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"Computerized Modeling of The Occipital-Atlanto-Axial Spine":

Comments on methodology and basic physics.

By James F. Palmer, M.S.

During the past six months NUCCRA has been involved in a project in pure research—a computerized modeling of the occipital-atlanto-axial elements of the spine. Whereas modeling by other researchers has focused on the orientation of spinal vertebrae and to a lesser extent on the external forces to the spine that are either directly or indirectly applied by muscles, tendons, and ligaments, this study focuses on the geometrial (geometrical/inertial) properties of the occipital condyles, C-1 and C-2.

Geometrical/inertial properties include cross-sectional areas, orientation of principal axes, location of centroidal axes, moments of inertia, and products of inertia. These properties are inherent in the vertebrae and thus are not dependent on the orientation of the vertebrae. However these properties for a given vertebrae over the life-time of the individual are not constant.

In 1892 Wolf stated that bone tissue phenotypically responds to its mechanical environment such that it displays the maximum resistance to failure while utilizing the minimum amount of material; that is, bone alters its growth and arrangement in response to the mechanical environment. One can reasonably conclude that some if not all of the geometrical/inertial properties change with the development of the individual because the size and the distribution of mass are a function of time. Also one can reasonably conclude that a C-1 subluxation in an adult if given sufficient time could change some if not all of these geometric properties.

(Continued on page 2)

An Analysis of the Lateral Cervical X-Ray

By Daniel C. Seemann, Ph.D.

Background

The lateral cervical x-ray is basically used for two reasons. The film is used to determine the S-line for the nasium film and it is used to ascertain the evidence of any pathology in the cervical region. More recently there has been interest shown in the lateral film as an analytical tool in predicting rotations of the atlas (Seemann, 1984). The hypothesis was that "When the center of gravity in the sagittal plane falls anterior to a mid-point of the odontoid process the rotation will be anterior, and when the CG falls posterior to the mid-point of the odontoid point the rotation will be posterior". The 1984 study triggered many questions and perhaps the most important was determining the relationship between the center of gravity of the skull, the atlas and the axis. If the relationships between these three elements are understood then perhaps there might be a clue to better understanding the behavior of the subluxation, especially with regard to holding the adjustment.

For an example, Gregory has hypothesized the more anterior the atlas is on the condyles of the occiput, the more unstable the atlas is in relationship to the skull and the axis. To test the hypothesis, a knowledge of the above relationships (skull, atlas and axis) in the sagittal plane would be helpful. Kapandji (1974) has illustrated what he thinks is the proper juxtaposition of the skull, atlas and axis. See Figure 1. The skull sets on the condyles of the atlas much as a spheroid with the center of the skull bisecting the atlas condyles even though the center of the atlas is located at the posterior of the atlas condyles, which suggests that a more anterior position of the skull is preferable. The above hypotheses therefore raise enough questions that a further analysis of cervical lateral x-ray is appropriate.

Method

In order to analyze the lateral film it was necessary to establish some landmarks that were somewhat constant and that were discernable. After many different trials, the following three measurements were used. For the skull mark the auditory meatus was used which is fairly easy to locate

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Occipital-Atlanto-Axial Spine

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The geometric/inertial properties of a solid object are a function of the mass of the object and of the distribution of mass. The (translational) inertia of an object is measured by the mass of the object. The mass of an object is a measure of the resistance that the object offers to any change in its translational velocity. The moment of inertia of a solid object is a measure of the resistance that the object offers to any change in its angular velocity.

The moment of inertia of an object is determined by the object's mass and mass distribution about the axis of rotation by the following:

$$I = \sum_{i=1}^{i=n} m_i r_i = MR^2$$

where I is the moment of interia
m_i is an element of mass
r_i is the distance of the element of mass from the axis of rotation
M is the total mass
R is the radius of gyration

An obvious example of the effect of the distribution of mass on angular velocity is that of the ice skater increasing the angular velocity by pulling the arms in closer to the axis of rotation or decreasing the angular velocity by extending the arms away from the axis of rotation.

A classical physics demonstration illustrating the importance of mass distribution is based on a comparison of the time for two cylinders—one a uniform solid cylinder (disk) and one a hollow cylinder (thin ring or hoop)—with identical values for mass and diameter and equivalent cylindrical axis of rotation—to reach the bottom of an incline if released at the same time from the same height. Because the uniform solid cylinder has a smaller moment of inertia ($I = \frac{1}{2} MR^2$) than the hollow cylinder ($I = MR^2$) (here R = Radius of cylinder), a larger fraction of the solid's potential energy is converted into translational kinetic energy, thus resulting in the solid cylinder reaching the bottom of the incline before the hollow cylinder (assuming no slipping).

The CAT scanner at The Medical College of Ohio at Toledo was used to obtain 51 contiguous sections of volume on a dry C-1 specimen; each volume was 1.5mm thick. C-1 was scanned from the left transverse process to the right transverse process with the slices in a sagittal plane (anterior to posterior). Each section was viewed on a CRT screen. Regions of similar Hounsfield numbers were identified. By definition the Hounsfield number is

$$H = \frac{\mu \text{ bone} - \mu \text{ water}}{\mu \text{ water}} \times 1000$$

where μ's are linear attenuation coefficients. The importance of the Hounsfield number is that the linear attenuation coefficients are related to mass (H = –1000 air; + 1000 for bone).

Coordinates (x, y, z) of selected/representative locations on the perimeter of each region were identified along with a representative Hounsfield number. Up to 5 regions were identified on each slice. Some sections had more than 60 locations identified; a total of 1466 locations with a Hounsfield number for each location were recorded by hand.

On C-2 21 contiguous sections of volume each 3.0mm thick were obtained (529 locations) with a selection process identical to that of C-1. On C-0 12 contiguous sections were made in a transverse plane; Hounsfield numbers were not recorded for C-0.

Data from each scan includes the cartesian coordinates of points describing the outer surface in addition to interior locations on the perimeter of regions. The cartisian coordinate data can be used in the construction of a graphical model, while the Hounsfield numbers can be used to calculate the ratio of consistency (R.C.) for various locations.

$$R.C. = \frac{[H \text{ (spongy bone)} + 1000]}{[H \text{ (cortical bone)} + 1000]}$$

This ratio differs from one cross section to another.

The hand tabulated data was taken to the University of Toledo's Computer Aided Engineering and Design Manufacturing Center, entered into files on the mainframe, and manipulated by a Calma Computer Aided Design System and some proprietary programs. With the help of computer graphics, the complex geometric shapes can be constructed. Once the shape is defined, cross-sectioned geometric/inertial properties can be closely approximated using numeric integration techniques (trapezoidal rule).

The most difficult part of this research was in making the best choices in constructing the computer models. This task was done by Michael S. Levy, the principal researcher on this project who is a product development engineer with Howmedica. When this project began M. S. Levy was completing his thesis in biomechanics at the University of Toledo; his thesis title is "Computer Graphic Methodology for Analyzing the Geometric Properties of the Human Femur".

