MEASUREMENTS OF A SPECIFIC ATLAS AND ITS RELATIONSHIP IN NORMAL POSITION TO THE CIRCUMFERENCE OF ITS ARC OF LATERAL TRAVEL

The measurement across the antero-posterior centers of the superior rims of the superior articulating facets of the atlas is one and twenty-thirty-seconds inches.

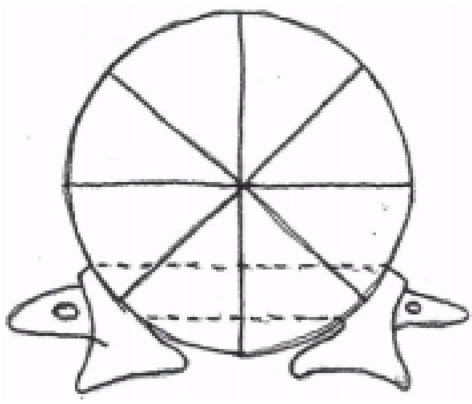
The measurement across the antero-posterior centers of the inferior rims of the superior articulating facets is one and four/thirty-second inches.

The measurement from the inferior to the superior rim at the antero-posterior center of the superior articulating facet is eleven/thirty-seconds of an inch.

The diameter of the circumference of the arc of travel is one and twenty-eight/thirty-second inches.

The ratio of the diameter of the circumference of the arc of travel to the transverse width of the atlas is as 1.1538 is to 1.

The diagram below shows the lateral masses of the atlas in normal relation to the condyles and shows their relation to the circumference of the arc of travel as determined by the arc of the facets and their distance-relation. This relation allows for concentric arc-travel with the centers of the facets ninety degrees apart with respect to the circumference of movement and bisecting the lower two quadrants with the atlas in parallel relation to the horizontal midline of the circle.



RELATIVE VALUES OF FORTY-FIVE DEGREES TRAVEL

FROM VERTICAL CENTER

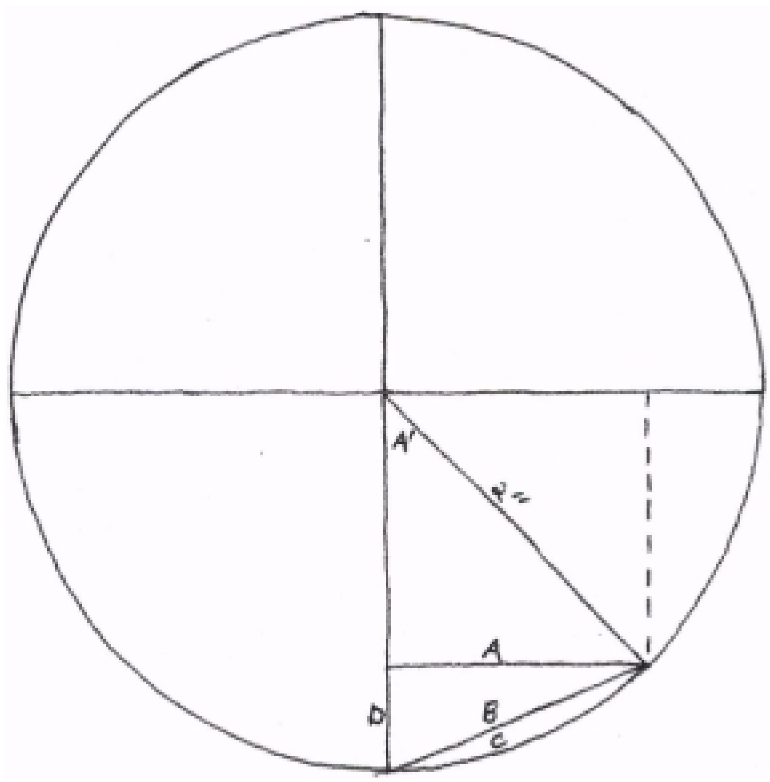
ON A CIRCLE OF FOUR INCH DIAMETER

- Circumference of circle equals four times 3.1416 equals 13.5664".
- A equals two times .7071 (sine of angle A) equals 1.4142", the actual, lateral travel.
- B equals 1.5308", the shortest distance from start to end of travel
- C equals one-eighth of the circumference or 1.5708", the arc of total travel.
- D equals 2" minus 1.4142" equals .5858", actual vertical travel.

Relative Values of Five Degrees Travel from Vertical Center

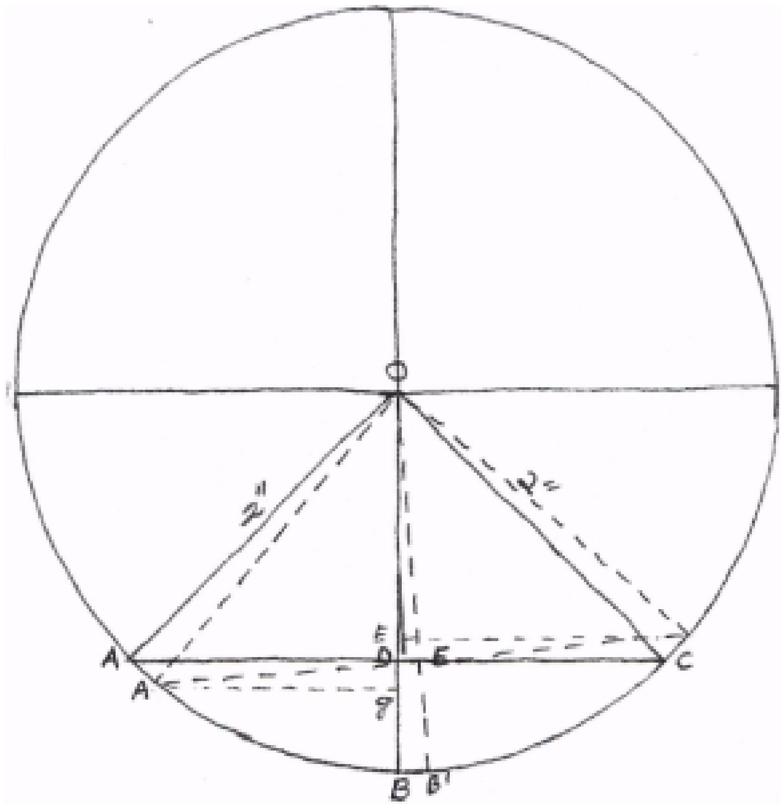
A equals two times .08715 (sine of angle A) equals .1745", actual lateral travel.

C equals one/seventy-second of 13.5664" or .1745", the arc of total travel.



RELATIVE VALUES IN A FIVE DEGREE SIDESLIP

ON A CIRCLE OF FOUR INCH DIAMETER



Note: {Figures in brackets} represent Max Sutter's penciling in for 2" diameter approx.

