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Correlation between TMJ and Cervical Vertebral Bone Mineral Density during Peak Mandibular Growth Period in Adolescent Undergoing Functional Therapy

Dr Asmita Shetty , Dr Suma T, Dr Rajkumar S Alle

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ABSTRACT

INTRODUCTION: In order to accelerate mandibular development and enhance the face profile, functional appliances are frequently used. The cervical vertebral maturation (CVM) approach has been widely utilised by orthodontists to measure skeletal maturity and decide the best time to deploy growth-modification equipment. The CVM approach has been shown to be useful in determining the adolescent development peak in both body height and mandibular size. The placement of the functional appliance causes the condyle to be displaced in the glenoid fossa, stimulating condylar cartilage development. The goal was to see if there was a link between temporomandibular alterations and cervical vertebral bone mineral density in teenagers who were receiving functional appliance treatment.

AIM: This study used cone beam computed tomography to examine the relationship between pre and post TMJ alterations and cervical vertebral bone mineral density in adolescents receiving functional appliance treatment

MATERIAL AND METHOD: At (TI) pre-treatment and (T2) 6 months after the start of the therapy, 3D CBCT pictures were collected from 9 participants aged 9-14 years of both sexes. TMJ, mandible characteristics, and cervical vertebral C2-C3 images were taken. All of the measurements were automated and standardised based on the equipment's characteristics, and they were compared.

RESULT: The student pair 't' test and Karl Pearson's test were used to analyse the data. There were changes in the length of the mandibular body, the height of the condyle, and the condylar process. In comparison to C2-C3, there was an increase in bone mineral density.

CONCLUSION: There was an increase in the height of the condyle and condylar process in the TMJ before and after therapy. There was an increase in the length of the mandibular body in the mandible. When it comes to comparing. Treatment both before and after Vertebrae of the cervical spine Bone mineral density was found to be higher in comparison to C2-C3**.**

KEY WORDS: Cervical vertebral C2-C3, peak mandibular growth, bone mineral density, TMJ

I. INTRODUCTION

In order to establish appropriate orthodontic treatment programmes, it is necessary to assess patients' face development status. The skeletal maturity state should be taken into account when determining the best time to utilise growth-modification equipment like Class II functional appliances and headgears. The skeletal maturity state should be taken into account when deciding when to utilise growth modification devices like Class II functional appliances and headgears.[2]

The identification of phases of fast or intensive growth that can contribute considerably to the repair of skeletal imbalances in the particular patient is closely connected to the question of optimal timing for dentofacial orthopaedics. Maturational indices have been presented as a way to assess skeletal maturity in growing patients while planning orthodontic or orthopaedic therapy, as well as for clinical research.[7]

The Cervical Vertebral Maturation (CVM) method has been shown to be effective in detecting the adolescent growth peak in both body height and mandibular size. Several items, including Class II functional appliances and headgear

Lamarck was the first to establish a method for assessing maturational phases in the cervical vertebrae, which was then used by O'Reilly and Yan niello, and Baccate et al. In terms of the link between cervical vertebral maturity and mandibular development alterations, O'Reilly and Yan niello discovered statistically significant increases in mandibular length, corpus length, and ramus height in correlation with distinct cervical vertebral maturation phases[8]

More sagittal changes occur as a result of functional appliance therapy than vertical changes, such as an increase in mandibular length (Co-Gnu), which corrects the facial profile from convex to straight, an increase in antero-posterior diameter and height of condyle, forward positioning of condyle, and backward movement of disc. Stretch forces of the ventrodistal tissues, capsule, and altered flow of viscous synovium cause glenoid fossa alteration. Six months of twin block treatment results in significant glenoid fossa bone growth. The impact of viscoelastic tissues on condyle-glenoid fossa expansion with orthopaedic progression may be important, and it should be evaluated alongside the conventional skeletal, dental, neuromuscular, and age considerations.