The femur, the most widely studied bone in the human body, has a shape that is considered complex. In 1986 Hoeltzel used a CAT scan to construct graphical models of femur using a CAD system in order to conduct a finite element analysis of joint replacement protheses. In 1986 Levy improved the model, redefined the longitudinal axis, and determined geometrical properties. M. Levy considers the atlas to be much more complex than the femur.

All of the data for this project has been obtained and a more complete analysis should yield significant information.

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Lateral Cervical X-Ray

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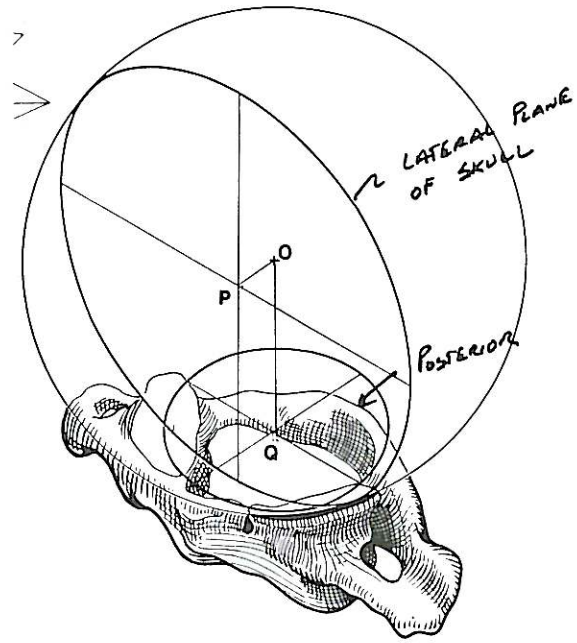

Figure 1
Juxtaposition of the skull on the condyles of the atlas. (From Kapandji).

and close to the center of gravity of the skull (Seemann, 1981). For the atlas, the S-line (Gregory, 1986) and a horizontal line was drawn to form an angle which determines the degree of atlas tilt. For the axis, the midpoint of the odontoid process was located at the tops of the lateral masses, and a line was drawn through the center of the odontoid process. See Figure 2. Another line was drawn from the midpoint to the auditory meatus. With the lines drawn, three rotatory measurements are formed, which establish a relationship between the components. The atlas angle can be measured in degrees from the horizontal, and

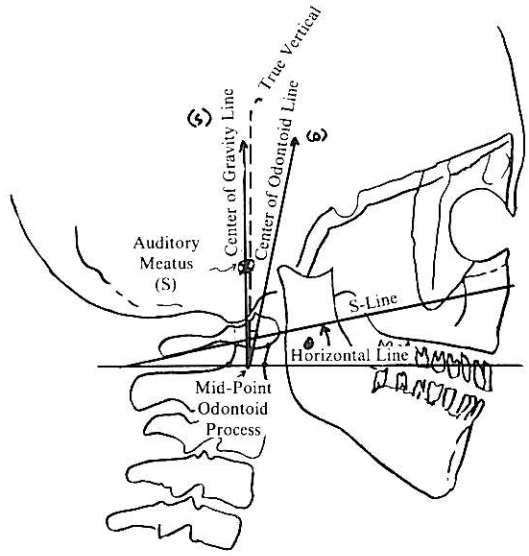

Figure 2
A rotatory system of measurement for the skull and atlas in relationship with the mid-point of the odontoid process.

the skull and axis can be measured in degrees from the vertical. Now it can be argued that others (Kapandji, Harrison, White and Panjabi) have offered systems of measurement which could be used in the NUCCA analysis. But a closer look at the other systems shows they would not be adaptable. For an example, there is a disagreement as to where the center of gravity is with both Kapandji and Harrison. At any rate, the proposed system seems workable and reliable.

Approximately 58 lateral films were analyzed using the proposed system, and an additional 25 pairs of pres and post films were analyzed.

What Is A Normal Curve?

One is lead to believe that a normal curve is concave posteriorly or a cervical lordosis (Kapandji, 1974). A lateral film of a child suggests this is true, (See Figure 3) but the

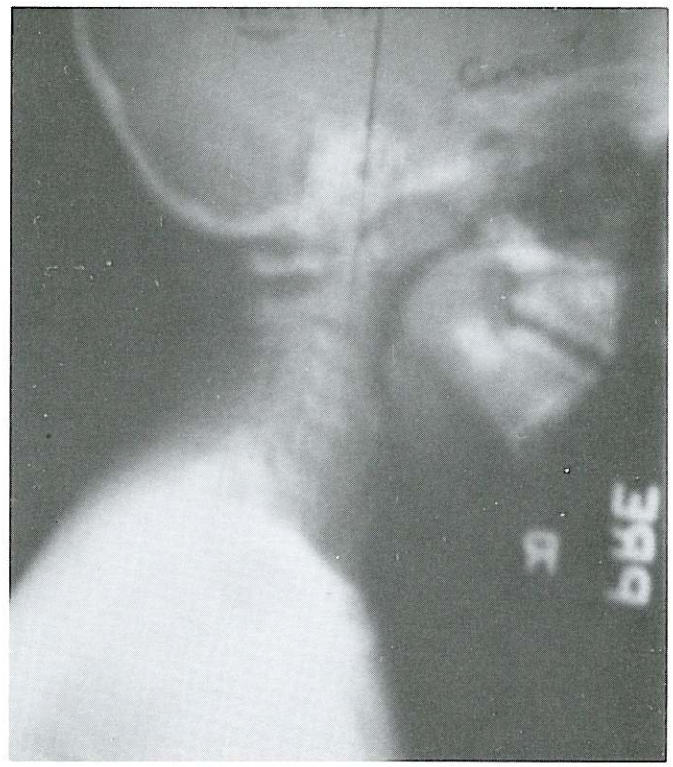

Figure 3
A lateral film of a child showing a lordotic curve.

analysis of the lateral films shows that the norm out of the sample listed above was a straight or military curve with the lordotic and kyphotic curve occurring about a lesser number of times.

Type Curve	Number
Lordotic	21
Kyphotic	10
Military	27

There were exceptions to the findings, but in general, the angle of the S-line was low for the kyphotic curves, medium

for the military curves (10-20 degrees) and high for the lordotic curves (20 or above degrees).

It is still a preliminary finding, but the odontoid seems pivotal in predicting the curve. For an example, if the center of the odontoid line forms an acute angle with the horizontal line on the anterior side of the film, chances are the curve is kyphotic. If the midline of the odontoid is pointing toward the vertical, the curve will be more military. And if the midline of the odontoid forms an acute angle with the horizontal line on the posterior side, there is a good chance the curve will be lordotic.

A surprising finding was that with the lordotic curve, the S-line angle increases. This behavior was also noted with the pre and post analysis. After an adjustment, the prediction was that the S-line would lower to stabilize the reduction. In most cases, just the opposite occurred, i.e., the curve tended toward lordotic and the S-line increased its angle.

An example of the lordotic, kyphotic and military curves are found in Figures 4, 5, 6 respectively.

