INTER AND INTRA—
EXAMINER RELIABILITY OF THE UPPER CERVICAL X-RAY MARKING SYSTEM: A THIRD AND EXPANDED LOOK

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ABSTRACT

The purpose of this research is to determine the degree of reliability for four Orthospinology (Grostic) practitioners, by analyzing, reading and rereading 10 sets of upper cervical film. Each set of upper cervical film consisted of a lateral, nasium and vertex view. The reading and re-reading were done manually and with computer assisted analysis using the software program "The DOC." Analysis of all measured components of the upper cervical marking procedure was made by using average deviations from the median, standard deviations and the Design I One Way ANOVA for reliability calculations. The analyzed components were: C1 laterality, odontoid, C2 spinous, C1 rotation and lower angle; also analyzed were the measured components for height factor calculations i.e., plane line, condylar surface circle, axial surface circle, the height factor and the S-Line measurement from the lateral film.

Examination of the results suggests the reliability for the atlas laterality, odontoid, C2 spinous, lower angle and height factor measurements are very good. C1 rotation measurements are acceptable. The median of the intra-examiner standard deviations for atlas laterality is 0.45 degrees. This is comparable to the Jackson et al.'s findings of a median atlas standard deviation of 0.41 degrees.[1] This study reveals the atlas laterality can be measured much more accurately than was reported in the Sigler and Howe study which *demonstrated 0.82 and 1.10 average difference between readings.[2] The side of atlas laterality (right or left) is in 100% agreement in this study, 120 of 120 readings, indicating consistent patient care. If the deviation of the mean atlas measurement on the post x-ray is greater than 2 standard deviations (0.90 degrees), then there is a 95% probability that the deviation is due to factors other than measurement error, i.e.; C1 position change from the adjustment, pt. placement error, etc.*

Key indexing terms: *Atlas Laterality, Chiropractic X-ray Analysis, Upper Cervical Technique and Grostic Analysis*

INTRODUCTION

Many techniques and procedures in the chiropractic profession are based on the premise that there exists a vertebral misalignment as compared to the vertebra above and/or below and interferes with the transmission of electrical messages traveling over the nervous system. The Orthospinology (Grostic) Procedures are built on this premise. The cornerstone to the success of the procedure is being able to measure alignment, and demonstrate correction of the occipital-atlanto-axial misalignment on pre and post x-rays. Upper cervical practitioners use these measurements to determine the side and angle that the adjustment is given. In order to establish the validity of this process, it first has to be scientifically demonstrated that one can measure vertebral position at an acceptable level of accuracy from an x-ray, and that the x-ray is representative of the actual arrangement of the spine of the patient. This study deals only with the measuring reliability of four Orthospinology (Grostic) practitioners and examines all of the measured components and height factor calculations.

Few research studies have been published that investigate the accuracy of the upper cervical marking procedures. Sigler and Howe had two examiners read and reread 20 nasium films determining atlas laterality. A third examiner read the 20 films once. They found that the average difference in measurement between doctors was 1.05 degrees and within doctors was 1.10 and 0.825 degrees, when measuring atlas laterality.[2] They conclude that with ranges of errors of this magnitude any measured differences produced using this system will be just as likely to be from marking error as from actual atlas position change. Jackson, Barker, Bentz and Gambale demonstrated a median standard error of 0.41 degrees for trained, experienced Pettibon practitioners and concluded that the reliability, inter and intra examiner, was very good.[1] Their conclusion contradicts the conclusions of Sigler and Howe. Grostic and DeBoer examined the alignment of the upper cervical spine before and after an adjustment showing the measurements were significantly different in laterality and rotation but did not test the reliability of the measuring process.[3] It is noted that the average atlas laterality was 2.63 degrees before and 1.43 degrees after, a change of 1.2 degrees. They also state that the examiner was not "blinded" to any part of the taking and reading of the x-rays. This study seeks to expand on Sigler and Howe; attempts to reproduce the results of Jackson and examines the reliability/acceptability of all measured components of the Orthospinology (Grostic) marking procedures.

METHOD

Four doctors trained and experienced in the use of the Orthospinology (Grostic) procedure of radiographic analysis participated in the study.