CBCT has recently been utilised to provide three-dimensional (3D) pictures in the sagittal, coronal, and axial planes, allowing for accurate images with great resolution and little distortion. Because there are no projections or overlapping of bilateral features, more exact measurements of craniofacial structures may be made. Many benefits of cone beam computed tomography include determining condylar alterations, mandibular length, and intercondylar distance before and after functional treatment. The purpose of this study is to measure the quality of craniofacial bone structures by calculating bone mineral density using grey scales from the pictures collected. The quantity of mineral mass contained in a given volume of a structure is measured in units of mass per area (in bidimensional pictures) or per volume (in tridimensionality images), with solely mineral content taken into account. Bone mineral density may be determined using a variety of approaches, including digital image analysis. Of microradiographs, single photon absorptiometry, dual photon absorptiometry, dual energy X-ray absorptiometry (DEXA) and quantitative ultrasound.[1]

After the development of CBCT, a less complex device with low operational cost and reduced radiation emission used for the acquisition of tridimensional images of dentmaxillofacial structures by Mezzo et al, the indication of medical CT for the evaluation of these structures decreased considerably, especially due to the higher radiation dose applied to the patient during image acquisition. Thus, CBCT has been proposed as a diagnostic method for the determination of bone mineral density. Gray values obtained with CBCT are used in an analogy way as the Hounsfield Unit values for the determination of mineral density in CT.

It is hypothesised that CBCT might be a useful tool for assessing condylar and mandibular morphology, as well as for forecasting mandibular development, measuring treatment effects, and determining bone mineral density. So, in this investigation, a CBCT scan was utilised to examine skeletal changes in condyle height, length, height of condylar process, glenoid fossa depth, height of ramus, mandibular body length, and mandible length before and after functional appliance therapy. Pre- and post-treatment Cervical Vertebral Anatomy Mineral density of the bones**.**

II. MATERIALS AND METHODS

Patients between the ages of 9 and 14 years of both sexes who reported to the department of orthodontics and dentofacial orthopaedics, Raja Rajeswari dental college & Hospital, Mysore Road, Bengaluru, were chosen

The inclusion criteria were as follows:(1) Adolescent patients who receive functional appliance therapy (as confirmed by hand wrist radiograph) (2) age group 9- 14 years. The exclusion criteria were: (1) Patients in post pubertal stage (2) Facial asymmetry (3) History of trauma (4) Craniofacial anomalies

METHOD OF COLLECTION OF DATA

The following radiations were given to all 9 patients who met the inclusion criteria: one pre-treatment CBCT (T1), a second CBCT 6 months after the commencement of treatment (T2), and one pre-treatment Handwrits radiograph to check growth status. The subjects will be informed about the study's purpose and given their permission to participate.

PROCEDURE

Each CBCT image was taken at 12 mA and 70-90 kV with a SanoraSEDEX scanner with the patient seated in the natural head position (Figure 1). 20 3D CBCT images from 9 subjects were obtained at (TI) pre-treatment and (T2) 6 months from the start of the treatment. Each whole image was first cropped to isolate a smaller field of view surrounding the vertebra,TMJ and mandible of interest was taken.

In vertebra either C2 or C3 Gray levels, which is equivalent to the Bone Mineral Density were obtained for C2 and C3 at T1 and T2 at the same anatomical positions in the vertebral body. (Figure 2). This process was repeated for both C2 and C3 for all 18 images. In TMJ and mandible following parameters were taken:

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PARAMETERS	LANDMARKS
HEIGHT OF CONDYLE	Distance between top of condyle and cross-sectional line that goes from the most prominent point of condyle and is perpendicular to the tangent of ramus mandible (Figure 4)
GLENOID FOSSA DEPTH	Linear distance between highest point of condyle and deepest point in glenoid fossa (Figure 10)
LENGTH OF CONDYLE	Linear distance between the anterior and posterior point of the condyle in the sagittal plane (Figure 6)

PARAMETERS	LANDMARKS
HEIGHT OF CONDYLAR PROCESS	Linear distance between the highest point of condyle and line that goes through incisura mandubulae and is perpendicular to the tangent of rams mandible (Figure 8)
LENGTH OF MANDIBLE	Distance between the most distal point of condyle and gnathion (Figure 7)
HEIGHT OF MANDIBULAR RAMUS	Distance between the highest point of condyle and gonion (Figure 5)
MANDIBULAR BODY LENGTH	Distance between points gonion and agnation (Figure 9)