Four inch diameter equals 12.5664" circumference. {-6.2832"}
Five degrees travel equals .1745" distance of arc-travel. {0.873"}
AA equals .1745" distance of arc-travel of LLM. {0.873"}
CC equals .1745" distance of arc-travel of RLM. {0.873"}
BB equals .1719" distance of arc-travel of atlas center. {0.859"}

DD equals 1.4142" {.7070"} RLM equals .1288" actual vertical travel {.0644}
EC equals 1.532" {.766"} LLM equals .1178" actual vertical travel {.0589"}
EC-DC equals .1178" {.0589"} RLM equals .1178" actual lateral travel {.0589"}
AG equals 1.2854" {.6427"} LLM equals .1288" actual lateral travel {.0644"}
AD-AG equals .1288" {.0644"}

OG-OE equals .2466" {.1233"} actual vertical difference between right and left lateral mass.
OD equals 1.4142" {.7071"}
OE equals 1.2854" {.6427"}
OD-OE equals .1288" {.0644"}
EC-AG equals .2466" {.1233"} actual lateral difference from center between right and left lateral mass.
OG equals 1.532" {.766"}
OG-OD equals .1178" {.0589"}

The lateral travel of the left lateral mass toward vertical center plus the lateral travel of the right lateral mass away from vertical center equals .2466" {.1233"}

The actual travel of the lateral masses on the condyles is .1745" {.0873}.

The ratio of the actual travel of the lateral masses in sideslip is the sum of the lateral movement of the lateral masses toward and away from the vertical center of normal relation to the circle of actual arc-travel is as 1.4155 is to 1.

When the fixed point of the dividers is placed at the lateral center of the anterior arch of the foramen magnum, and the free point measures the distance from the fixed point to the lateral side of the lateral mass et the foramen transversarium on the side opposite laterality, and the free point with this measurement is swung around to the lateral side of the lateral mass on the side of laterality to a point lateral to the foramen transversarium, the distance from the lateral side of the lateral mass on the side of laterality to this determined point will measure approximately twice the actual lateral movement of the lateral masses upon the condyles and approximately one and one-half times the actual travel of the lateral masses upon the condyles.

PRACTICAL COMPUTATION OF ATLAS SLIDESLIP

IN DEGREES

1. The majority of atlases as viewed upon x-rays vary between 2" and 2.5" from small children to large adults in their transverse widths (distance between lateral sides of the lateral masses at the foremen transversarium).

2. The difference in distance from the lateral center of the anterior arch of the foramen magnum between the right and left lateral masses when an atlas of 2" transverse width sideslips one degree is .02443" or .78 thirty-seconds of an inch.

3. The difference from the lateral center of the anterior arch of the foramen magnum between the right and left lateral mass when an atlas of 2.5" transverse width sideslips one degree is .03052" or .97 thirty-seconds of an inch.

4. For practical purposes the difference between the lateral sides of the atlas as measured from the center of the anterior arch of the foramen magnum with dividers will show one degree of sideslip for each one/thirty-second, of an inch difference.

The sum of the lateral movement of the lateral masses away from and toward center being roughly one and one-half times the movement of the facets on the condyles, if this measurement is three-thirty-seconds of an inch the actual movement of the facets on the condyles will be roughly two/thirty-seconds of en inch.

The ratio of the lateral movement of the facets on the condyles to that of the antero-posterior movement for each degree of movement is approximately as 7 (the average circumference of lateral movement) is to 2.55 (the circumference of antero-posterior movement) or approximately as 3 is to 1.

One degree of lateral movement has then a value of three times that of 1° of antero-posterior movement in actual movement between the facets of atlas and the condyles. This, however, does not by any means infer that this is the ratio of their importance since the sweep of the posterior arch of the atlas is augmented in antero-posterior movement by its distance-relation to the center of movement.

The actual distance of travel and that viewed upon the x-ray differ because of increase in the latter due to film-object-tube distance.

AN ANALYSIS OF POSSIBLE MOVEMENT BETWEEN ATLAS AND CONDYLES BASED UPON MEASUREMENTS OS A SPECIFIC ATLAS

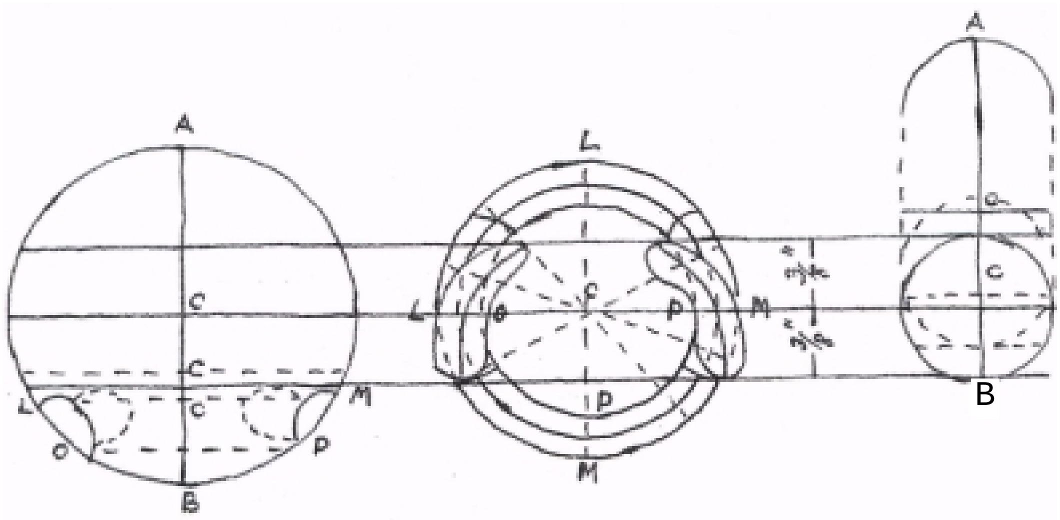


Fig. 1 Fig. 2 Fig. 3

Fig. 1-

Shows circle of lateral arc-travel of facets on condyles.

Upper c represents the axis center of lateral travel.

Red c represents the axis center of antero-posterior travel as determined by its correspondent c in Fig. 3 and red dotted line represents the axis of antero-posterior travel.

Line LM represents the distance between the superior rim of the AP center of the facets while line OP represents the distance between the inferior rims. These lines correspond with lines LM and OP in Fig. 2.

The position of facets is shown in relation to a disk conforming to en extended surface of condyles. The red dotted lines depict the anterior portion of the facets, the black lines the posterior portion. Note overlapping of facets.

The dimension of AB in Fig. 1 conforms to that, in Fig. 3, while the vertical distance between the two dotted lines indicating, the superior and inferior rims of the facets is identical with that between the red dotted lines in Fig. 3.

Note that the axis of lateral movement differs greatly from that of antero-posterior movement.

Fig. 2-

Figure in red designates the position of facets necessary for concentric rotation.