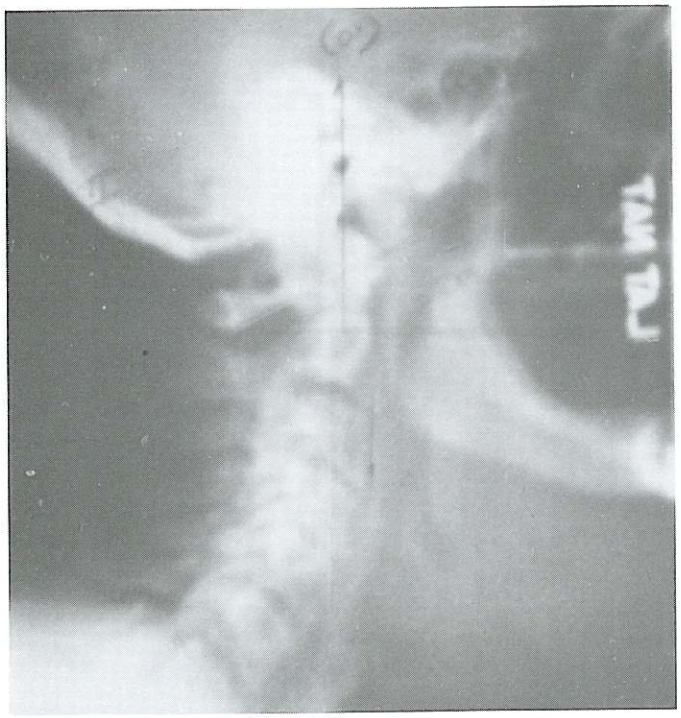

Figure 4
An example of a lordotic curve.

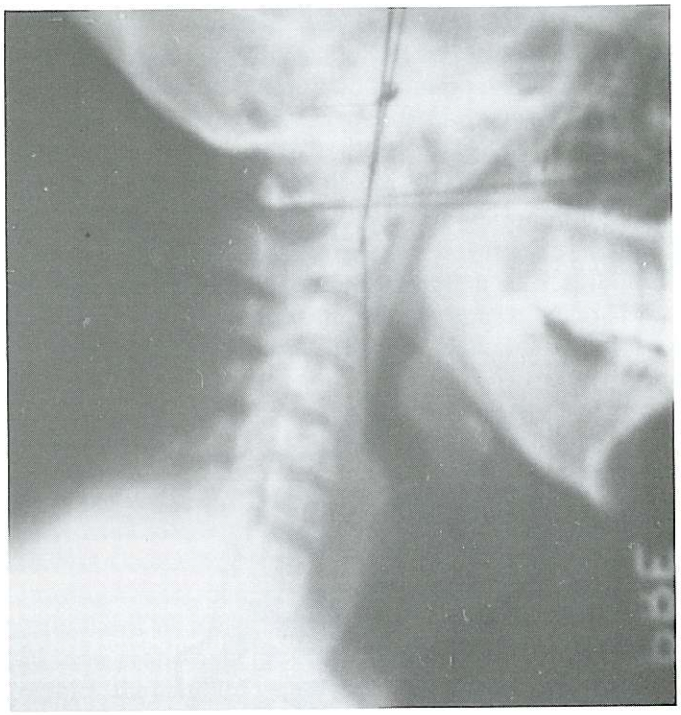

Figure 5
An example of kyphotic curve.

Figure 6
An example of a military curve.

Conclusions

The main point of this paper should not be lost in classifying curves. The main point is to better understand the lateral film in order to hold the adjustment for longer periods of time. What this paper has done is to raise more questions than is answered and some of these questions are noted below.

Probably the most unpredictable thing that happened was the fact that the S-line tended to increase after the adjustment, and at this writing there is no explanation that can be given as to why this happens. There is perhaps something that is not seen in the relationship between the condyles of the occiput and the superior condyles of the atlas.

There generally was agreement that the curve did change after an adjustment, but only after several months. The analysis of the pre-post films supported this notion, but it was really not known whether a change could be realized immediately. So a post x-ray was taken within a day of the adjustment. There was a significant curve change, which was quite surprising. A closer examination of the post x-ray with the pre x-ray minimized the surprise. It was found that the jaw was located slightly different in the post than in the pre

x-ray. This had apparently made a change in the curve. So as a result of this finding, NUCCA is in the process of standardizing how the lateral cervical should be taken and presently there are two suggestions that are made. The first is to make sure the head and jaw are level to the horizontal. The other suggestion is the Frankfort Plane should be used as a landmark (Dorland's, 1974). The Frankfort Plane is a line that runs horizontally between the superior aspect of the auditory meatus and the inferior aspect of the orbit (eye socket). The head should be placed so as the Frankfort Plane is parallel to the horizontal each time that the lateral is taken.

And finally the reader probably does not have to be reminded that the curves that were studied came from patients that were subluxated. Perhaps in another population that was not subluxated a different curve may have appeared. An argument against this position is that several of the posts taken were made of patients who had held their adjustments for long periods of time, to determine if there had been a curve change over a long period of time.

It is the writer's hypothesis that the ideal curve is one that is lordotic where the skull center of gravity is located directly over the center of the odontoid process and the S-line is about 15 degrees above the horizontal.

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Editorial

Recently the International Chiropractors Association's (ICA) President, Michael D. Pedigo, D.C., sought the opinion of the profession's leaders regarding merger of the ICA and the ACA. An opinion from NUCCA was not solicited although NUCCA is a national organization that includes both ICA and ACA members, is recognized by several chiropractic colleges; and, through its companion organization, NUCCRA, conducts chiropractic research which is released gratis to the profession and for which it enlists the expertise of non-chiropractic institutions and personnel at its own expense.

Many assertions for and against merger were expressed in response to Dr. Pedigo's request. It serves no purpose here to defend or to criticize any of these contentions. But one matter that does require discussion because it has not been adequately considered and lies at the roots of the question of merger of the two organizations entertaining such widely different ideologies, is the training and education of the chiropractor.

How a chiropractor thinks and acts in practice is largely conditioned by his/her education; the conclusions at which he/she arrives in forming opinions both as to practice methods and regarding momentous professional questions, such as the merger issue, spring to a great extent from that source. He/she was not born with the educational background; they acquired it. The educational process, therefore, is the reason why the liberal-thinking chiropractor is slowly winning the struggle to incorporate alien practices into chiropractic as more chiropractic colleges expand their curricula and move away from the traditional chiropractic principles and practices that establish chiropractic as a separate and distinct healing art.

The weakness of the chiropractic practitioner lies in his/her lack of truly efficient performance in the practice of the basics of the art in the writer's opinion. Research in the correction of the subluxation as well as education and training have not been adequate. The full potential of the subluxation has not been realized. To meet these defects, manipulation and modalities have been substituted. Few would adopt these systems if their training and education, backed by research, were sufficient. To those who have become competent, there is no substitute for subluxation correction.

Many efficient chiropractors who practice corrective adjustments and the vertebral restoration principle will practice no other way but within the orthodox chiropractic principles and practices. They do not fear competition because their methods are based on research findings acquired after college, and they are practicing a predictable system. They know that chiropractic is a mechanical system, not a chemical one. They are incompatible methods.

