Mandibular deviations in TMD and non-TMD groups related to eye dominance and head posture

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This study was designed to determine whether eye-dominance affects head posture (rotation) and in turn, whether head posture is associated with mandibular frenum midline deviation, in both TMJ and control subjects. Eye dominance was determined using three tests: Porta, Hole, Point tests. Natural head posture was evaluated using the Arthrodial protractor. Mandibular frenum deviation was recorded as left, right or no deviation. Fifty female subjects were included in the study, 25 TMJ patients attending the Gelb Craniomandibular Pain Center and 25 non-TMJ control subjects. The findings indicate that eye dominance and direction of head rotation are strongly associated in both TMJ and control subjects. Further, in TMJ subjects mandibular deviation occurred in greater frequency than in controls and tends to occur in the contra lateral direction of head rotation.

J Clin Pediatr Dent 25(2): 147-155, 2001

INTRODUCTION

The craniomandibular system is designed to function as a unit and its parts cannot be considered independently. The idea of a malfunctioning unit is reflected in the term, craniomandibular disorders, (CMD) which is a collective term embracing a number of clinical problems that involves the masticatory musculature, the temporomandibular joint (TMJ) or both.[1] The guidelines of the American Academy of Craniomandibular Disorders propose that abnormal jaw and head position are suspected as perpetuating factors affecting CMD.[1] Mohl[2] supports this notion and adds that head posture appears to have the most significant and immediate effect on mandibular postural rest position.

Dysfunction of one component of this complex system frequently affects other components of the craniomandibular system as well as adjacent systems.[3-5] Rocobado[6] found this to be true and has stated that when mandibular position is altered in space in all planes, it is a result of occlusion, muscle activity, and head and neck posture.

The function and resting position of the head has been shown to be directly dependent on the posture of the cervical spine.[7] Head posture, however, always dominates. When dealing with the upper quarter of the body, cervical spine dysfunction will lead to a compensatory change in head position. The center of gravity of the head is located slightly anterior to the cervical spine.[8] Unless the posterior muscular antagonists exert a sufficient counter force, the head will fall forward on the cervical spine. The posterior cervical musculature has no problem maintaining balance.[8-11]

Mandibular postural rest position has been widely discussed in the literature in relation to the head posture. Brill *et al.*[12] have stated that postural rest position will alter with changes in head position. The muscles of mastication and postural position, have been found to be affected by head positon.[13-18]

Rocabado[6] states that the need for maintenance of the horizontal line of vision is ultimately of prime importance, i.e. vertical axis rotation of the head position. In the presence of normal cranio-cervical posture, the bipupilar, otic, and transverse occlusal planes should be all horizontal and parallel to one another.[8, 9]

One eye is usually dominant over the other eye and may affect the horizontal rotation of the head. Natural head position as defined by Broca[10] is when a man is standing with his visual axis horizontal. In order to maintain the horizontal vision it is suspected that compensatory postural accommodations may occur and driven by the dominant eye. In 1993 White[19] suggested

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Figure 1. QUESTIONNAIRE
Self-Report Items for Measurement of Eye Preference

EYE PREFERENCE ITEMS

1. Which eye would you use to peep through a key hole?	R	L
2. If you had to look into a dark bottle to see how full it was, which eye would you use?	R	L
3. Which eye would you use to sight down a rifle?	R	L
4. Suppose you are bending to look under a bed, which eye would be closest to the floor?	R	L
5. Most people carry their head with a tilt. Do you carry head tilted to the left or right?	R	L
6. If someone ask you to wink your eye, which one do you wink?	R	L

that the dominant eye maybe the driving force, which leads to postural compensations of the head.

The question occurs, if the head position is changed due perhaps to eye dominance, would the mandibular position also be changed and in what direction? Also, how would one evaluate this new position of the mandible?

Rocabado[6, 9, 20] uses the relationship of the lower lip frenum to the upper lip frenum with the mandible in the occlusal position to assess mandibular deviation.

To study these relationships between vision, head posture and mandibular position this study was designed to investigate:

1. Dominant eye effect on head posture.
2. Head posture effect on mandibular position.
3. Frequency of midline deviation in a TMD sample and a non-TMD control sample.

MATERIALS AND METHODS

Fifty female adult subjects were included in this study: 25 TMJ patients at the Gelb Craniomandibular Pain Center and 25 control student subjects (non-TMJ) from Tufts University School of Dental Medicine were randomly selected. Average age in the TMJ group was 31 years and 28 years in the control group. The average age of all subjects was 30 years.