The study was to research the measurement of atlas laterality and rotation, odontoid, C2 spinous and lower angle lateralities. The height factor calculation with components atlas plane line, condylar surface and axial surface circles were also examined. The examiners used both manual marking procedures as well as computer assisted analysis using the software program, "The DOC!"

Ten sets of upper cervical film were randomly selected from the patient files of a doctor not participating in the study. The films were checked for identifying artifacts and labeled A - J covering the names of the patients. The doctors then read the films with approximately one week between readings. Doctors 1 and 3 read the films twice manually and twice with the computer. Doctors 2 and 4 read the films once manually and once with the computer. To ensure anonymity and unbiased review, all marks were thoroughly cleaned, the films reordered and re-labeled A-J between each reading. The average time taken to read manually and computer assisted was observed. Average deviations from the median, standard deviations and the Design I One Way ANOVA - Random Model calculations were used to estimate reliability "R". Inter-examiner reliability was examined across all doctors (12 readings of 10 sets of film or 120 readings in all). Inter-examiner reliability was examined for manual readings and for computer readings (60 readings each). Intra-examiner reliability for each of the 4 doctors (doctors 1 and 3, 40 readings, doctors 2 and 4, 20 readings each) as well as Intra-examiner reliability for manual and computer readings were also analyzed.

RESULTS

The reliability for each of the four experts is at an acceptable level for all aspects of the upper cervical marking procedure. The reliability estimates ranged from 0.83 - 0.94 for atlas laterality, 0.84 - 0.96 for odontoid, 0.89 - 0.96 for C2 spinous and 0.86 - 0.96 for lower angle. Rotation estimates are lower at 0.54 to 0.68 possibly due to the fact that the computer uses a slightly different algorithm for rotation than does the manual process (Appendix 1). This difference was set up intentionally to compare the results of computer readings to that of manual readings. The mean rotation estimate for only manual readings is 0.87 and for the computer readings is 0.82. When you compare the mean measurement for rotation of the manual readings at 1.47 degrees to 1.86 degrees for the computer mean, it is demonstrated that the two systems are slightly different but within an acceptable tolerance (Appendix 2). The height factor reliability estimates range from 0.81 to 0.97. The plane line estimates range from 0.96 to 0.98. The reliability for the condylar and axial surface measurements are lower overall ranging from 0.29 to 0.88. The manual intra-examiner readings for condylar and axial surface measurements range from 0.29 to 0.88 compared to 0.81 to 0.98 for the computer readings. Examining the standard deviation of the condylar surface at 0.18 to 0.46 inches compared to 0.56 to 1.74 inches for the axial surface reveals that the axial surface measurement is the weakest component of the height factor calculation causing about l inch of fluctuation in the height factor (Appendix 1). Even with this weakness, the height factor reliability is still very good overall.

The experts ranged between 10 - 15 minutes per film reading manually and 6 - 10 minutes reading with the computer.

Reliability for the four doctors is very good when evaluating the standard deviation. The standard deviation for atlas laterality ranged from 0.36 - 0.55 degrees with a mean of 0.45 degrees (approximately 0.30 mm). The lower angle ranged from 0.50 - 0.74 degrees with a mean of 0.59 degrees. The atlas rotation ranged from 0.44 - 0.70 degrees with a mean of 0.59 degrees. The height factor standard deviation ranged from 0.35 inches to 0.93 inches with a mean of 0.50 inches (Appendix 1).

The estimates for the inter-examiner reliability via the One Way ANOVA is 0.83 for atlas laterality, 0.88 for lower angle, 0.46 for rotation and 0.83 for the height factor. The standard deviation is 0.59 degrees for atlas laterality, 0.80 degrees for lower angle, 0.68 degrees for rotation and 0.77 inches for height factor (Appendix 3)

Comparing manual readings to computer readings we find all ANOVA estimates for atlas, odontoid, C2 spinous, lower angle and height factor range from 0.81 to 0.94 indicating very little difference between the manual and computer readings.

When you compare the average measurement between computer readings and manual readings (60 readings each) there is near exact measurement. For atlas laterality the average measurement is 3.03 degrees - computer, 3.07 degrees - manual, the lower angle average is 2.05 degrees - computer and 2.16 degrees - manual.

