 17" film and rare earth screens were used.

Data Analysis

To examine reliability-stability over time for each of three experts, the scores resulting from the reading and re-reading of thirty-eight x-rays were analyzed using bivariate scattergrams, Pearson Product-moment correlation coefficient esti-

Figure 1

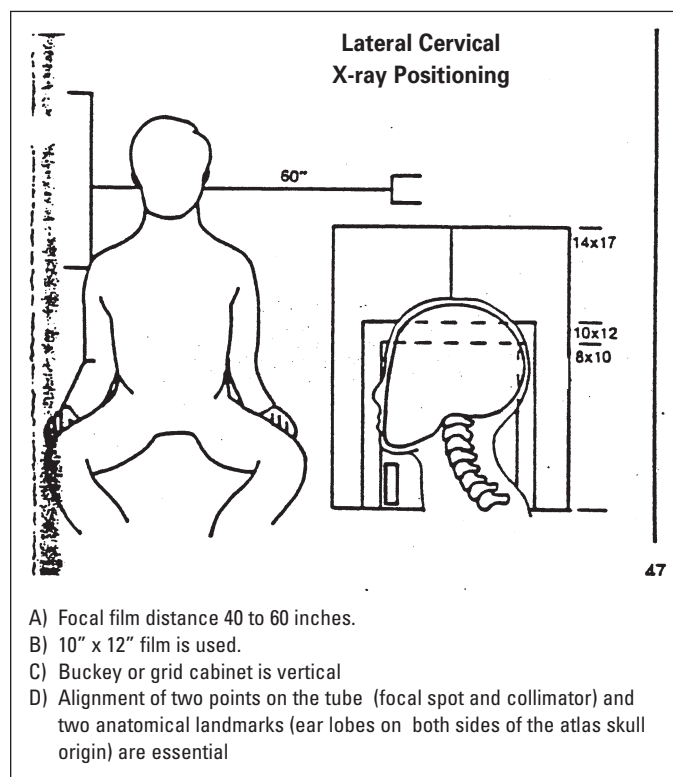


Figure 2

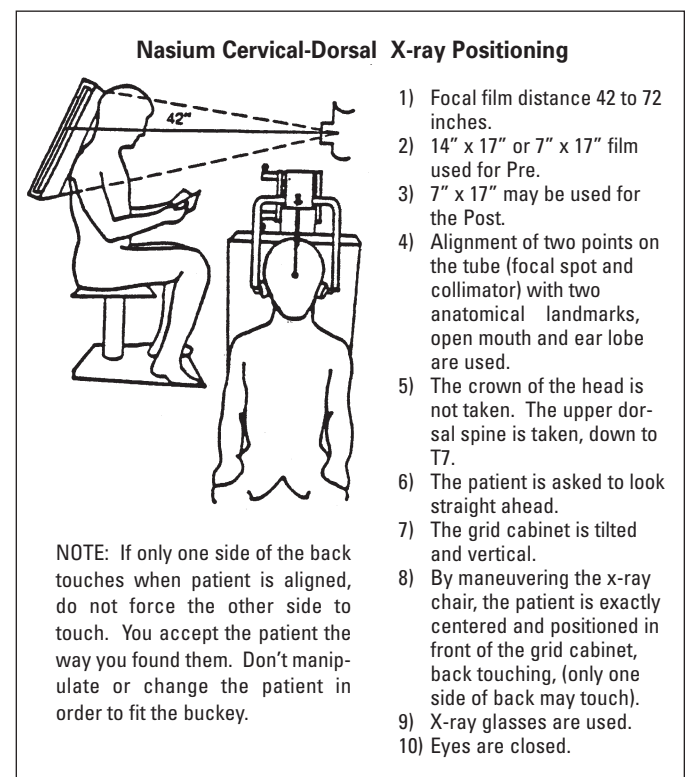


Table 1. Reliability for each three experts: upper and lower angle reading and re-reading for thirty-eight radiographs.