Figure 2. Porta Test. Subject aligning vertical pencil with a vertical mark on the wall.

Exclusionary criteria

1. No history of physical trauma on the head and neck area.
2. No clicking, grating or popping noises of the cervical vertebrae during neck movement.
3. No chronic illness.
4. No limitation in head, neck movement.
5. No tingling or numbness in the head, neck or shoulder area.
6. Fairly intact occlusion, and teeth present up to first molar.
7. No upper face (maxillary) midline asymmetry.

Eye dominance

A questionnaire (Figure 1) was filled out by each subject regarding eye preference. Eye dominance was tested by three methods, described by Merrell,[21] Porac and Coren,[22] Suchman,[23] Porta[24-26] test.

Porta test

A pencil held vertically was lined up with both eyes open, with a vertical mark places on the wall, it was found that pencil and vertical mark no longer lined up when the dominant eye was closed.[24-26] (Figures 2 and 3)

Hole test

A pencil-sized hole was punctured in a large sheet of paper, (15.5 inches by 15.5 inches) which was held at half an arms length by the subject. In other hand, a pencil held vertically at full arm's length was lined up by the subject with both eyes open, so that it was visible through the hole. When the dominant eye was closed, the pencil was not seen.[22, 23] (Figures 4 and 5)

Point test

The investigator checks the alignment of the pencil with the eye, when the subject points to experimenter nose.[25, 27, 28] (Figure 6).

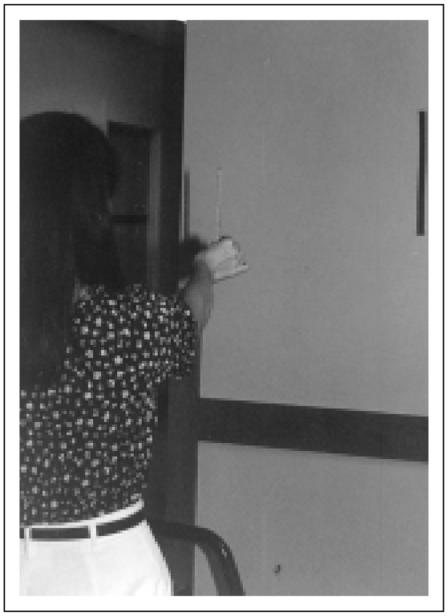

Figure 3. Porta Test. Subject aligning vertical pencil with a vertical mark on the wall.

Figure 4. Hole Test. Paper at half an arm length and pencil at full arm's length.

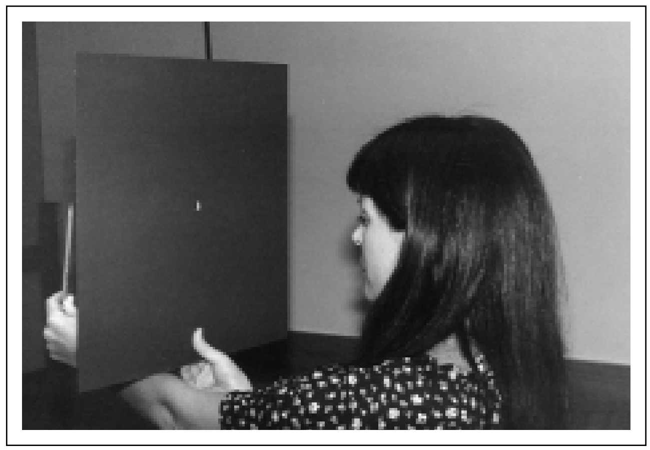

Figure 5. Hole Test. Close up view.

Head Posture Evaluation

The head rotation was evaluated by using the Arthrodial Protractor, (Reeedco Research) which is one piece clear acrylic plexiglass, and permits the examiner to check articulation for both active and passive movement. (Figure 7).

Natural Head Posture

Subjects were asked to sit on a chair without leaning back, and to close their eyes and think as if they were sitting in a group of friends or family, and a photographer is about to take a picture. How would you hold your head? This question was asked three times. Natural head posture was then evaluated for rotation.

Cervical Rotation

Arthrodial Protractor base lines were placed underneath the antrum of the ears, and the pointer in line with the episternal notch. Protractor was leveled by aligning the stabilizer bubble in the center. Standing over and behind the seated subject, the chin alignment to protractor marking was recorded: right rotation, no rotation, or left rotation. (Figures 8 and 9).