The struggle between the conservative and the liberal has been a long and hard one. Its solution lies in research and in education. Merger of ICA and ACA will not resolve this problem; it can only deepen the chasm and cause more problems because chiropractors practicing conservatively will never change. They will resist strenuously. Another national organization will emerge and the struggle continue more bitterly than before. The time to merge is not yet ripe and that time will come only when the subluxation complex and its restoration is more fully researched and more effective techniques developed to restore biomechanical integrity to the spinal column.

Unification of the profession is a desirable objective but not at the expense of further weakening basic chiropractic principles that won us public recognition and legislative victories. We cannot logically or morally protest the adoption of chiropractic practices by other healing arts when we utilize their systems.

The C1 Subluxation Syndrome

By Ralph R. Gregory, D.C.

BACKGROUND

For over twenty years, NUCCA has conducted clinical investigations of the physical signs exhibited in individuals with C1 subluxations. These physical signs comprise what NUCCA has termed the C1 Subluxation Complex Syndrome, abnormal conditions in the human body that are measurable and always associated with the C1 subluxation as determined by cervical x-rays and other checks. These signs indicate that a C1 subluxation is a physical stressor, causing postural defects, bodily strains, and ultimate damage to the intervertebral discs, and to hip and knee joints.

This article discusses three of the physical signs: (1) How the C1 subluxation is produced; (2) distortion of the spine and pelvis from the vertical axis of the body, and (3) leg disparity or what is commonly called the "short leg". The apparent causes of each sign will be discussed with evidence of the causes, and supporting reasons. Reference data is also included.

The term "adjustment" as used in this article means the correction of the misalignments of the subluxation complex: the C1 subluxation, its misalignments, head position in relation to the vertical axis, misalignments of the cervical spine and subjacent vertebrae, and the pelvic girdle. The word "adjustment" means the restoration of these structures to their normal position, not by manipulation, to forcibly and passively move vertebral joints beyond their active limits of motion.

METHOD

In this study thousands of cases were examined. Each case was measured in the supine position for leg disparity, according to the orientation planes. The leg checking procedure included turning the patient's head to alternate sides to reduce the size of the neural canal by torqueing the dura mater, thus increasing or decreasing the effect of the C1 subluxation. The legs were also checked for resistance to a bilateral equal upward pressure. Anatometer measurements for pelvic distortion and excursions of the spine from the body's vertical axis were made and recorded. Cervical spine x-rays—lateral, nasium, and vertex—were taken and measured in degrees for misalignments of the skull, C1 in its different planes, C2 misalignments, and the deviation of the cervical spine from the vertical axis and the relationship of each misalignment to another.

PRODUCTION OF THE C1 SUBLUXATION

The first physical sign—how the C1 subluxation is produced—requires that the vertical axis be established. The vertical axis is the normal along which positioned vertebrae should lie. It is the "Y" coordinate of the orientation planes. The vertical axis is the primary step in film analysis because the adjuster must visualize the normal before analysing the film and be able to predict the result of his adjustment in any given case. To be able to predict the outcome of the adjustic action is scientific procedure.

Vertical axes of the human body can be erected from either the base of support or the pelvis. These are accurate unless the individual subject is subluxated and has a distorted pelvis and a short leg.

NUCCA establishes a line representing the vertical axis for the cervical spine from the center of the first or second dorsal vertebra on a nasium x-ray film. This is called the Fixed Point. A triangular square is placed over a 10 x 12 x-ray plate so that it aligns with the base of the film and its right-angled side passes upward through the center of the fixed point. A line is then inscribed along the right-angled side of the square up through the skull (Fig. 1).

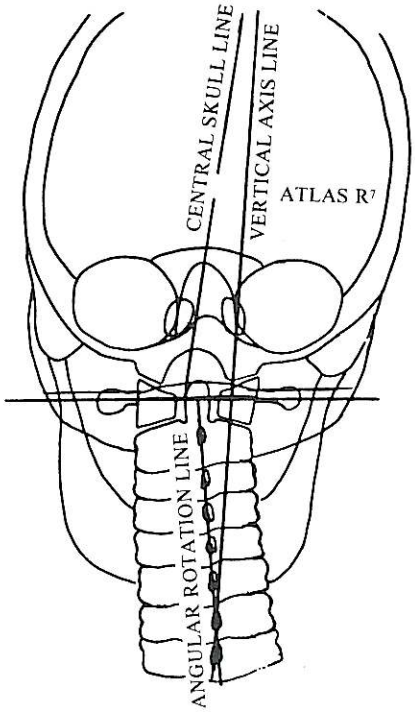

Figure 1 Vertical Axis Line

How can the vertical axis so described be proved? Sufficient evidence of its accuracy appears on the post x-ray film, the x-ray taken immediately after the adjustment. If the adjustment is a corrective process, i.e., if it has restored to normal position the misalignment factors of the C1 subluxation, all the cervical vertebrae will align to the vertical axis so erected. Anomalies, of course, can make a difference.

Further evidence supporting the NUCCA vertical axis line is seen when analysing one of the basic type C1 subluxations, the third basic type (Fig. #2). In this type case, no deviation of the cervical spine below C2 exists from its normal position. A vertical axis line drawn from the fixed point equally divides the centers of the vertebral bodies and the spinous processes, indicating that the cervical spine below C2 has not deviated into either of the two frontal planes or rotated into the transverse plane.

Studies conducted in film analysis show that cervical vertebral rotations below C2 depends on two factors: (1) the

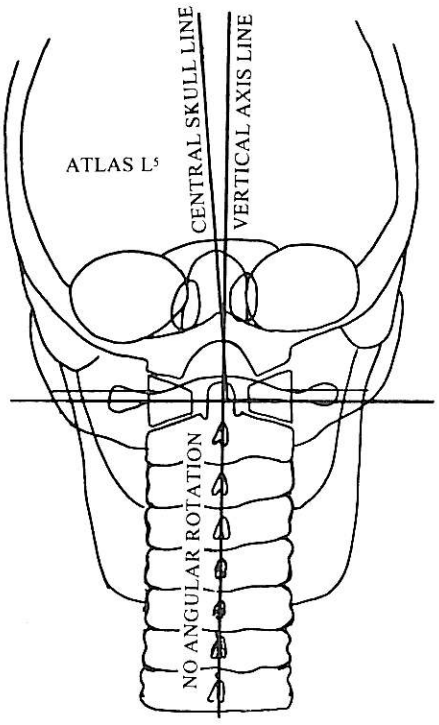

Figure 2
Third Basic Type

amount of excursion of the cervical spine as a unit into one of the frontal planes, and (2) the degree of rotation of the C2 spinous process. The greater the shift of the cervical spine into a frontal plane, the larger will be the cervical vertebral rotation of the spinous processes. The general pattern of cervical rotation will be influenced by the rotation of the C2 spinous.