Note the rapid shortening of radius at the anterior portion of the facets and lengthening of radius in lesser degree at the posterior portion.

Lines LM and OP correspond with identical Lines in Fig. 1.

The center point c corresponds with the vertical axis AB in Fig. 1 and 3.

Fig. 3-

Black circle at bottom is the circle of antero-posterior arc-travel determined by the chord, produced by the depth of the facets (one-quarter inch) and the antero-posterior distance between the anterior and posterior rims of facets (three-quarter inch).

Red dotted circle shows the actual center of antero-posterior arc-travel in relation to the center of lateral travel determined by the position of the facets in relation to the circle of the ere of lateral travel as shown in Fig. 1.

In lateral travel although the radii decrease from the center of facet to the anterior and to the posterior all these radii agree in their axis in concentric movement. The longest radius is determined by the center of the facet the concavity of which also determines the arc of travel agreeing with its companion facet in radius of movement upon a circle of specific dimensions and also agreeing with its companion facet with respect to their relative positions upon such circle.

In antero-posterior travel although the radii decrease from the rim of the inferior lip laterally all these radii agree in their axis in concentric movement. The longest radius is determined by the rim of the inferior lip of the facet, the depth of the chord by the vertical distance between the inferior and superior lip of the facet, and the length of chord by the antero-posterior distance of the superior lip or rim which two factors in turn determine the circle of travel.

For free concentric movement to be possible laterally, antero-posteriorly, and rotatory it would be necessary for all parts of the superior articular facets and condyles to agree to portions of a sphere and all portions of the superior facets and condyles in relation must agree with all radii with the longitudinal and lateral axis of such sphere. This would be the equivalent of a ball and socket joint allowing the condyles to swivel freely in any and all directions upon the superior facets of atlas. The circle of antero-posterior movement would then of necessity agree in diameter with that depicted in red in Fig. 2 and the articular surface of the condyles in convex relation with the concavity of the facets must agree uniformly throughout in agreement with such sphere. (See following page).

The superior articular facets of the atlas, and of necessity the articular surfaces of the condyles since they agree in their convexity with the concavity of the facets, obviously do not conform to these requirements, their construction being such as to prevent any rotatory movement since the arc of antero-posterior travel is much less than the arc of rotatory travel with which it would have to agree in conforming to the same portion of the same sphere.

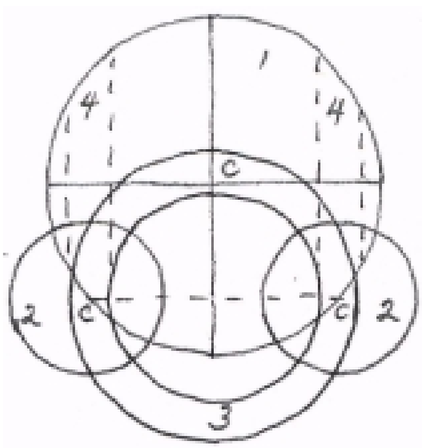
In view of the above, if the right lateral mass were to move anterior upon its condyle in a reciprocal rotatory movement with the left lateral mass moving posterior on its condyle, the anterior portion of the left articular facet would force the posterior portion of the right articular facet against the portion of condyle in apposition. Were the anterior and posterior portion of the condyles and facets vertical the effect would be a “binding" of the articulation. The facets and condyles, their articular surfaces being constructed in the arc of a circle, this "binding" effect would immediately serve to elevate the condyles and so force a separation of condyles and facets, and such separation would be proportionate to the size of the circle and the portion of circle the superior rims of the facets rest upon in relation to the horizontal and vertical diameter of such circle. Because of this relation the separating movement would be greater than the rotary movement. In addition the anterior portion of the right facet and condyle and the posterior portion of the left facet and condyle would be forced into further separation by rotation.

This "binding" effect would always occur at the anterior portion of the condyle and facet opposite the side of anterior rotation and at the posterior portion of the condyle and facet opposite the side of posterior rotation and the separating effect due directly to rotation at the anterior portion of the condyle upon the side of anterior rotation and at the posterior portion of condyle and facet on the side of posterior rotation. Encountering the resistance of separation of the condyles and facets in articulation the atlas would follow the lines of easier movement into sideslip, inferiority and superiority.

There appears to be no structural limitations in the superior articular facets of the atlas or in the condyles that would tend to limit either antero-posterior or lateral arc travel, so that any limitation to this travel must be due to ligaments and muscles. There is, however, a structural arrangement of this articulation that definitely prevents a rotatory movement between condyles and atlas.

ACTUAL CIRCLE OF LATERAL ARC TRAVEL CONTRASTED WITH

REQUIREMENTS ALLOWING ROTATION OF ATLAS ON CONDYLES



1. Circle of arc of lateral movement- one and twenty-eight/thirty-seconds inches in diameter.

2. Circle of antero-posterior movement- twenty-six/thirty-seconds of an inch in diameter.

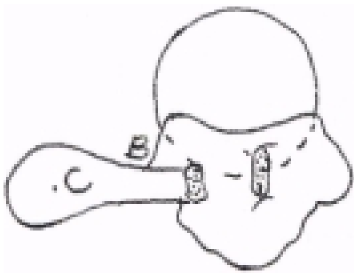
3. Circle of concentric rotary movement required- one and twenty/thirty-seconds inches at the superior rims of the superior articular facets of the atlas.

4. Circle of antero-posterior movement if the condyles and facets conformed to the requirements permitting concentric rotation,

   The diameter would be same as that of #3.

   Note that all movements obeying the requirements of concentric rotation conform to the center-point of axis C in the center of the circle of lateral travel.

VALUES OF MOVEMENT OF POINTS OF A SPECIFIC ATLAS ANTERO-POSTERIOR MOVEMENT UPON THE CONDYLES



The diameter of the circumference of the arc of greatest antero-posterior movement of the superior facets of the atlas upon the condyles is 26/32 of an inch. One degree of movement of the facets upon the condyles equals .224/52 of an inch actual distance travel. A five degree movement equals approximately one/thirty-second of an inch actual antero-posterior travel of those parts of the facets farthest from the center of movement.

The point B represents a point upon the vertebral notch upon the posterior arch of the atlas upon which rests the first spinal nerve and vertebral artery and above which is the interval in the posterior atlanto-occipital membrane. In antero-posterior movement of the atlas upon the condyles this point describes an arc the diameter of the circle of which is 1¼ inches and with a one degree movement of the atlas from anterior to posterior or posterior to anterior upon the condyles this point actually travels .32/32 of an inch. In five degrees antero-posterior travel this point actually travels 1.6/32 of an inch.

The point C represents a point at the center of the anterior aspect of the posterior arch of the atlas. The diameter of the circumference of the arc of travel of this point in antero-posterior movement of the atlas upon the condyles is two and one/eighth inches. In antero-posterior travel of the atlas of one degree this point actually travels .6/32 of an inch and in a travel of five degrees of the atlas this point actually travels a distance of approximately 3/32 of an inch.