Mandibular Frenum Midline

Subjects were asked to occlude the teeth and vertical alignment of maxillary and mandibular frena was checked. A recording was made of the alignment as: coincident (alignment), right (mandibular frenum to right), and left (mandibular frenum to left).

The following data were obtained: eye dominance (right or left), direction of head rotation (right or left) and direction of midline deviation (right or left).

RESULTS

Rationale for statistical tests

The Kappa statistic was applied to determine degree of association (agreement) between 1) eye dominance and head rotation and 2) head rotation and deviation.

Kappa was first proposed by Cohen[29] Kappa is a measure of agreement with desirable properties. When different sets of data are being compared, the chance expected agreement can be corrected by using kappa.

The ratio between obtained excess beyond chance and maximum possible excess is denoted by kappa (k).

$$k = (I_o - I_e)/(1 - I_e)$$

value 1 is complete agreement
I_o denotes observed value of the index
I_e expected value on the basis of chance alone
$I_o - I_e$ obtained excess beyond chance
$1 - I_e$ maximum possible excess

Figure 6. Point Test. Which eye is used to view the finger that is pointing?

Kappa may be checked by simple algebra that, for each of the indices of agreement defined above, the same value of k results after the chance expected value is incorporated as in the above formula.

$$k = \frac{2(ad - bc)}{p_1 q_2 + p_2 q_1}$$

The cells are defined as follows:

a	b	p_1
c	d	q_1
p_2	q_2	

The kappa statistic is regarded as an intraclass correlation coefficients in which a difference between the raters and their base rates is considered a source of unwanted variability.[30]

Landis and Koch[31] suggested different ranges of values for kappa with respect to the degree of agreement. 1) values greater than 0.75 represent excellent agreement beyond chance 2) values between 0.40 and 0.75 represent fair to good agreement beyond chance 3) values less than 0.40 represent poor agreement beyond chance.

Table I. Frequency of eye dominance with frequency of head rotation, right and left. TMJ Group.

		Head Rotation		
		Right (R)	Left (L)	Total (T)
Eye Dominance	R	14	0	14
	L	4	7	11
	T	18	7	25

Kappa = 0.66
Two tail binomial p of 4/25 disagreement or 84% agreement p<0.002

Table II. Frequency of eye dominance with frequency of head rotation, right and left. Control Group.

		Head Rotation		
		Right (R)	Left (L)	Total (T)
Eye Dominance	R	18	2	20
	L	0	4	4
	T	18	6	24*

Kappa = 0.75
Two tail binomial p of 2/24 disagreement or 92% agreement p<0.001
*One subject showed no rotation.

The probability of chance agreement in matching sidedness (left and right) was assessed by the binomial test, rather than the standard normal Z for kappa, which is based upon kappa error of variance.

Chi-square was chosen to analyze frequency of deviation in the comparison of the TMJ group versus nonpatient controls, because chi-square was designed to determine degree of difference.

Results of the analysis

The co-incidence of eye dominance and direction of ipsilateral head rotation in the TMJ group yielded Kappa of 0.66, see Table 1. In order to determine the probability of chance agreement, the binomial probability was used. There is a significant agreement between dominant eye and ipsilateral head rotation in TMJ subjects. Binomial probability of 4/25 disagreement (84% agreement) was significant (Two tail p<0.002).

The incidence of eye dominance versus direction of ipsilateral head rotation in control group, (Table II), showed a Kappa of 0.75. The 92% agreement between eye dominance and head rotation was significant with two tail binomial probability (p<0.001). Therefore, ipsilateral head rotation was found to occur significantly on the side of the dominant eye in both TMJ and control subjects.

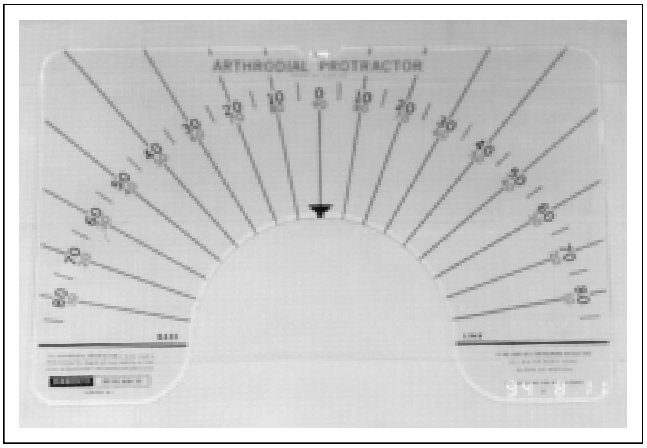

Figure 7. View of Arthrodial Protractor.