Examination of thousands of cervical x-ray films showed no exceptions to the NUCCA vertical axis system as described above nor to the factors that cause vertebral rotation of the cervicals and frequently the dorsals except in rare cases of aomaly. The vertical axis also strongly indicates that a normal does exist, a biomechanical normal that should be achieved by the adjustment.

Furthermore, the evidence obtainable from these thousands of x-ray films supports the hypothesis that a C1 subluxation is produced from the movement of the cervical spine into one of the frontal planes in all cases except the third basic type. In this type case the skull moves from the vertical axis, causing the C1 subluxation. These cases constitute less than eight per-cent of the total cases.

The first sign of the C1 subluxation syndrome, then, is disclosed from the x-ray analysis, what the objective is that must be achieved, what constitutes the normal, how the C1 subluxation is produced, and indicates why the syndrome exists. A cervical spine that moves into a frontal plane imbalances the second cervical whose superior articulating surfaces form the base of support for C1 and the skull. The skull's center of gravity is displaced and the line of gravity falls other than through the center of the vertebrae. A subluxation is not a vertebra or vertebrae that occurs within a normal range of motion, but vertebrae that are misaligned into an abnormal range of motion. It is the abnormal range of motion into which vertebrae move that "fix" them into their misaligned positions. The abnormal range of motion away from the vertical axis is the precursor,

DISTORTED PELVES AND THE SHORT LEG

The second and third signs of the C1 syndrome are discussed together because of their anatomical relationship, although each was investigated separately.

The short leg is a sign that many chiropractors depend upon to indicate the presence of a C1 subluxation, whether to adjust or not. For this reason it deserves deeper inquiry as to its reliability as an indicator of neurological detriment and as a means of prognosticating patient progress and spinal stability. Every subluxated patient exhibits a short leg and the degree of its shortness and the side on which it shortens can be of extreme importance in judging the case (Fig. 3). This requires, however, extreme accuracy in measurement and a rather sound knowledge of the mechanism involved in the shortening of the leg.

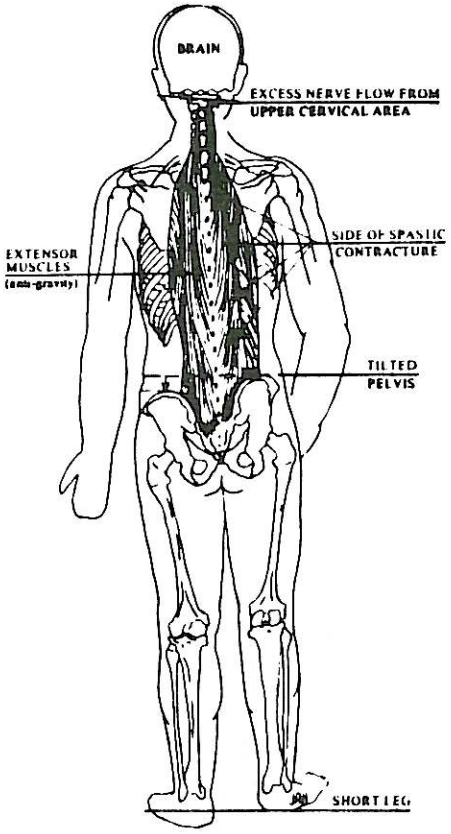

Figure 3 Atlas Subluxation
Complex Syndrome

Congenital and traumatically induced short legs exist. Our records show, however, that these types of leg disparity are rare. The subluxation caused short leg is very frequently observed. The former are not entirely a part of the C1 subluxation syndrome; the subluxation induced short leg is. The patient that has both a C1 subluxation and a congenital or traumatically caused short leg must have the degree of shortening that is caused by each factor ascertained accurately if the lift is a beneficial or a harmful modality. In this article, however, the concern is only with the C1 subluxation caused short leg.

While investigators of leg disparity to date seemed concerned only with measuring leg lengths, NUCCA found it necessary and of great value to move into other areas such as causes and the correlations between the short leg and its causes. Some simple questions were asked. For example, why does Smith have a short right leg while Jones has a short left leg and why are there different degrees of shortness? Why does the short leg change sides sometimes? Why does the short leg appear shorter sometimes than at other times? What really does happen in the body? What is the mechanism? Answers to this type of questioning might provide clues.

It is natural perhaps to assume that when both a short leg and a distorted pelvis exist together, as they always do, that it is the pelvic misalignment that is causing the leg to be short. But, if this were true, patients exhibiting the same degree of leg disparity (allowing for differences in build) should show similar pelvic distortions. For example, a case with a one-half inch short leg should show much the same pelvic distortion as another case with the same amount of leg shortness on the same side. But this is not the case. One may show a low pelvis into the frontal plane of four degrees while the other has only two degrees of distortion into the same frontal plane. Another case with a right short leg of one-half inch may show a pelvic distortion reading that moves high into the right frontal plane on the right side. The NUCCA computer records show that about two in every eight cases have a high pelvic girdle on the side of the short leg and the other eight are low. Thus, Anatometer recordings vary greatly in recording pelvic distortion readings on cases who exhibit the same degree of leg shortness on the same side.

In order to check the hypothesis that the short leg is not caused by a distorted pelvis, NUCCA designed and built the Anatometer (Fig. 4). The Anatometer is a device for measuring pelvic misalignments and deviations of the spine from the vertical axis of the body. The instrument is used both before and after an adjustment of C1. Post adjustic readings show the degree of reduction of the pelvic distortions and the amount of restoration of the spine to the vertical axis following an adjustic correction of C1.

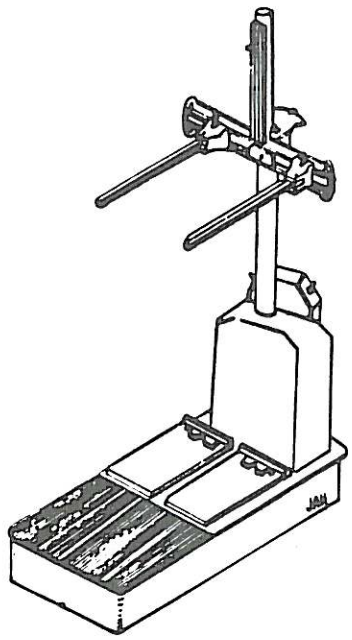

Figure 4 Anatometer

The Anatometer has two motorized foot pads which serve the purpose of measuring the amount of addition to the short leg required to balance the pelvic distortions. It also indicates any abnormalities in either the pelvis or leg. Thus it can measure the amount of leg disparity caused by either a C1 subluxation or a congenital or traumatically caused short leg and differentiate the two. It can also determine the effectiveness of the adjustment, and rule out the amount of curvature caused by a scoliosis and the amount in a scoliotic case caused by the C1 induced distortion.

Because the Anatometer measurements indicated so great a lack of agreement between the pelvis and the leg with the same amount of leg disparity, NUCCA looked for another cause of the short leg. We now knew it was an effect, not a cause of the leg shortening, and that the pelvic distortion was an effect.