THE ATLANTO-AXIAL ARTICULATION

Although in studying the character of movement possible between the condyles and the superior facets of the atlas one can, to some extent, ignore the ligaments entering into this articulation, this is not possible in the atlanto-axial articulation since the character of its movement is majorly determined by the pivoting action of the atlas around the odontoid process of the axis, the superior articular surface of the axis being in apposition with the two inferior articular surfaces of the atlas. This pivoting action is made possible by the ring formed by the anterior arch of the atlas and the transverse ligament.

This transverse ligament fits snugly against the constriction of the odontoid process, holding this process firmly against the anterior arch of the atlas, and its attachment to the lateral masses is sufficiently anterior to appear to limit any lateral movement of the odontoid process in relation to the anterior arch of the atlas. Any stretching of this ligament, however, will allow the odontoid process to depart from its contact with the anterior arch of the atlas and allow lateral play to the extent of such stretching. This naturally, would in turn affect the integrity of the articular relationship of the superior facets of the axis with the inferior facets of the atlas.

The transverse ligament is a very strong, thick band, being sufficient to maintain the odontoid in position after all other ligaments have been divided. Judging from x-rays viewed, it is my opinion that stretching of the transverse ligament sufficiently to enter into the mechanics of normal atlanto-axial movement can be excluded. From the standpoint of a subluxation, it is also my opinion, and for the same reasons as above given, that stretching of the transverse ligament is an infrequent factor for consideration, and can be majorly ignored in a discussion dealing with normal movement, and, the articular relationship in a subluxation.

Gray’s Anatomy quotes Corner as stating that the movement of the atlas upon the axis is of a complex nature, that the first movement is of a complex nature entailing the fixation, or partial fixation, of the atlanto-axial joint on the side toward which the head, rotates, by the muscles of the neck, the opposite inferior facet of the atlas gliding forward and downwards upon the superior facet of the axis in apposition. Following this eccentric movement is a second, symmetrical movement, the odontoid forming the axis of move me lit.

There is no detailed explanation given of the exact degree or nature of this eccentric movement, nor what muscles are involved in fixation of the joint acting as the pivot of eccentric movement.

It appears to me that the only muscles that can possibly enter into any such fixation would be the inter-transversarii between the transverse processes of atlas and axis. I further, however, cannot see how such eccentric movement could be possible since such movement would immediately encounter the resistance of the transverse ligament against the odontoid process, and any such fixation would only result in the atlas and axis rotating together until the limitation of such movement forced the atlas in concentric rotation upon the axis, the odontoid of the axis forming the center of movement.

The superior facets of the axis and the inferior facets of the atlas both slope laterally inferior at an angle of approximately twenty degrees. According to Gray's Anatomy both surfaces are somewhat convex in their long diameter.

There is some rocking movement between the atlas and axis in the forward and back rocking movement of the head.

In any subluxation of the atlas the odontoid process is carried with it, anterior-superior, posterior-inferior and right or left.

Any force that would tend, to sideslip the atlas upon the condyles would immediately meet with the antagonistic action of the abrupt lateral superior slope of the superior facets of the atlas driving the lateral mass on the side opposite laterality downward and off its condyle and at the same time the inferior lateral slope of the inferior facets of the atlas driving the atlas upward upon the side opposite laterality, (if the axis did not "give" .)

The mechanical action could as well be described by stating that the condyle on the side opposite laterality would be driven upward and the same side of axis driven downward. The momentum of force that appears necessary to break through the defensive mechanism of the region to initiate a subluxation, plus the greater inertia of the skull coupled with the more acute angle of the superior slope of the facets of the atlas appears to favor forcing the side of axis opposite laterality downward.

This action again forces the odontoid toward the side opposite laterality which simultaneously meets the movement of the atlas in the opposite direction. This action, it appears, must resolve itself into a rotary movement with the odontoid of the axis carried toward the side of atlas laterality the same distance that the atlas sideslips with the spinous process of the axis "whipping" to the opposite side.

The foregoing is an attempt to visualize some of the possibilities incident to atlas sideslip, realizing that the degree and character of the penetrative forces active in the production of a subluxation in this area are many and varied.

A CONSIDERATION OF THE LIGAMENTOUS

RELATION IN THE OCCIPITO-ATLANTO-AXIAL AREA

There seems to be an all too-frequent tendency in our profession to consider a study of the vertebral articulations without placing due stress upon the ligaments and muscles that make such articulation possible.

We speak of "locks" due to bony structure in apposition when the most rudimentary consideration reveals the obvious fact that whatever "locks" may exist so because limitations of movement by ligaments and muscles alone render such "locks" operative. Remove ligaments and muscles and no locks exist.

The only definite articular "lock" of the occipito-atlanto-axial area is that preventing a rotary movement between the condyles and the superior facets of the atlas. All other limitations of movement are due to ligamentous and muscular attachments.

The outstanding ligamentous variation in this region as distinguished from other spinal areas is the absence of any intervertebral disc. This lack guarantees the freedom and greater range of movement in this area, which appears to have been considered necessary by the forces operative in the construction of the body, as compared with the vertebral articulations from the inferior of the axis downward. This greater freedom and range of movement, balancing the heavy skull above, allows for the momentum of forces active in this area to pierce through its defensive structures.

A study of the ligamentous structures of this region appears to reveal that the greatest rigidity and limitation of movement is in the prevention of lateral sideslip. Other ligaments between atlas and axis and occiput limit movement beyond a certain greater range.

The greatest freedom of movement in this area is between the condyles and the superior facets of the atlas in anterior-posterior arc-travel, and between the superior facets of the axis and the inferior facets of the atlas in rotary movement around the odontoid process.

The articular capsules, being thin and loose, can apparently be disregarded from the standpoint of the prevention of movement beyond the danger-point.

It appears that the ligaments mainly responsible for the prevention of sideslip of the atlas upon the condyles are the two lateral atlanto-occipital ligaments extending from the bases of the transverse processes of the atlas obliquely upward and medialward to the jugular processes of the occiput.

Superiority of the atlas would appear to be checked by the posterior atlanto-occipital membrane. The lateral atlanto-occipital superior crus of the transverse, the membrana tectoria, alar and apical ligaments all most likely act as deterrents to superiority or inferiority of atlas beyond the normal range of movement in relation to the condyles. The anterior atlanto-occipital membrane would appear to check inferiority.

The alar ligaments are accredited with acting as check ligaments to the rotation of the skull upon the axis. Very likely, the anterior atlanto-axial, membrane tectoria and the posterior atlanto-axial ligaments have also some deterrent action. This area is buttressed with strong ligaments allowing a certain range of movement. I fail to see any arrangement of ligaments in this area that would allow for a ligamentous “lock" in the production and perpetuation of a subluxation.