UPPER ANGLE								
READING			RE-READING					
Experts	X	S	X	s	n	r	t	P
#1	0.61	2.3	0.61	2.4	38	0.94	-0.05	0.96
#2	0.39	2.2	0.45	2.3	38	0.96	-0.61	0.55
#3	0.45	2.1	0.53	2.1	38	0.95	-0.73	0.47

LOWER ANGLE								
READING			RE-READING					
Experts	X	S	X	s	n	r	t	P
#1	-0.59	3.2	-0.72	3.2	38	0.94	0.73	0.47
#2	-0.67	3	-0.78	3.1	38	0.95	0.66	0.51
#3	-0.94	3.1	-0.8	3	38	0.97	-1.14	0.26

Standard error of measurement = $3.0 \sqrt{1-.95} = .68$

mates and correlated samples t-tests. The scattergrams were used to check the linearity of the data used in each of the correlation estimates. The Pearson correlations were used to estimate stability and consistency from the first to second

reading for each expert. The t-tests were used to detect any statistically significant differences between the readings and re-readings for each expert.

To examine reliability-repeated individual measurement, a stan-

Figure 3
Upper and Lower Angle Lines of Mensuration

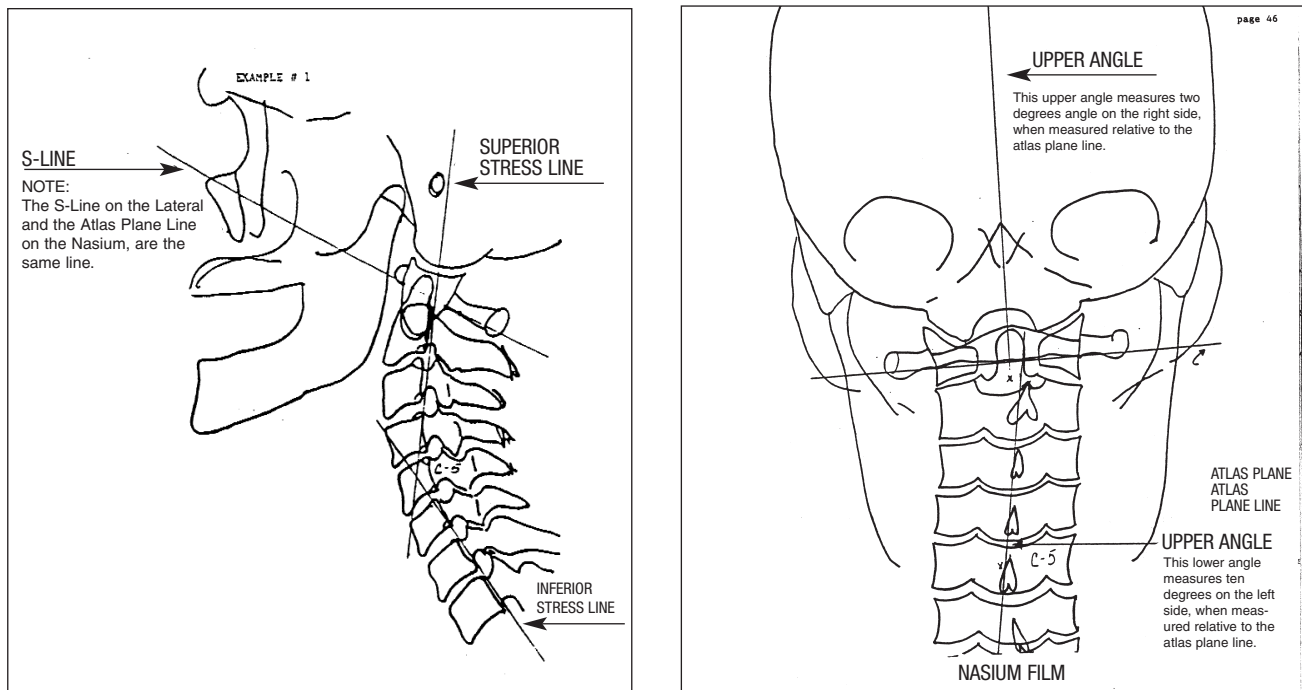


Figure 3. The Pettibon anthropometric line analysis includes the upper and lower angles. The upper angle is formed by the intersection of the central skull line and the atlas plane line. The central skull line is the center of mass of the skull and is found by triangulating the skull with a longitudinal skull divider. The atlas plane line is drawn along the intersection of the lateral, inferior posterior arch where it intersects with the lateral masses. The lower angle represents the center of the neural canal and intersects with the atlas plane line. The lower angle line is found by bisecting the vertebral bodies of C-2 (axis) and C-5. A dot is then placed at the spinous-laminae junction. The halfway point between these two dots represents the center of the neural canal.

Table 2. Reliability across three experts: upper and lower angle. First reading for thirty-eight radiographs.