NUCCA went further, however, in checking the hypothesis. Patients were placed in the supine position and their legs were carefully checked for leg deficiency. Then, the patient was instructed to turn his/her head to the right. Turning the head would either shorten the leg further, lengthen it, or in rare cases balance it. Turning the head to the left would also change the short leg length. This suggested that the cause of the short leg was in the upper cervical spine.

The reason for leg length changes when turning the head to alternate sides is because the dura mater is torqued when the head is turned. This torqueing procedure reduces the size of the neural canal, producing less tolerance in the canal at that area if a subluxation exists. If the patient is not subluxated, turning the head has no effect on the leg length. The conclusion was that a direct relationship exists between C0, C1, and C2.

Correlations, resultantly, were made of the misalignment factors of the C1 subluxation and bodily distortion. It was found that turning the head in some cases increased the length of the short leg when the misalignment factor that caused the short leg in the first place was increased. This misalignment might be C1 laterality, C1 rotation, or the rotation of the C2 spinous. In some cases it might be a combination of the misalignment factors. In some types of C1 subluxation it was the position of the skull in relation to the vertical axis. If, for example, the x-ray listing showed a small laterality to the right and a large rotation of C1, the right leg would be found to be the short leg if the laterality were anterior. Turning the patient's head to the right further shortened the right leg because it increased the rotation. Turning the patient's head to the left in this case reduced the length of the short leg because it reduced the effect of C1 rotation.

These finds were indicative of the fact that there existed certain misalignment factors of the C1 subluxation that were responsible for leg imbalance and, of course, pelvic distortion. It seemed that there must be some neurological imbalance that was caused by the C1 subluxation's mis-

alignment factors which affected the extensor or antigravity muscles, and it was clear that different misalignments had different effects on the musculature in different cases.

The observations lead to the predominant factor theory, Defined, the predominant factor is that direction of the misalignment of the Atlas Subluxation Complex that causes the greatest neurological detriment, resulting in spastic contracture of the extensor or antigravity musculature. Rotation of C1 on the occipital condyles (laterality) has proved to be the most sensitive and detrimental abnormal movement of C1. Rotation of C1 into the transverse plane has been secondary.

Muscular examination of the C1 subluxated patients disclosed spastic contracture evident on the side of the short leg which was not apparent after a C1 corrective adjustment of C1 was made.

So the hypothesis that a C1 subluxation produced spastic contracture of the extensor musculature which distorted the pelvic girdle and caused an excursion of the spine from the vertical axis, shortening the leg on the side of the contracture, was made; and that one or more misalignment factors of the C1 subluxation were primarily responsible because of their greater and detrimental effect on the central nervous system at the occipital-atlanto-axial area of the cervical spine.

With this knowledge, a practitioner could produce a short right leg where a left short leg existed before simply by rearranging the misalignment factors. If such a re-arrangement occurred through accident and the opposite leg was found to be the short leg, re-x-ray of the case always showed the extent and the pattern of the re-arrangement. This also served to confirm the hypothesis.

Cases returning for service after months or even years have shown a short leg opposite to the one originally noted on their record cards. In all such cases, these patients, when re-x-rayed showed changes in either the misalignment factors or the relationship between them. Not only was there a change in the side to which the leg shortened but in the Anatometer recordings as well.

Still another method used in checking the short leg was testing for resistance to an upward applied pressure. This pressure is applied separately and equally to each leg. The short leg will always show considerably less resistance to the pressure; the longer leg will resist the applied pressure. When a C1 subluxation is in the inceptive stage, the loss of resistance is quite apparent even before the leg shortens. Such a resistance results from the tonicity of the musculature and when the tonicity is lessened and spastic contracture sets in there is much less resistance in the muscles affected. Following a corrective adjustment, equal resistance is found whenever applied pressure is exerted on the legs.

On the basis of these clinical investigations, it is logical to accept the hypothesis as proved that pelvic distortions and the short leg result directly from the effect of the misalignment factors of the C1 subluxation on the central nervous system of the patient.

What, then, is the neurological mechanism involved in a C1 subluxation?

More than one theory has been advanced in the chiropractic profession to account for the neurological mechanism involved in the C1 subluxation. These have ranged from "nerve pressure" to the "dentate ligament neural traction mechanism"[1] theory, which has considerable merit and bears further investigation. NUCCA has concerned itself with the Reticular Formation because it more nearly relates to spasticity of extensor musculature.

Neurologists describe the reticular formation as located in the brainstem at its central part, receiving afferent (sensory) innervation from the cerebral cortex, from the periphery by way of the spinal cord, from the cerebellum, the vestibular nuclei, and the nuclei of the crainial nerves. "In fact", states Grinker's Neurology," it appears likely that the reticular formation receives impulses from all parts of the central and peripheral nervous systems. Likewise, it sends impulses downward into the spinal cord, upward into the thalmus, the ganglia, and the cerebral cortex. The neurons of the reticular formation are so extensive in their dendritic and axonal connections that a single neuron of this system may be related functionally with thousands of other nerve cells."[2]

Mountcastle's MEDICAL PHYSIOLOGY states "Physiologic studies indicate that it (reticular formation) exerts powerful facilitatory and inhibitory influences on all types of motor activities at all levels of the nervous system".[3]

The rather large cells scattered throughout the formation account for numerous reflex connections within the brainstem and also give rise to the reticulospinal fibers which, of course, descend into the spinal cord and synapse upon anterior gray column cells, according to neurologists. They further state that the ratio of facilitatory and inhibitory impulses converging on the lower motorneurons is such as to maintain normal muscle tone. When facilitory impulses predominate, excess muscle tone (rigidity or spasticity) occurs. Facilitatory impulses normally slightly exceed inhibitory impulses. (Fig. 5.)

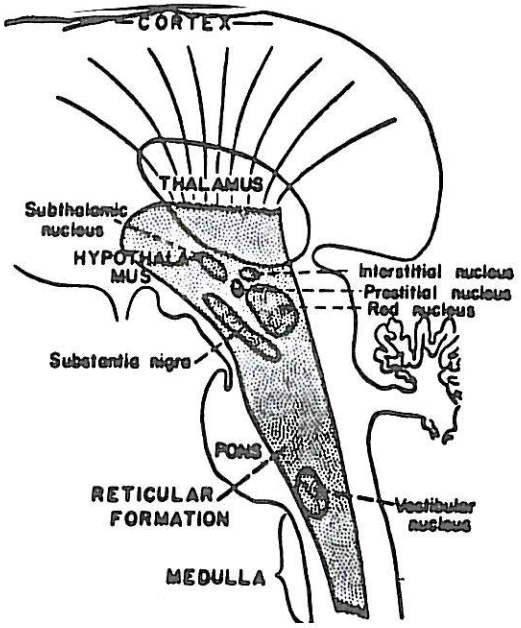

Figure 5 The reticular formation and associated nuclei.

From A. C. Guyton's **Textbook of Medical Physiology, 3rd Edition, W. B. Saunders Co., Philadelphia, 1966.**

Facilitatory tracts are so termed because they conduct impulses that facilitate, i.e., decrease the resting potential of lower motorneurons. The impulses that inhibit are carried by the inhibitory tracts; they increase the lower motorneurons's membrane potential above its resting level. Facilitation is the effect produced in nerve tissue by the passage of an impulse. The resistance of the application of the stimulus evokes the reaction more easily.