DISCUSSION

During the last several years the chiropractic profession has responded to the demand for scientific validation of it's theories and practices. Research in the field has increased significantly; however, the surface has just been scratched. Sigler and Howe began a very important investigation into the x-ray marking reliability of the upper cervical work in chiropractic with conclusions of unreliability.[2] Jackson et al; continued this investigation with conclusions of very good reliability.[1] This study expands on these investigations. Following the observations of Sigler and Howe plus Jackson et al; that a need for examination of more than just atlas laterality is required to make the procedures scientifically valid, this study provides the next step. This study successfully reproduces the results of the Jackson study concerning reliability in measurement of the atlas and lower angle lateralities, plus provides research demonstrating that the overall x-ray marking procedures are very reliable. It further demonstrates, based on the marking procedures, that patient care is also very consistent from doctor to doctor. It is important to note that further research is needed demonstrating the range of error of the radiographic process. The errors in patient placement and x-ray distortion also need to be investigated.

The participating doctors were asked to rate the importance of the various components of the occipito-atlanto-axial misalignment. There was agreement that the side of atlas laterality was the most important factor with few exceptions, followed by the C2 spinous measurement and then the odontoid - lower angle measurement. In this study the side of atlas laterality and C2 spinous laterality was in perfect agreement and the side of lower angle laterality agreed over 90% of the time. All discrepancies on the lower angle occurred on film that had an average lower angle measurement less than 0.5 degrees. The height factor and rotation were next in importance. Rotation had 4 of 120 that listed opposite sides of rotation. From this information, it can be deduced that patient care is very consistent from doctor to doctor.

Based on this study, it can be concluded that if the mean atlas measurement on the post x-ray is greater than 2 standard deviations (0.90 degrees) then there is a 95% probability that the deviation is due to factors other than measurement error (Graph 1). It is interesting to note that the Grostic and DeBoer study demonstrated an average change of 1.2 degrees; however, the examiner was not blinded during the taking and reading of the film.[3]

Another important observation in this study is in the averaging of multiple readings. This procedure is used in many other areas such as EMG readings that take multiple readings over a few seconds and average the measurements. Using the same technique could drastically improve reliability in the upper cervical measuring system, and prove valuable in the pursuit of scientific validation of the effects of the adjustment procedure. Using computer assisted analysis is 25 - 50% quicker and is more objective in the sense that the examiner is blinded to the results of the measurement until all points are selected and calculated. The use of the computer analysis and multiple reading averaging may be a good combination for future research.

CONCLUSION

It is concluded that all aspects of the upper cervical marking procedures are reliable. This study successfully reproduced the results of Jackson et al; and contradicts the conclusions of Sigler and Howe. It is demonstrated that the computer assisted analysis is interchangeable with the manual process of reading upper cervical film for vertebral misalignment.

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Appendix 1 Intra-Examiner Reliability Comparison of Manual and Computer

Doc 1 Intra-Exam AVG. DEVIATION		Doc 2 Intra-Exam AVG. DEVIATION		Doc 3 Intra-Exam AVG. DEVIATION		Doc 4 Intra-Exam AVG. DEVIATION	
0.27	ATLAS	0.28	ATLAS	0.40	ATLAS	0.39	ATLAS
0.26	OD	0.28	OD	0. 38	OD	0.49	OD
0.62	SP	0.44	SP	0.91	SP	0.71	SP
0.37	LA	0.53	LA	0.39	LA	0.43	LA
0.38	ROT	0.50	ROT	0.47	ROT	0.41	ROT
0.33	S-LINE	0.35	S-LINE	0.39	S-LINE	0.28	S-LINE
0.10	PL	0.13	PL	0.14	PL	0.09	PL
0.14	C	0.13	C	0.17	C	0.33	C
0.37	A	0.48	A	0.45	A	0.50	A
0.29	HF	0.25	HF	0.78	HF	0.40	HF

AVG. MEASUREMENT		AVG. MEASUREMENT		AVG. MEASUREMENT		AVG. MEASUREMENT	
3.08	ATLAS	2.85	ATLAS	2.99	ATLAS	3.19	ATLAS
3.41	OD	3. 05	OD	3.27	OD	3.39	OD
7.01	SP	6.71	SP	6.79	SP	6.59	SP
2.29	LA	2.30	LA	2.09	LA	1.93	LA
1.47	ROT	1.79	ROT	1.82	ROT	1.85	ROT
2. 06	S-LINE	1.95	S-LINE	2.43	S-LINE	2.43	S-LINE
1.22	PL	1.13	PL	1.17	PL	1.16	PL
3.26	C	2.93	C	2.96	C	3.08	C
6.73	A	7.43	A	8.06	A	7.05	A
3.85	HF	3.95	HF	4.43	HF	3.85	HF