THE MUSCULAR INFLUENCE IN THE OCCIPITO-ATLANTAO -AXIAL ARTICULATION

I fail to see any basis for ascribing a subluxation of the atlas to either an articular or ligamentous lock. It follows then that any abnormal position of the atlas vertebra must be ascribed to some failure of muscular function actively involved in the perpetuation and possible increase in degree of malposition of the atlas vertebra.

In as much as the malposition of the atlas is limited to laterality, superiority or inferiority an analysis of the muscles of this area, and their action determined by their attachment should give us some clue in regard to the muscles involved, in particular malpositions of the atlas.

There are in all seven pairs of muscles that attach to the atlas vertebra. Of these seven, four have their insertion into the occiput, two have attachment to the axis, and one attaches to the third, fourth and fifth cervical vertebrae.

Three pairs of muscles definitely appear to influence an inferiority of atlas; - the superior oblique of the Longus Colli, the Rectus Capitis Posterior Minor and the Obliquus Capitis Superior. The first arises from the anterior tubercles of the transverse processes of the third, fourth and fifth cervical vertebrae and is inserted by a narrow tendon into the tubercle of the anterior arch of the atlas. The second has its origin on the posterior arch of the atlas and is inserted into the medial part of the inferior nuchal line of the occiput and the surface between it and the foramen magnum. The third arises by tendinous fibers from the upper surfaces of the transverse processes of the atlas and passing upward and medialward are inserted into the occipital bone between the superior and inferior nuchal line. It can be readily seen that any abnormal contracture of any one of these muscles not balanced by opposite pull would result in an inferior position of the atlas vertebra. These muscles, on the other hand, would be operative in the prevention of any superiority of the atlas.

One pair of muscles, the Recti Capitis Anterior, appears to influence toward a superiority of the atlas. It has its origin at the anterior surface of the lateral mass of the atlas and its transverse process, and extends medialward into the inferior surface of the basilar process of the occiput immediately in front of the foramen magnum. It appears that any contracture of this muscle not counteracted by the Longus Colli, the Rectus Capitis Posterior Minor and/or the Obliquus Capitis Superior would tend to produce a superiority of the atlas.

The muscle that appears definitely involved in atlas laterality is the Rectus Capitis Lateralis. It has its origin on the upper surface of the transverse process of the atlas and it is inserted into the under surface of the jugular process of the occiput.

Of the eight pairs of muscles directly involved in the maintenance of the normal articular relationship between the occiput, atlas and axis, five pairs are concerned in the maintenance of the normal articular relationship of the occiput and the atlas, and three pairs are concerned in the maintenance of the normal articular relationship of the atlas and axis.

Of the three pairs of muscles having their origin on the axis two pairs have their insertion into the transverse processes of the atlas and one inserts into the occiput. Two of these pairs of muscles have their insertion on the spinous process of the axis. The Rectus Capitis Posterior Major has its point of origin on the spinous process of the axis and its insertion into the lateral part of the inferior nuchal line of the occiput and the surface of bone immediately below this line. This pair of muscles would normally act to hold the odontoid process against the anterior arch of the atlas and counteract any tendency toward, inferiority or rotation of the axis vertebra.

Any unbalanced contraction would rotate the axis toward the side of greater contracture and tend to pull the spinous of the axis toward the superior.

The Obliquus Capitis Inferior has its origin on the spinous process of the axis and is inserted into the lower back part of the transverse process of the atlas. It would normally act to hold the odontoid process firmly against the anterior arch of the atlas and prevent any rotation of the axis vertebra. Any unbalanced contraction of this pair of muscles would draw the spinous process of the axis toward the side of greater contracture .

The Intertransversarii are situated between the transverse processes of the atlas and the axis. Their action appears to guard against any sideslip of the atlas upon the axis which, because of the odontoid process in normsl relation with the transverse ligament and fovea dentis, would be immediately transformed into a rotary movement of the axis with the odontoid process acting as the pivot of rotary movement. Any unbalanced contracture of either muscle would tend to produce a rotation of the spinous process of the axis toward the side opposite greater contracture.

The foregoing presents nothing more than a basis for the possible determination of the involvement of the possible variations of muscular tensions and/or relaxations involved in the production of the various abnormal positional relationships of the atlas and the axis as observed in x-rays.

It may be of interest to note that three pairs of muscles are provided to guard against a superiority of the atlas, and that could be involved in the development of inferiority, and that one pair each buttress against inferiority and sideslip and could be responsible for sideslip and superiority .

On the other hand, the main action of the muscles attached to the axis appears to be to prevent rotation and inferiority of the axis and to guard against the intrusion of the odontoid process into the neural canal.

OCCIPITO-ATLANTAL MUSCLES

Four pairs of muscles are directly concerned with the articular relationship of the condyles and atlas:

1. Rectus Capitis Anterior.

2. Rectus Capitis Lateralis.

3. Rectus Capitis Posterior Minor.

4. Obliquus Capitis Superior.

Only one, the Rectus Capitis Anterior, influences toward superiority in contracture, antagonizing inferiority.

The Rectus Capitis Lateralis influences toward laterality if unbalanced in tension.

Both the Rectus Capitis Posterior Minor and the Obliquus Capitis Superior influence toward inferiority in equal contracture and toward inferiority and laterality in unbalanced tension.

OCCIPITO-AXIAL AND ATLANTO-AXIAL MUSCLES

Three pairs of muscles, the Rectus Capitis Posterior Major, the Obliquus Capitis Inferior and the Intertransversarii are directly concerned in the articular relationship of the atlas and axis. The first two muscles may rotate the atlas upon the axis or counteract such rotation. The Rectus Capitis Posterior Major would also tend to draw the spinous of the axis superior and might influence toward laterality and inferiority of the atlas. The Intertransversarii are described on the preceding page.

In view of the fact that most atlas malposition are superior with respect to antero-posterior movement it may be worthy of note that those muscles whose contracture would be most apt to influence toward superiority and also laterality are controlled by the anterior division of the first and second cervical nerve.

Number 3 is supplied by the posterior divisions of the first and second.

lumber 4 is supplied by the posterior division of the first only.

In addition to the muscles hereinbefore mentioned as directly concerned in the maintenance of the normal articular relationship of the occiput, atlas and axis several other muscles attach to this region. Whereas they do not appear to have as direct a bearing upon the positional relationship of the atlas, axis and occiput they still unquestionably influence the position of the occiput and cervical region.

The Longus Capitis arises by four tendinous slips from the anterior tubercles of the transverse processes of the third, fourth, fifth and sixth cervical vertebrae and is inserted into the basilar part of the occipital bone. Both muscles acting together antagonize the muscles of the back of the neck and prevents the head from being thrown back; acting independently they rotate the head toward the side of contracture. They are supplied by the first, second and third cervical nerves.