Figure 1:patient head position

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Figure 2: Profile of Gray level values of C3

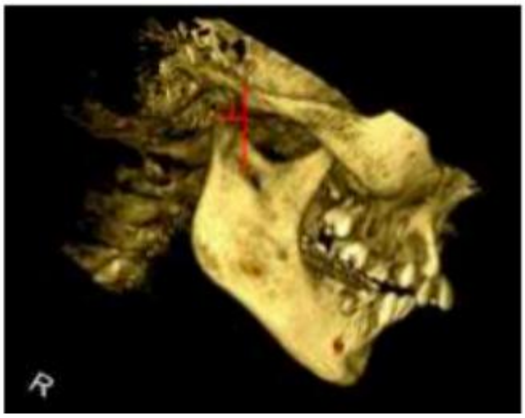

Figure: 4 Height of condyle

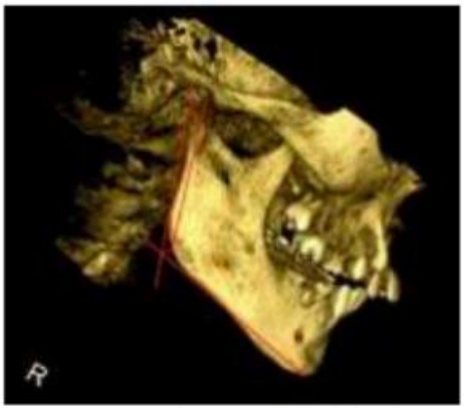

Figure: 8heights of mandibular process

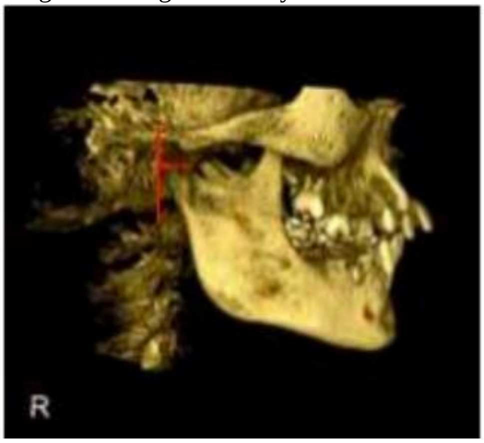

Figure 6: length of condyle

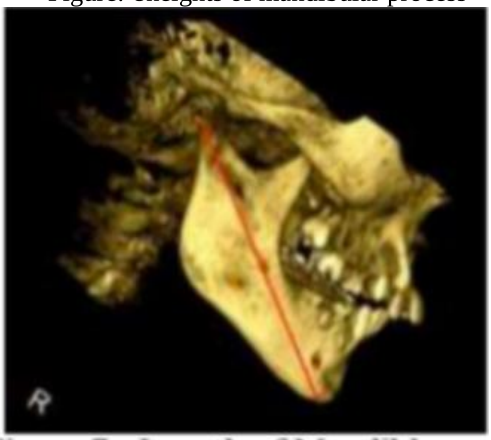

Figure 5: length of mandible ramus

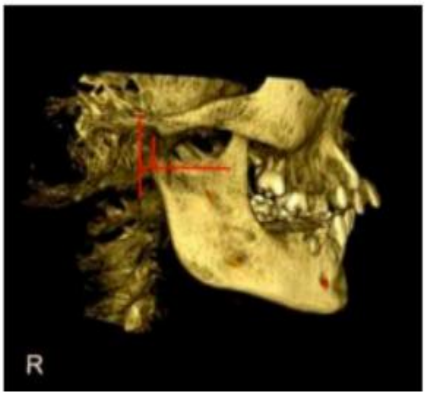

Figure8:Height of condylar process

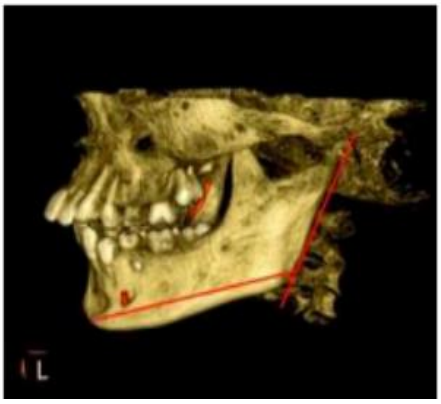

Figure9: mandible body length

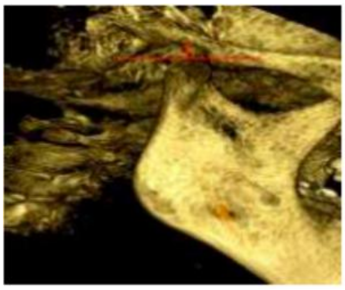

Figure 10: Glenoid fossa depth

STATISTICAL ANALYSIS:
Statistical Package for Social Sciences [SPSS] for Windows, Version 22.0. Released in 2013. Armonk, NY: IBM Corp., was used to perform statistical analyses

DESCRIPTIVE STATISTICS:
Descriptive analysis includes expression of all the explanatory and outcome variables in terms of frequency and proportions for categorical variables, whereas in terms of Mean & SD for continuous variables.

INFERENTIAL STATISTICS:
Student Paired t test was used to compare the mean values of various study parameters between Right & Left Sides during pre & post treatment time period. Similarly, the mean values of various study parameters including the BMD values were compared between pre & post treatment time periods using the same test.Karl Pearson's correlation test to assess the relationship b/w BMD values at C2 & C3 Areas and Mandibular, TMJ parameters during the Post Functional Therapy period. The level of significance [P-Value] was set at P<0.05.

III. RESULTS:

Table 1 shows the age and gender distribution among study subjects. Subjects in the age range of 9-11 were more in number in the study compared to the subjects in the age range of 12-14. Males comprised 55.6% of the total sample and female patients were 44.4%. The level of significance [P-Value] was set at P