Figure 8. View of Arthrodial Protractor is use to show cervical rotation.

Table III. Frequency of eye dominance. TMJ Group.

	Right Eye	Left Eye
No. of Subjects	14	11
Percentage	56%	44%

Two tail binomial p = 0.345

Table IV. Frequency of eye dominance. Control Group.

	Right Eye*	Left Eye
No. of Subjects	21	4
Percentage	84%	16%

Two tail binomial p<0.001
*70% of total 50 subjects were right eye dominant.

Table V. Frequency of midline deviation associated with head rotation. TMJ Group.

		Deviation		
		Right (R)	**Left (L)**	**Total (T)**
Head Rotation	R	3	14	17
	L	3	3	6
	T	6	17	23

Kappa =-0.20
Two tail binomial p of 6/23 agreement or 74% disagreement p=0.034. 23 subjects with right and left deviation (2 coincidences disregarded)

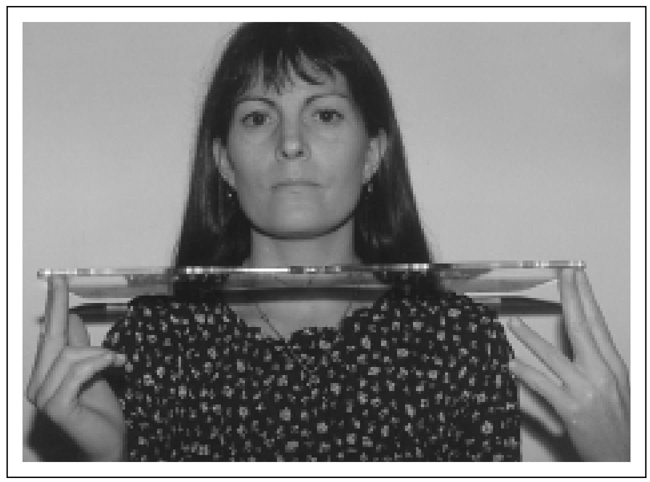

Figure 9. Frontal view of Arthrodial Protractor in place.

The percentage of right eye dominance in the TMJ group was 56%, while, left eye dominance was 44% (two tail binomial p=0.345). In contrast, frequency of eye dominance in the control group was 84% right and 16% left, a significant difference (two tail binomial p < 0.002) Table IV and Table III.

A kappa of –0.20, an indication of disagreement was found for the association between mandibular deviation and direction of head rotation in the TMJ group. Two tail binomial p of 6/23 agreement (p=0.034) indicated significant disagreement (see Table V).

For the control group, kappa was incalculable for the association between midline deviation and head rotation because of zero cells in the diagonal. The binomial probability of the distribution of zero agreement out of 6 was significant, two tail p=0.032 (see Table VI).

Table VII shows that frequency of midline deviation in the TMJ group, 92% (23 versus 2 no deviation) was significant that 24% in control group (6 versus 19 no

Table VI. Frequency of midline deviation associated with head rotation. Control Group.

		Deviation		
		Right (R)	Left (L)	Total (T)
Head Rotation	R	0	6	6
	L	0	0	0
	T	0	6	6

Kappa incalculable because of zero diagonal.
Two tail binomial p=0.032. (19 coincidences disregarded)

Table VII. Midline deviation TMJ Group versus Control Group.

	Deviation		
Group	Right	Coincidence	Left
TMJ	6	2	17
Control	0	19	6

Chi-square = 25.02
Df = 2
Cont. Coef = 0.57
P level <0.001

Table VIII. Frequency of mandibular frenum midline deviation. TMJ Group.

	Right	Coincidence	Left
Frequency	6	2	17
Percentage	24%	8%	68%

Total frequency of deviation 92%.
For binomial probability 2 coincident versus 23 deviation p<0.001

Table IX. Frequency of mandibular frenum midline deviation. Control Group.

	Right	Coincidence	Left
Frequency	0	19	6
Percentage	0%	76%	24%

Total frequency of deviation 24%.
For binomial probability 19 coincident versus 6 deviation p=0.014

deviation); Chi-square=25.02, df=2, Cont. Coef=0.57, p<0.001. (See Tables VIII and IX) the significant tendency of deviation in the TMJ group (binomial p<0.0001) was the reverse of what occurred in the controls where alignment was significantly more frequent (19 of 25 subjects, binomial p=0.014).