The Longissimus Capitis arises by tendons from the transverse processes of the upper four or five dorsal vertebrae and the articular processes of the lower three or four cervical vertebrae and is inserted into the posterior margin of the mastoid process. It is supplied by the lower five cervical nerves. These muscles acting together would draw the head back, and acting separately would rotate the head.

The Semispinalis Capitis arises by a series of tendons from the tips of the transverse processes of the upper six or seven dorsal vertebrae and that of the seventh cervical vertebra and from the articular processes of the fourth, fifth and sixth cervical vertebrae and is inserted between the superior and Inferior nuchal lines of the occiput; action similar to the above and supplied by all the cervical nerves.

The upper portion of the Trapezius arises from the external occipital protuberance and the middle third of the superior nuchal line of the occipital bone, the ligamentum Nuchae and the spinous process of the seventh cervical; its action is essentially the same as the above and is supplied by the accessory, third and fourth cervical nerves.

The Sternocleidomastoideus arises from the sternum and clavicle by two heads which blend into a thick, rounded muscle which is inserted into the lateral surface of the mastoid process and by a thin aponeurosis into the lateral half of the superior nuchal line of the occipital bone; its action is essentially the same as that above and it receives its nerve supply from the Accessory and the anterior divisions of the second and third cervical nerves.

The Splenius Cervicis arises from the spinous processes of the third to sixth dorsal vertebrae inclusive and is inserted into the posterior tubercles of the upper two or three cervical vertebrae; it receives its nerve supply from the posterior divisions of the middle and lower cervical nerves; these muscles acting together would draw the upper cervical region backward, acting separately they would in addition rotate the upper cervical region.

The Spinalis Cervicis arises from the lower part of the Ligamentum Nuchae, the spinous process of the seventh cervical and sometimes the first and second dorsal and is inserted into the spinous process of the axis and sometimes into the spinous processes of the third and fourth cervical vertebrae. Its action would tend to draw the spinous of axis downward and the upper cervical region downward and backward. This is an inconstant muscle.

The Semispinalis Cervicis extends from the spinous processes of the upper five or six dorsals into the spinous processes of the axis to the fifth cervicals inclusive. Its action would draw the cervical region backward. It is supplied by the lower three cervical nerves.

The Interspinalis exist in pairs between the spinous processes of contiguous vertebrae on either side of the Interspinal Ligament. There are six pairs in the cervical region from the axis to the first dorsal. Their action would approximate the spinous processes.

The Levator Scapulae arises by tendinous strips from the transverse processes of the atlas and axis and from the transverse processes of the third and fourth cervicals and is inserted into the vertebral border of the scapula; both acting together would draw the upper cervical downward and backward, and acting independently would in addition rotate the upper cervical region; supplied by the third and fourth cervical nerves.

The vertical portion of the Longus Colli arises from the front of the bodies of the upper three dorsal vertebrae and the lower three cervical vertebrae and is inserted into the front of the bodies of the second, third and fourth cervical vertebrae; its action would antagonize a backward pull on the cervical region.

The Longissimus Cervicis arises from the summits of the transverse processes of the upper four or five dorsals and is inserted into the posterior tubercles of the transverse processes of the cervical vertebrae from the second to the sixth inclusive; both acting together would draw the cervical region backward and acting independently would in addition rotate the cervical region; it is supplied by the lateral branches of the lower five cervical nerves.

The Scalenus Medius, the largest and longest of the three Scaleni, arises from the posterior tubercles of the transverse processes of the lower six cervical vertebrae and is inserted into the upper surface of the first rib by a broad attachment between the tubercle and the subclavian groove. The Scaleni, acting from above, elevate the first and second ribs, and acting from below bend the neck laterally when acting separately and flex, the neck slightly when acting together. They are supplied by the second to seventh cervical nerves.

It must also be remembered that the position of the skull and atlas is influenced by the general spinal balance.

THE FACTORS INVOLVED IN A

SUBLUXATION OF ATLAS

As the muscles directly involved in the occipito-atlantal-axial area are responsible for the maintenance of the normal articular relationship of this area it follows that some influence has rendered them incapable of exercising their normal function.

We can reasonably assume that in the vast majority of subluxations no actual trauma effecting the muscles directly has rendered them unable to maintain the normal articular relationship of the vertebrae in question. In as much as the muscles are not structurally incapable of normal function any functional variation from the normal must, be ascribed to some deficiency in the nerve control of these muscles directly responsible for muscular insufficiency.

This in turn leads to the question of the manner in which such deficiency of nerve control has been brought about.

Since the muscles involved in this area are controlled by the first and second cervical nerves it leads to the inevitable conclusion that these nerves are involved in any subluxation of the atlas vertebra.

The question next arises as to the manner in which these nerves are involved and how such involvement perpetuates itself, and it is precisely at this point that the greatest difficulty arises in arriving at a definite, conclusive, factual basis. The most reasonable point of view appears to be that some physical, structural variation produces a structural or functional alteration of either one or both of these nerves so as to interfere with their normal transmission of mental impulses. Any disturbance, from their point of origin or anywhere along the course of these nerves might prove sufficient to disturb their capacity for normal functional control.

Structurally, all evidence points to the atlas vertebra as responsible for the initiation of nerve interference affecting the vital control of the muscles in this region. Due to a momentum of forces piercing the structural defenses of this region the atlas vertebra can be driven beyond its safe, normal limits of movement to initiate an interference affecting the first and/or second cervical nerves sufficiently to render certain muscles of the area incapable of restoring, normal alignment.

The manner in which this interference occurs is a matter for conjecture. Both nerves leave the spinal cord practically on a straight lateral line. Their points of emission from the spinal column differ from that of all other spinal nerves. Whereas the latter leave the spinal canal through comparatively large, bony openings formed by the articulation of the adjacent vertebrae with the comparatively small nerve protected, by a thick padding of soft, fatty tissue, the mobility necessary in the occipito-atlanto-axial region apparently precluded the use of this interlocking bony foramen.

The anterior division of the first cervical nerve, together with the vertebral artery, leaves the spinal canal through an opening in the posterior atlanto-occipital membrane at the groove on the posterior arch of the atlas just posterior to the lateral mass, the vertebral artery lying superior to it in this groove. It then curves forward around the lateral aspect of the superior articulating process of the lateral mass medial to the vertebral artery. This position of the nerve appears to me significant in the light of possible interference. This anterior division of the first cervical nerve joins with the anterior divisions of the second, third and fourth cervical nerves to form the Cervical Plexus with extensive intercommunication including that with the Vagus and the Hypoglossal nerves. It supplies the Rectus Capitis Lateralis and, in conjunction with the second cervical nerve, the Rectus Capitis

Anterior.

The posterior division of the first cervical nerve emerges above the posterior, arch of the atlas and beneath the vertebral artery. It enters the sub-occipital triangle and supplies the Rectus Capitis Posterior Major, the Obliquus Superior and Inferior, the Rectus Capitis Posterior Minor and the Semispinalis Capitis.