UPPER ANGLE

Source of Variation	SS	df	MS	F	p
Between X-rays	504.2	37	13.6		
Within X-rays	25.6	76	0.3		
Between Experts	0.9	2	0.5	1.41	0.25
Residual	24.7	74	0.3		
Total	529.8	113	4.7		

LOWER ANGLE

Source of Variation	SS	df	MS	F	p
Between X-rays	1024.7	37	27.7		
Within X-rays	37.2	76	0.5		
Between Experts	2.5	2	1.3	2.71	0.07
Residual	34.7	74	0.5		
Total	1061.9	113	9.4		

SP SSX ALPHA = .98 BARTKO (15) = .94

dard error of measurement was estimated for the upper angle measurement and the lower angle measurement over the three experts. For these calculations, the median standard deviation and the median correlation coefficient over the three experts was used.

To examine reliability-equivalence over experts across the three experts, a repeated measures analysis of variance approach was used.¹⁶⁵ The first reading of the thirty-eight x-rays by the three experts was the data structure used in the ANOVA.

This approach was employed to estimate an Alpha reliability coefficient for the upper angle and the lower angle reading. All statistical analysis was done using SPSSX on a Honeywell CP-6.¹⁶⁶

Results

The reliability for each of the three experts is at an acceptable level (See Table 1). The scattergrams (not shown) showed that the data were in no case non-linear in nature. Thus, confidence in the appropriateness of the Pearson correlation for estimating reliability for each expert seems well founded. The reliability estimates ranged from 94-97. Further, there were no statistically significant differences between the first reading and the re-reading for any of the experts. Examination of this data suggests that reliability-stability over time for each of the experts is very good.

Reliability, as represented by the standard error of measurement, is approximately one-half a degree for the upper angle measurement and two-thirds of a degree for the lower angle measurement (See Table 1). In both cases, the measurement error estimate is less than the one degree claimed by the author of the method used.¹⁶⁷

The reliability for all experts combined is at an acceptable level (See Table 2). The repeated measures analysis of variance described by Winer¹⁶⁸ resulted in an Alpha reliability estimate for the upper angle and the lower angle of .98. Using Bartko's¹⁶⁹ more conservative approach to estimate the intraclass correlation (his formula 15) resulted in estimates of .94 for both.

Examination of this data suggest that reliability-equivalence over experts-across the three experts is very good whether a liberal or conservative approach to statistical estimation is used.

Discussion and Conclusion

Chiropractic technique approaches which use pre and post-adjustment x-rays require a reliable working system and a reliable set of x-ray production procedures to justify exposing a patient to the additional radiation necessary to make post-adjustment x-rays. In any procedure in which radiation is involved, there is a potential risk to the patient, which must be balanced against the potential benefit. Information about a patient's basic skeletal configuration and other pathology is necessary for the assurance of good care both to determine what needs to be done and to rule out contraindications to thrusting procedures. Thus, pre-adjustment x-rays are justified by the diagnostic value of the procedure. Post-adjustment x-ray exposure can only be justified if additional information, necessary for the patient's care, can be gained.¹⁷⁰

If pre and post-adjustment data are to be used conjointly in chiropractic treatment to determine initial diagnosis, course of treatment and adjustment outcomes, a reliable marking system is needed. If the measurement system is unreliable, then such things as the reliability of patient positioning, the use of patient

headclamps, and ultimately the efficacy of the adjustment system cannot be proven.

The previous research by Jackson et al. has indicated that, when properly used by qualified practitioners, the Pettibon upper cervical marking system is reliable. For this reason the system was used in this study to help determine the degree of reliability of the Pettibon patient positioning system.

It is suggested that the patient risk/benefit factor scale would be tipped in favor of the use of the post-adjustment x-rays if both a measurement system and a patient positioning system were found to be reliable and have a small degree of error in measurement. The results of this investigation tend to support the reliability of the Pettibon patient positioning system and indicate a standard error of measure which is within the limits established as part of the upper cervical technique.

Thus it appears that Pettibon technique practitioners have empirical justification for the use of pre and post-adjustment radiographs in the course of patient care. Post-adjustment x-ray exposure and its inherent risk factor appear justified on the basis of the value of the information gained about the actual skeletal configuration after care is provided. Furthermore, it may be inferred that good treatment practice would require periodic post-adjustment x-rays as a means of verification of treatment success. If further investigations replicate these research outcomes, perhaps there may be an ethical and legal mandate to employ post-adjustment x-rays as part of the minimum "standard of care" in chiropractic.¹⁷¹

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