According to physiologic studies, impulses over facilitatory reticulspinal fibers facilitate the lower motor neurons that supply extensor muscles while at the same time inhibiting the lower motorneurons that supply the flexor muscles. Resultingly, facilitatory reticulospinal impulses tend to increase the tone of extensor muscles and decrease the tone of flexor muscles.

It is logical to see that a C1 subluxation can produce such a widespread distortion effect on the human body by causing an imbalance in the reticular formation between the facilitatory and inhibitory fibers. When the C1 vertebra misaligns, it affects detrimentally the inhibitory control over the facilitatory mechanism, resulting in an over-innervation of the motorneurons. A C1 subluxation, then, is an over-innervation of the central nervous system, not a reduction in the nerve impulse flow.

Of course NUCCRA's problem was to obtain evidence supporting the hypothesis that a C1 subluxation could cause an imbalance in the reticular formation sufficient to over-innervate the spinal cord, cause disparity of leg length, and spastic contracture of the extensor or antigravity musculature. Whenever a C1 subluxation was present, the indication was that it did because of the objective signs; their absence when no C1 subluxation was recordable indicated support of the hypothesis.

But this was insufficient evidence. While a connection was indicated, it was too gross from which to draw sound conclusions. The fact that measurements from the x-ray film of only the thickness of a sharp pencil mark of the lateral movement of C1 on the occipital condyles caused spastic contracture without exception of the antigravity musculature provided some support of the hypothesis that a C1 subluxation could cause an imbalance between the facilitatory and inhibitory neural mechanisms.

When post-x-rays were taken immediately after a C1 adjustment which showed by measurement that the misalignments of C1 were restored to normal position and the spastic contracture disappeared, this evidence was supportive, more so because there were no exceptions.

Was it tractionization that produced the imbalance in the reticular formation? Patients who had received a corrective service, recovered, and five or six years later returned for service because of some injury, exhibited a short leg to the same degree or greater than previously recorded, with pelvic distortions of greater magnitude as observed on the Anatometer, were x-rayed. These x-rays disclosed one-third to one-half the amount of misalignment that they had originally. In other words, their neural canals were not nearly as reduced in size on their second visits. The foramen magnum was aligned better, C1 was not as shifted laterally or rotated, C2 was more aligned, and so on, yet the C1 subluxation syndrome was as great or more so.

The only explanation that fits the above situation is that less tolerance exists in the case that returns after receiving corrective service some months or years later, and the only change that conceivably could take place is that previously tractionized neural tissue had increased in diameter.

But obtaining acceptable evidence that a misalignment factor of C1 could imbalance the neural mechanisms was more complicated than it appeared to be. NUCCA had been aware for many years that a lateral misalignment of C1 on the occipital condyles (laterality) would cause a contralateral short leg and spastic contracture on the contralateral side of the patient. When rotation of C1 was in excess of six times the laterality of C1 and anterior, the spastic contracture was ipsilateral and so was the short leg. If the rotation of C1 was posterior on the side of laterality only in the amount of three or four degrees, the spastic contracture and short leg were ipsilateral. (The reasons for the change of sides so far as rotation is concerned lies in the axes of motion about which each type of rotation takes place) The position of the skull in relation to the vertical axis, the rotation of C2, and the degree to which the cervical spine has deviated from the vertical axis are also factors in determining the side of spastic contracture and the short leg.

So the problem is very complicated and has been under observation and testing for years under the hypothesis of the predominant factor, or that misalignment direction that causes the greatest neurological imbalance and, resultantly, spastic contracture of the extensor muscles.

A study some years past disclosed that when a C1 subluxation is in its inception period some patients would show an opposite short leg to that always seen when they were subluxated for a day or two. A few patients cooperated with the study and were checked nearly every day. Nasium and vertex x-rays were taken whenever they showed evidence of a short leg and later when the opposite leg shortened—the original short leg. No adjustment was given between the x-rays.

These x-rays showed that in some cases during the inception period, one misalignment factor of the C1 subluxation—either laterality or rotation—appeared first, shortening one leg, and when the original short leg appeared, the x-rays taken then showed that the misalignment that caused the spastic contracture and short leg had increased to the point where it became the predominant factor. This was rather convincing evidence.

Further testing is still being conducted by NUCCA. The predominant factor theory is not nearly completed yet. The evidence, however, seems highly supportive of the imbalance in the reticular formation caused by a C1 subluxation as the cause of the spastic contracture and the short leg.

The term "short leg" is not descriptive if the leg is shortened by spastic contracture of the antigravity muscles. NUCCA suggests the term "contractured leg" when caused by the subluxation. The term "short leg" should be applied only to those cases in whom the leg is shortened from congenital or traumatic reasons. Even in these cases the leg

may be shortened to some extent by the C1 subluxation, and only after a corrective adjustment of C1 can it be determined which factor is causing how much of the leg disparity.

CONCLUSION

This paper has discussed some of the clinical investigations that have been conducted by NUCCA over the years. It is hoped that it will stir an interest in other investigators to pursue the subjects included herein.

References:

1. A discussion of the dentate ligament neural traction mechanism. J.E. McAlpine, International Review of Chiropractic, October-November 1980.
2. Neurology, 6th Ed., R. R. Grinker and A. L. Sahs, Chas. C. Thomas Co., Springfield, Illinois, 1966.
3. Medical Physiology, 13th Ed., Volume 2, C. V. Mosby Company, St. Louis, 1974. Edited by V. Mountcastle.

Palmer College Approves NUCCA

In a letter under date of November 12, 1986, Dr. Patrick T. Keefe, Sr., Dean of the Palmer College Department of Continuing Education advised Daniel C. Seemann, Ph.D., Executive Director of NUCCA, that the Executive Committee of the Palmer College of Chiropractic had approved the NUCCA work, both Basic and Advanced, to be taught at Palmer College.

NUCCA looks forward to setting up a format for the NUCCA Course.

NUCCRA Receives Donation From Fair Estate

NUCCRA recently received a check for $10,000 from the estate of the late Dr. Helen Fair of Dallas, Texas, for research. Dr. Fair was a member of the National Upper Cervical Chiropractic Association, Inc. (NUCCA), and a Practitioner of NUCCA technique for several years. She attended many of the NUCCA Seminars, and will be sadly missed by her many friends and colleagues.

NUCCA Visits Life College

The National Upper Cervical Chiropractic Association, Inc. (NUCCA) was represented at Life Chiropractic College in Marietta, Georgia, December 5th and 6th at the Third Annual Upper Cervical Symposium by Mr. James F. Palmer, M.S., Keith E. Denton, D.C., and Ralph R. Gregory, D.C.

Mr. Palmer and Dr. Denton discussed computerized modeling of C0, C1, and C2. Mr. Palmer is a Professor at the University of Toledo and a member of the NUCCRA Research Board; Dr. Denton is a practicing Chiropractor and also a member of the NUCCRA Research.