AVG. STD DEVIATION		AVG. STD DEVIATION		AVG. STD DEVIATION		AVG. STD DEVIATION	
0.36	ATLAS	0.39	ATLAS	0.51	ATLAS	0.55	ATLAS
0.36	0D	0.39	0D	0.50	0D	0.69	0D
0.88	SP	0.62	SP	1.23	SP	1.01	SP
0.50	LA	0.74	LA	0.58	LA	0.60	LA
0.44	ROT	0.70	ROT	0.59	ROT	0.58	ROT
0.41	S-LINE	0.49	S-LINE	0.51	S-LINE	0.39	S-LINE
0.14	PL	0.18	PL	0.18	PL	0.12	PL
0. 18	C	0.10	C	0.21	C	0.46	C
0.56	A	0.67	A	1.74	A	0.71	A
0.43	HF	0.35	HF	0.93	HF	0.57	HF

RELIABILITY		RELIABILITY		RELIABILITY		RELIABILITY	
0.94	ATLAS	0.94	ATLAS	0.89	ATLAS	0.83	ATLAS
0.96	0D	0.96	0D	0.94	0D	0.04	0D
0.93	SP	0.96	SP	0.91	SP	0.09	SP
0.96	LA	0.86	LA	0.95	LA	0.92	LA
0.68	ROT	0.57	ROT	0.54	ROT	0. 63	ROT
0.87	S-LINE	0.78	S-LINE	0.83	S-LINE	0.78	S-LINE
0.98	PL	0.96	PL	0.96	PL	0.98	PL
0.67	C	0.29	C	0.46	C	0.32	C
0.83	A	0.88	A	0.32	A	0.74	A
0.95	HF	0.97	HF	0.81	HF	0.86	HF

Appendix 2 Intra-Examiner Reliability

Doc 1 Man. Intra-Exam AVG. DEVIATION		Doc 3 Man Intra-Exam AVG. DEVIATION		Doc 1 Comp. Intra-Exam AVG. DEVIATION		Doc 1 Comp. Intra-Exam AVG. DEVIATION	
0.23	ATLAS	0.15	ATLAS	0.14	ATLAS	0.34	ATLAS
0.28	OD	0.15	OD	0.14	OD	0.39	OD
0.45	SP	0.43	SP	0.33	SP	0.89	SP
0.24	LA	0.30	LA	0.18	LA	0.36	LA
0.20	ROT	0.20	ROT	0.17	ROT	0.36	ROT
0.23	S-LINE	0.15	S-LINE	0.20	S-LINE	0.30	S-LINE
0.06	PL	0.05	PL	0.05	PL	0.15	PL
0.08	C	0.03	C	0.05	C	0.05	C
0.35	A	0.53	A	0.25	A	0.65	A
0.31	HF	0.25	HF	0.26	HF	0.46	HF

AVG. MEASUREMENT		AVG. MEASUREMENT		AVG. MEASUREMENT		AVG. MEASUREMENT	
2. 98	ATLAS	3.03	ATLAS	3.19	ATLAS	2.96	ATLAS
3.33	OD	3.33	OD	3.49	OD	3.21	OD
6.53	SP	6.70	SP	7.50	SP	7.19	5P
2.51	LA	2.20	LA	2.20	LA	2.06	LA
1.38	ROT	1.63	ROT	1.57	ROT	2.00	ROT
2.18	S-LINE	2.70	S-LINE	2.00	S-LINE	2.20	S-LINE
1.21	PL	1.10	PL	1.23	PL	1.23	PL
3.38	C	2.98	C	3.15	C	2.95	C
6.50	A	6.88	A	6.95	A	9.25	A
3.86	HF	3.88	HF	3.84	HF	5.01	HF