The posterior division of the second cervical nerve emerges between the posterior arch of the atlas and the lamina of the axis below the Obliquus Inferior supplying a ‘twig’ to this muscle and receiving a communicating branch from the first cervical nerve and dividing into a large medial and a small lateral branch. The medial branch, the Greater Occipital Nerve, ascends obliquely between the Obliquus Inferior and the Semispinalis Capitis and pierces the latter muscle and the Trapezius near their attachments to the occiput. Joined by a filament of the third cervical nerve it ascends on the back of the head with the occipital artery and divides into branches which communicate with the Lesser Occipital supplying the skin of the scalp as far forward as the vertex. It gives off muscular branches to the Semispinalis Capitis and occasionally a twig to the back of the auricula. The lateral branch sends filaments to the Splenius, Longus Capitis and the Semispinalis Capitis.

The anterior division of the second cervical nerve joins with the anterior divisions of the first, third and fourth cervical nerves to form the Cervical Plexus with its extensive intercommunication including that with the Vagus and the Hypoglossal nerves. This anterior division of the second, cervical nerve, as do all other cervical nerves with the exception of the first, passes outward between the anterior and posterior Intertransversarii. This latter appears significant in view of the possibility of interference in abnormal rotations of the axis vertebra.

The first and second cervical nerves are also peculiar in that their ganglia lie upon the posterior arch of the atlas and the lamina of the axis respectively.

A CONSIDERATION OF THE MANNER

IN WHICH NERVE INTERFERENCE IS EFFECTED

THROUGH A SUBLUXATION OF THE ATLAS VERTEBRA

A study of the structures of the nervous system situated in the region adjacent to the occipito-atlanto-axial articulations shows that the Medulla Oblongata, a part of the hind brain, descends through the Foremen Magnum and is continuous with the Medulla Spinalis at a level with the posterior arch of the atlas where the first pair of spinal nerves emit from the Medulla Spinalis. Evidence appears to point toward the Medulla Oblongata and the immediately adjacent structures as concerned in the centralized control of coordinated activity of body function. Its equivalent is apparent in the first rudimentary beginnings of the nervous system, as observed in lower forms of life.

In this area lie important nuclei and nerve connections as yet little understood. In this area lie the nuclei of origin of the cranial nerves, and this area appears to serve as a connection between spinal and cranial nerve paths and as an intermediary in these nerve paths between the cortex and the body. Through the Foremen Magnum with the Medulla Oblongata, through which course the nerve fibers to and from the spinal cord, extends the cranial portion of the Spinal Accessory, and the descending branch of the Trigeminal extends to the second segment of the Medulla Spinalis. There is but little question that any disturbance of this section of the nervous mechanism could have far-reaching effects upon any and all parts of the body.

The question that we are here mainly concerned with is the explanation of how a malposition of the atlas vertebra to the degree observed in subluxations can produce sufficient disturbance of the normal function of nerve structures in this area, to interfere with the nervous regulation of body function leading to functional and pathological incoordinations.

It is precisely at this juncture that exact knowledge fails us, and we must limit ourselves to the possibilities that present themselves within the range of our present knowledge of the structural relationships of this region.

In viewing the possibility of pressure produced by the malposition of bony structure itself, two possibilities appear to present themselves; either a pull and/or pressure upon the first cervical nerve due to its positional relationship to the lateral aspect of the superior articular process of the lateral mass or the opening of the posterior atlanto-occipito membrane through which it leaves the spinal canal, or indirectly by pressures upon tissues surrounding the nerve structures by the odontoid process and/or the posterior arch of the atlas and the lamina of the axis.

Of the two the first, appears more reasonable and possible. All evidence appears to point definitely to an involvement of the first nerve as a requisite to the presence of a subluxation. The far-reaching consequences of such interference can be readily grasped when we note the relationship of the first cervical nerve to the cervical Plexus, to the Hypoglossal, and above all to the important Vagus with its extensive visceral distribution and the probability that this nerve conveys vasomotor impulses to certain sympathetic neurons throughout the Medulla Spinalis (Gray's Anatomy).

Another point of importance to note in regard to any involvement of function of the first cervical nerve is that each spinal nerve after leaving the intervertebral foramen gives off a small meningeal branch which reenters the vertebral canal through the intervertebral foramen and supplies the vertebra and its ligaments and the blood vessels of the Medulla Spinalis and its meninges. It requires no imagination to visualize the extensive possibilities of general involvement of the nervous system and communication with the entire body incident to an involvement of the recurrent meningeal branch of the first cervical nerve.

The same possible effects apply with almost equal emphasis to any involvement of the second cervical nerve since their connections and relation to the Medulla Spinalis are closely associated although the first nerve would be more closely related to the Medulla Oblongata. Any pull and/or pressure upon the second cervical nerve would appear to be due to rotations of the axis existing as a secondary effect resulting from the subluxation of the atlas vertebra.

There appears to be some possibility of a direct involvement of the vertebral artery as it leaves the foramen transversarium and passes along the lateral aspect of the superior articulating process of the lateral mass of the atlas to the posterior through the interval in the posterior atlanto-occipital membrane above the first cervical nerve on the groove on the posterior arch of the atlas, but I question very much that any primary involvement of the blood vessels in this area would enter into any disturbance because of the anastomosis with its mate and connection with the Circle of Willis.

Another possibility that appears worthy of note is the possible effect of malpositions of the atlas and axis upon the ligaments of the region.

The only ligaments that appear to present a possibility of involving nerve structures are the Posterior Atlanto-occipital membrane, the Posterior Atlanto-axial Ligament and the Membrane Tectoria, with possible effects of tension on the Medulla Spinalis and the Medulla Oblongata through connection with the Dura Mater and the Dentate Ligaments.

The meninges of the Medulla Spinalis are continuous with those of the brain. The Dura Mater is closely adherent to the Foremen Magnum at its margin. The space between the vertebral canal and the Dura Mater, the Epidural Space (what is its thickness in the occipito-atlanto-axial area?), contains loose areolar tissue and a plexus of veins. The spinal Dura Mater is considered much larger than necessary for the accommodation of its contents (Gray's Anatomy), and is composed of white fibers and elastic tissue. The spinal Dura Mater and the Arachnoid Membrane are in contact except where separated by a minute quantity of fluid and are connected by isolated fibrous trabeculae, most numerous on the posterior surface of the Medulla Spinalis. The Arachnoid Membrane is supplied by a rich plexus of nerves derived from the Trigeminals, Facial and Spinal Accessory nerves. The Subarachnoid Space between the Arachnoid Membrane and the Pia Mater is occupied by spongy tissue and trabeculae of delicate connective tissue with intercommunicating channels containing Cerebrospinal Fluid. The Subarachnoid Cisteraae of the brain connect with the spinal Subaraohnoid Space at the Foramen Magnum. The Pia Mater is intimately adherent to the Medulla Spinalis and sends delicate septa into its substance. The central canal of the spinal cord connects with the floor of the 4th ventrical of the brain.