DISCUSSION

The purpose of the study was to assess: 1) The relationship between eye dominance and head posture 2) examine the association between head posture and mandibular shift and 3) determine the incidence of mandibular shift in TMJ and control non TMJ.

Human beings are two-sided organisms, bilaterally symmetrical, to a general vision, but upon close scrutiny asymmetries are detected in human body. When examining of the appearance of the eyes and ears, it is not surprising to find that one eye is somewhat larger or is positioned slightly lower than the other. The right ear is placed somewhat lower on the head than the left for the majority of the individuals. For these reasons, portrait artists argue that a truly symmetrical face is both unnatural and unlikely.[22]

There are four major manifestations of lateral preferences in humans: handedness and footedness, related to limb functions, and eyedness and earedness, related to sensory function.[22]

Sighting dominance is the form of eye preference encountered most often in the literature.[32] It has been reliably measured in infants, children, and adults[33] and cross culturally.[34] The sighting dominance performed by Porac and Coren[22] found something else in common with all other forms of lateral preference, namely the population tends to show a right bias, with 65-70% of the population manifested a preferred right eye. This is in accord with the findings of our study, where we found that combining group (TMJ and Control) of 50 subjects, 70% were right and 30% were left eye dominant.

Fink[35] investigated dominant eye in relation to other factors including facial asymmetry, and found that there was no relation between facial asymmetry and eye dominance. All patients showed an average degree of facial asymmetry, and even those who showed somewhat greater degree of facial asymmetry did not show greater degree of eye dominance. He found that 75% of all human beings are right eyed and 23% are left eyed; and in 2% eye dominance is indifferent or distributed between the two eyes. His findings are also in agreement with our findings that 70% of the subjects were right eye dominant. He further states that practically all right-eyed person are right sided. In the case of left-eyed persons this relation is not as constant, because many of them are right handed through training.

Porac and Coren[22] reported that eye preference shows a 9% shift rightwards from infancy to adulthood, while the most systematic changes appear in handedness, where the adult samples seems to be about 12% more right handed than the infant samples. On the contrary, Fink[35] agrees partially and reports that stability of eye dominance is not like handedness and it cannot be shifted unless vision is greatly lessened in dominant eye.

Hand and eye coordination has been discussed widely in the literature. One of the first theorists to suggest that handedness and eyedness might affect sensorimotor coordination was Parson.[36] His "primitive warfare" theory explains the predominance of right handedness in the population, further explaining that preference for right hand is presumed to have arisen because the left hand was needed to hold a shield over the heart while the right hand wielded a spear or sword. He concluded that ipsilateral patterns of hand and eye preference offer survival advantage.

The desirability of ipsilateral patterns of hand and eye preference is very well documented in the following quotation from Mills.[37] "Thought is conceived in the brain, formed by the eye and executed by the hand, and that perfect coordination of mind, eye and body which enters into the performance of all combined bodily movement, especially during games, would appear to make the placing and habitual fixing of control on one side of the body almost a necessity."

Wile[38] discussed that there is a hazard problem for those whose hands no longer operate in harmony with the dominant eye. Explaining that unilateral cortical function is the common rule, but contra-lateral neural pathways tend to create muscular and visual confusion. Further as a treatment modality, suggested that when left eye is dominant with natural right handedness, wearing a patch over the left eye will permit greater cerebral attention to the right eye, which will promote involved learning leading to progression from left to right so essential for reading.

Porac and Coren[22] conducted laboratory measurements to find relationships between hand and eye preference, by checking the individual for both speed and accuracy in sensorimotor guidance. They found "there is a strong handedness effect, with preferred hand performing significantly faster than non-preferred hand. Binocular exposure results in the best performance, followed by the preferred and the non-preferred eyes in that order. Finally, concluded that the use of the preferred eye and the preferred hand contribute, independently, to increase the efficiency of the task completion."

Hand dominance was a part of investigation in a study by Wheaton.[39] who studied the association of hand dominance with head tilt, incisive position, chewing dominance, longer leg and mandibular postural rest position. He concluded that chewing dominance and hand dominance were shown to correlate positively to mandibular postural rest position and positively to each other (same sidedness).

Further, he postulated that head tilt showed to have weak positive and negative correlations with mandibular postural rest position. On the basis of these findings, one may expect that the mandible to be positioned opposite to the head tilt and towards the side of increased muscle activity of the temporalis muscle.