Dr. Gregory, President of NUCCA-NUCCRA and a Research Board Member, talked on the C1 subluxation syndrome.

Following a hosted luncheon at the Waverly Hotel in Marietta, Dr. Sid Williams, President of Life College, talked about future plans for the college, and his interest in Upper Cervical work.

Donors to NUCCRA Research

NUCCRA Research has expanded in the search for solutions to many problems regarding the subluxation, its effects, and its correction. Non-chiropractic institutions have become involved with their expertise. Many thousands of dollars have been raised, and more money to finance research is needed.

Contributors wishing to assist may contribute directly to NUCCRA or through the Ruth O. Gregory Memorial Fund. This fund was established by the NUCCA Directive Board after Mrs. Gregory's death in 1982 and is to exist in perpetuity. It is in memory of Ruth O. Gregory, who devoted time, effort, and money so unselfishly to the organizations that chiropractic would become more scientific and of greater benefit to the patient, the practitioner, and the profession.

All contributions are tax deductible.

Listed below are the most recent donations to NUCCRA and to the Ruth O. Gregory Memorial Fund. NUCCRA extends its heartfelt thanks to all who have so kindly contributed.

Dr. Marshall Dickholtz, Sr.	Illinois
Mr. Bert Kizer	Illinois
Mrs. Marynelle Shields	Indiana
Mr. & Mrs. M.J. Anderson	Ohio
Dr. K.A. Sheppard	Texas
Dr. R.N. Danec	Washington
The Lees (H.F. Memorial)	Texas
Dr. K. Moon	Ohio
Dr. D. Fedeli	Illinois
Mr. Andrew Lesko	California
Dr. Mary Madden	Texas
Dr. P. Kanwischer	Vancouver, B.C., Canada
Dr. E. Stein	Washington
Dr. H. Iwo	California
Dr. K. Nakano	California
Dr. S. Duff	California
Mr. John Savage	Ohio
Dr. Glenn Cripe	California
Dr. D. Gordon Hasick	Calgary, Alberta, Canada
Dr. L.D. Vinson	Alabama
Dr. Charles Hough	California
Dr. Eloise Chambers	Washington
Dr. Larry Schrock	Indiana
Drs. James & Lauren Downes	California
Dr. Albert Berti	Burnaby, B.C., Canada
Dr. Lloyd Pond	New Mexico
Dr. Lonnie Pond	New Mexico
Pond Chiropractic Clinic	New Mexico
Dr. Ralph R. Gregory	Michigan
Mr. J.P. McNerney	Ohio
Dr. K.E. Denton	Michigan
Mr. James Palmer	Ohio

The 1987 NUCCA Convention and Educational Conference

The 1987 NUCCA Convention and Educational Conference will be held at the Howard Johnson Motor Lodge, 1440 North Dixie, Monroe, Michigan (48161). It will start on Saturday, May 2nd at 8:00 a.m., and close on Tuesday, May 5th at 12:00 noon. The Educational Conference will be supervised by Daniel C. Seemann, Ph.D., University of Toledo.

The Convention Chairman is Dr. Daniel Fedeli, Chicago, Illinois.

Theme of the Educational Conference is: The Application of Biomechanics to the Spinal Column.

Past NUCCA educational conferences and seminars have been accepted by many state boards for License-Renewal. Participants at the 1987 conference who wish to avail themselves of credit must attend all the educational sessions, be monitored by NUCCA, obtaina NUCCA attendance card, and have it punched at each session.

Subjects will include basic film analysis for beginners, advanced film analysis for more experienced doctors, classifications of the C1 subluxation complex, patient placement on adjusting tables for each type subluxation, mechanical levers, subluxation resistances, anatometer exercises, leg checking, and problem exercises in biomechanics, adjusting, and film analysis. Most of the instruction will be "hands on."

Prepared video-tapes will include: structure identification; adjusting errors; x-ray machine alignment; patient placement for upper cervical x-rays; and others as time permits.

The fee for a professional is $350. For doctors in practice two years or less, the fee is $200. Students are admitted for $150. The fee in each case includes membership for one year. A $25 charge is added to all registrant's fees who have not sent in either their fall fee or a deposit of $50 by the deadline date.

Income above expenses from the convention will be donated to NUCCRA for research. Dr. Seemann and James F. Palmer, M.S., University of Toledo, will discuss current research projects.

NUCCA will host a banquet on Monday evening, May 4th, 1987 at 7:30 p.m.

The deadline for the 1987 convention is March 20, 1987. Please register early because only a limited number can be accommodated.

Further information can be obtained by writing NUCCA, 217 West Second Street, Monroe, Michigan 48161.

NOTICE

The fees set by the NUCCA Board of Directors for applicants taking the Certification Tests are as follows:

1st Segment -	$ 50.00
2nd Segment -	$100.00
3rd Segment -	$100.00

Fees are payable prior to taking each segment. Applicants should make checks payable to NUCCA, Inc.

NUCCA CERTIFICATION

A certification program has been initiated by the National Upper Cervical Chiropractic Association, Inc. (NUCCA). The purpose of the program is to NUCCA-qualify doctors in the NUCCA work. Doctors who successfully complete the program will be eligible to conduct and teach basic classes. A certification committee will be established from the initial group of doctors first certified. Examinations will be given at NUCCA seminars and conventions.

Doctors who wish to be NUCCA-certified must meet the following prior conditions: (1) be in practice for a period of at least three years, (2) have possession of, or access to, equipment and instrumentation recommended by NUCCA, and (3) permit NUCCA inspection of their office facilities. The entire examination must be completed in two years. Certificates will be issued successful candidates.

Doctors who have not engaged in practice for three years but who have attended NUCCA seminars are eligible to take the examination which covers a two-year period. A fee is charged each candidate. In the event of failure of the examination, or any part thereof, the candidate is re-examined in the part of the examination he failed without paying an additional fee, provided re-examination takes place within the two-year period.

Certification will be evaluated every three to five years, and certified doctors will be requested to either take an oral examination on updated data or provide evidence that they have attended a NUCCA seminar at least once each year.

The examination is in three segments, as follows:

1. X-RAY AND INSTRUMENTATION
   - A. Understanding of x-ray alignment procedures
   - B. Theory about distortion, magnification, collimation
   - C. Produce ten sets of cervical films suitable for analysis
   - D. Examination on x-ray procedures
   - E. Submit a set of x-ray alignment films
   - F. Examination on instrumentation
2. FILM ANALYSIS
   - A. Knowledge of osseous structures
   - B. Read ten sets of cervical spinal x-rays with an inter-observer reliability of .90
   - C. Examination of film analysis
3. ADJUSTING
   - A. Submit ten sets of consecutive pre and post cervical x-rays. The post x-rays presented to the examining board be those taken after the initial adjustment. Reductions in the height and rotation vectors to be evaluated at the discretion of the examining board.
   - B. Oral examination in which the candidate is given various listings for which he is to explain reduction procedures.
   - C. Written examination on adjusting. 100 questions with a passing grade of 85.