The spinal portion of the Subarachnoid Space is very wide (Gray's Anatomy- how wide?). It is partially divided by a longitudinal septum connecting the Arachnoid Membrane to the Pia Mater opposite the Posterior Medial Sulcus forming an incomplete cribiform partition above but more complete in the thoracic section. It is further subdivided by the Ligamentum Denticulatum.

The Ligamentum Denticulatum is a narrow fibrous band situated on either side of the Medulla Spinalis throughout its entire length separating the anterior from the posterior nerve roots. Its medial border is continuous with the Pia Mater at the side of the Medulla Spinalis. Its lateral border presents a series of tooth-like processes the points of which are attached at intervals to the Dura Mater. These processes are twenty-one in number, the first being attached to the Dura Mater opposite the margin of the Foramen Magnum, between the vertebral artery and the Hypoglossal nerve.

The Foramen Magnum transmits the Medulla Oblongata and its membranes, the Accessory nerves, the anterior and posterior spinal arteries, and the Membrane Tectoria and the Alar ligaments.

The Medulla Oblongata extends from the lower margin of the Pons transversely below the Pyramidsal Decussation to the first pair of spinal nerves on a level with the upper border of the atlas behind and the middle of the odontoid process in front, where it is continuous with the Medulla Spinalis. Its anterior surface is separated from the basilar part of the occipital bone and the upper part of the odontoid by the membranes of the brain and the Membrane Tectoria. Its posterior surface fits into a fossa between the cerebellar hemisphere, and its upper part forms the floor of the fourth ventricle. It measures a little over one inch in length, three fourths of an inch in breadth and is one half inch in thickness at its widest part.

Above and anterior to the Medulla Oblongata is the Pons, separated from it in front by a furrow in which the Abducent, Facial and Acoustic nerves appear. The Pons and upper portion of the Medulla Oblongata lie in a grooved surface formed by the basilar part of the occipital bore and the posterior part of the sphenoid anterior to the Foremen Magnum.

The Membrane Tectoria passes through the Foramen Magnum attaching to the basilar groove in front of the Foramen Magnum blending with the Cranial Dura Mater. It is in relation in front with the transverse ligament and in back with the Dura Mater. The Dura Mater attaches to the body of the axis and the third cervical vertebra at the posterior and is intimately adherent to the Posterior Atlanto-occipital Membrane.

This relation of the Dura Mater to structures in the occipito-atlanto-axial region and in turn to Dentate Ligaments attaching both to the Dura Mater and to the Medulla Spinalis appear to me to be worthy of note in considering the manner in which disturbances within the nervous system may be initiated through malpositions of the atlas and axis vertebra.

The relationship of the Accessory nerve, particularly that of the spinal portion, is worthy of note. The Spinal portion is made up of fibers from motor cells in the lateral part of the Medulla Spinalis as low as the fifth cervical. These unite to from a single trunk which ascends between the Ligamentum denticulatum and posterior roots of the spinal nerves, enters the skull through the Foramen Magnum, passing to and having its exit through the Jugular Foramen. It connects with Cranial portion, which in turn sends filaments to the second, third and fourth cervical nerves.

THE MENINGES AND NERVE TENSION

The meninges of the brain and spinal cord form one complete membrane and are continuous, consisting of the Dura Mater, the Arachnoid Membrane and the Pia Mater.

The Dura Mater is a dense, inelastic membrane and in the cranium consists of two layers closely connected together except where separated at the sinuses for the passage of venous blood. Its outer surface adheres closely to the inner surfaces of the bones. It sends inward four processes which divide the cavity of the skull into several freely communicating compartments for the lodgement and protection of different parts of the brain. It is continuous with the pericranium through foramina at the base of the skull and its fibrous layer forms sheaths for nerves passing through these apertures. The external layer is continuous with the periosteum of the vertebral canal, the internal layer being continuous with the Dura Mater of the spinal cord.

The spinal Dura Mater is closely adherent to the foramen magnum, the posterior occipito-atlantal membrane, the second and third cervical vertebrae, and is connected by fibrous strips to the posterior longitudinal ligament, particularly near the lower end of the vertebral canal. In the occipito-atlanto-axial area the Dura Mater is in relation in front with the membrane tectoria which attaches to the posterior surface of the body of the axis and to the basilar groove of the occipital bone in front of the foramen magnum where it blends with the Dura Mater. Below the level of the second sacral segment the Dura Mater blends with the Pia Mater, closely investing the filum terminale, and descending to the back of the coccyx fuses to the periosteum. Each nerve as it leaves the spinal cord receives a sheath from the Dura Mater. Where the roots join to form the spinal nerve this sheath is continuous with the epineurium of the nerve.

The Arachnoid Membrane invests the spinal cord loosely and is connected to the Dura Mater by isolated fibrous trabeculae most numerous upon the posterior surface of the cord. Between the Arachnoid Membrane and the Pia Mater is the subarachnoid space occupied by spongy tissue, trabaculae of delicate connective tissue, and intercommunicating channels filled with cerebrospinal fluid. The subarachnoid space of the spinal cord is continuous with the subarachnoid cisternae of the brain which in turn connect with the fourth ventricle of the brain. The spinal part of the subarachnoid cavity is very wide and partially divided by a longitudinal septum connecting the Arachnoid Membrane with the Pia Mater opposite the posterior medial sulcus. It is further subdivided by the ligamentum denticulatum. The Arachnoid Membrane is supplied by a rich plexus of nerves derived from the motor roots of the trigeminal, facial and accessory nerves. The Arachnoid Membrane invests the cranial and spinal nerves to their points of exit from the cranium and spinal canal respectively .

The spinal Pia Mater is a vascular membrane intimately adherent to the spinal cord and forms sheaths for the cranial and spinal nerves blending with their common membranous investments. On either side of the spinal cord is a narrow fibrous bend extending throughout its entire length and separating the anterior from the posterior nerve roots. Its lateral border consists of tooth-like processes, twenty-one in number, the points of which are attached at intervals to the Dura Mater. The first process attaches to the Dura Mater opposite the margin of the foramen magnum between the vertebral artery and the hypoglossal nerve and the last near the lower end of the spinal cord.

The attachment of the outer surface of the Dura Mater to structures in the occipito-atlanto-axial area are both movable and immovable; its continuity with the epineurium of the nerves leaving the spinal cord; the connection of it in turn to the Pia Mater of the spinal cord, and through the ligamentum denticulatum to the spinal cord appear significant in the light of possible tension upon nerve structures in the region of the foramen magnum, atlas and axis effected by ligamentous tension secondary to atlas malposition.