Our findings are in agreement with Wheaton[39] where we found that mandibular shift showed a significant tendency for disagreement with direction of head rotation in the TMJ group, e.g. deviation occurred in the opposite direction of head rotation.

There was a significant association of the dominant eye side and the ipsilateral head rotation, 84% agreement occurred in the TMJ group, and 92% agreement in the control. This suggests that it is the dominant eye that drives head position. Possibly there is a reflex tendency that the non-dominant eye moves closer to the object.

When discussing head posture and mandibular position, Schwarz[40] stated that the position of the jaws at rest is dependent upon the position of the head and the jaws will be permanently influenced by the position of the head if its habitually or forcibly kept in one certain position. Thompson[41] and Brodie[14] have stated that the pattern of the head of the individual is laid down before the third month of post natal life, or probably much earlier, and therefore does not change. Further they state that the mandible assumes its pre-ordained relation with the rest of the face and head, long before any teeth have erupted, and this position is constant and characteristic for the individual.

Through this discussion it becomes evident that head posture, plays a prime role in dictating the rest position of the mandible. Through the findings of our study we can say that possibly it is the dominant eye, which makes compensatory adjustment of the head posture and might have been laid down very early in life. This would be in agreement to Fink[34] who states that, eye dominance is established early in life. Little or no evidence is available as to when the preference for one eye develops or whether the habit is established as a result of environmental conditions or tendencies of motor coordination. Indications are that impartial eyedness is more common in preschool children than in children of school age. It may seem justifiable to believe that eye dominance is not established in many children before the age of three, thereafter it is commonly found. Dominancy is established apparently early in life and becomes more evident with age. Therefore, eye dominance seems to be a centrally located process rather than a peripheral one, as it is evidently not related to vision, refraction and habits.

Examining mandibular midline frenal deviations in the present study showed a significant distinction between the TMD and control group. The TMD group showed a midline deviation of 92% as opposed to 24% in the controls. Further the predominance of these deviations in both groups were to the left side. Left sided deviation were again significantly more in the TMD group (68%) versus the controls (24%).

These findings are in agreement with clinical findings reported by Mehta and Alammar[42] and are at the core of the three dimensional analysis of occlusion as described by Mehta.[43]

Future Research

The finding of the present study opens questions for further research. It would be interesting to look at dominant eye through growth and development prospective, and identify the asymmetry between dominant and non-dominant eye that which is higher and associate it with maxillary canting and mandibular shift.

Investigation should be done in children for association between dominant eye and head posture, as to what will happen if the dominant eye is patched early in childhood, will it change the head posture?

Effect of eye dominance leading to compensatory head posture adjustment and EMG activity of the posterior cervical muscle should be investigated.

Eye dominance and its association with hand dominance should be investigated in relation to head posture and mandibular shift.

SUMMARY

Fifty female subjects, twenty-five TMJ patients and twenty-five non-TMJ Control subjects were included in the study, to evaluate the effect of eye dominance on head posture and mandibular midline deviation.

Eye dominance was determined by three test, Porta test, Hole test and Point test. Natural head posture was evaluated by using Arthrodial Protractor and direction of head rotation was determined. Finally the direction of mandibular deviation was recorded.

The results showed that eye dominance and ipsilateral head rotation was significant in both groups. Head rotation and mandiublar shift to the contra lateral side was significant in the TMJ group only. In TMJ subjects mandibular deviation occurred in greater frequency than in controls and tends to occur in the contra lateral direction of head rotation.

The strong relationship observed in the present study between eye dominance and direction of head rotation, suggests that possibly it is the dominant eye which dictates the position of the head.

CONCLUSIONS

These findings suggest a strong tendency for dominant eye to rotate the head to the ipsilateral side and influencing a compensatory balancing movement of the mandible to the contra lateral side.

1. In a general condition (irrespective of TMJ) head posture appears to be determined by dominant eye.
2. With TMJ subjects head rotation is significantly associated to a shift in mandible to contra lateral side.
3. TMJ subjects tend to show significant deviation than controls.
4. When head rotation occurs in TMJ subjects, mandibular shift tends to be greater to the left. The reason for this phenomenon may be the majority of the population 70% are right eye dominant, which leads to compensatory adjustment of head posture to the ipsilateral direction, and further leads to mandibular shift to the contra lateral direction i.e. left.

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