AVG. STD DEVIATION		AVG. STD DEVIATION		AVG. STD DEVIATION		AVG. STD DEVIATION	
0.32	ATLAS	0.21	ATLAS	0.19	ATLAS	0.48	ATLAS
0.39	OD	0.21	OD	0.19	OD	0.55	OD
0. 64	SP	0.60	SP	0.46	SP	1.26	SP
0.34	LA	0.42	LA	0.25	LA	0.51	LA
0.28	ROT	0.28	ROT	0.24	ROT	0.50	ROT
0.32	S-LINE	0.21	S-LINE	0.28	S-LINE	0.42	S-LINE
0.09	PL	0.07	PL	0.07	PL	0.21	PL
0.11	C	0.04	C	0.07	C	0.07	C
0.49	A	0.74	A	0.35	A	0.92	A
0.44	HF	0.35	HF	0.37	HF	0.65	HF

RELIABILITY		RELIABILITY		RELIABILITY		RELIABILITY	
0.96	ATLAS	0.97	ATLAS	0.99	ATLAS	0.94	ATLAS
0.96	OD	0.98	OD	0.99	OD	0.95	OD
0.95	SP	0.96	SP	0.90	SP	0.92	SP
0.99	LA	0.98	LA	0.99	LA	0.95	LA
0.87	ROT	0.06	ROT	0.95	ROT	0.68	ROT
0.91	S-LINE	0.95	S-LINE	0.94	S-LINE	0.80	S-LINE
0.99	PL	0.99	PL	0.99	PL	0.96	PL
0.06	C	0.29	C	0.98	C	0.93	C
0.89	A	0.53	A	0.96	A	0.81	A
0.94	HF	0.98	HF	0.97	HF	0.92	HF

Appendix 3 Inter-Examiner Reliability

Inter-Exam All AVG. DEVIATION		Intra-Exam Computer OVERALL AVG. DEVIATION		Intra-Exam Manual AVG. DEVIATION	
0.48	ATLAS	0.45	ATLAS	0.45	ATLAS
0.50	OD	0.52	OD	0.44	OD
0.98	SP	0.93	SP	0.79	SP
0.59	LA	0.52	LA	0.49	LA
0.54	ROT	0.48	ROT	0.49	ROT
0.50	S-LINE	0.48	S-LINE	0.45	S-LINE
0.22	PL	0.16	PL	0.25	PL
0.27	C	0.27	C	0.21	C
0.98	A	1.12	A	0.71	A
0.58	HF	0.68	HF	0.39	HF

AVG. MEASUREMENT		OVERALL AVG. MEASUREMENT		AVG. MEASUREMENT	
3.03	ATLAS	3.03	ATLAS	3.07	ATLAS
3.28	OD	3.24	OD	3.37	OD
6.87	SP	7. 13	SP	6.67	SP
2.12	LA	2.05	LA	2.16	LA
1.70	ROT	1.86	ROT	1.47	ROT
2.23	S-LINE	2.13	S-LINE	2.38	S-LINE
1.13	PL	1.20	PL	1.05	PL
3.08	C	3.00	C	3.18	C
7.34	A	7.80	A	6.87	A
4. 06	HP	4.21	HF	3.92	HF

AVG. STD DEVIATION		OVERALL AVG. STD DEVIATION		AVG. STD DEVIATION	
0.59	ATLAS	0.58	ATLAS	0.56	ATLAS
0.64	OD	0.66	OD	0.57	OD
1.30	SP	1.26	SP	1.07	SP
0.80	LA	0.68	LA	0.61	LA
0.68	ROT	0.64	ROT	0.69	ROT
0.62	S-LINE	0.65	S-LINE	0.55	S-LINE
0.36	PL	0.22	PL	0.35	PL
0.35	C	0.33	C	0.26	C
1.30	A	1.46	A	0.92	A
0.77	HF	0.90	HF	0.50	HF

RELIABILITY		RELIABILITY		RELIABILITY	
0.83	ATLAS	0.86	ATLAS	0.82	ATLAS
0.87	OD	0.88	OD	0.89	OD
0.83	SP	0.84	SP	0.87	SP
0.88	LA	0.91	LA	0.94	LA
0.46	ROT	0.52	ROT	0.39	ROT
0.70	S-LINE	0.72	S-LINE	0.75	S-LINE
0.66	PL	0.94	PL	0.48	PL
0.35	C	0.52	C	0.16	C
0.46	A	0.53	A	0.57	A
0.83	HF	0.81	HF	0.92	HF

Graph 1
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