Table 2 shows the comparison of mean mandibular length in mm between pre and post functional therapy treatment time intervals on right and left side using student paired t test. The mandibular length on both sides showed an increase during the observation time interval. The mandibular length on right side showed a mean difference of -0.93 between pre and post functional therapy time intervals and the left side showed a mean difference of -1.73. The level of significance [P-Value] was set at P

Age and Gender Distribution among study subjects			
Variables	Category	n	%
Age	9-11 yrs.	6	66.7%
	12-14 yrs.	3	33.3%
Sex	Males	5	55.6%
	Females	4	44.4%

Table 1 shows the age and gender distribution

Comparison of mean values of various study parameters between Right & Left Sides during pre-treatment time period using Student Paired t test						
Parameters	Sides	N	Mean	SD	Mean Diff	P-Value
Height of condyle	Right	9	4.37	0.67	-0.47	0.07
	Left	9	4.84	0.92		
Length of condyle	Right	9	9.44	0.76	0.02	0.85
	Left	9	9.43	0.91		
Height of Condylar	Right	9	12.48	2.80	-0.25	0.76

process	Left	9	12.73	2.63		
Height of Ramus	Right	9	46.29	3.50	0.57	0.43
	Left	9	45.72	3.42		
Length of Mandibular Body	Right	9	58.30	3.91	1.40	0.17
	Left	9	56.90	4.13		
Mandible length	Right	9	92.46	5.74	-0.95	0.17
	Left	9	93.41	5.07		
Glenoid fossa depth	Right	9	1.50	0.83	-0.45	0.21
	Left	9	1.95	0.96		

Table 2 shows the comparison of mean mandibular length in mm between pre and post functional therapy treatment time intervals on right and left side using student paired t test

Table 3 shows the comparison of mean and SD of BMD values in C2 and C3 areas between pre and post functional therapy treatment time intervals using Wilcoxon Signed Rank test. The Mean of the Mean Gray levels of both C2 and C3 showed significant increase post functional treatment (T2). The mean of the mean gray levels for C2 vertebral body was significantly lower than that for C3 vertebral body both before (T1) and after (T2) treatment. The mean BMD values of C3 showed more increase post functional therapy than the mean BMD values of C2 post functional therapy. The level of significance [P-Value] was set at P

Table 4 shows the correlation test to assess the relationship b/w BMD values at C2 & C3 areas and mandibular, TMJ parameters during post functional therapy period using KarlPearson'stest. When compared to C2 & C3 with condylar height showed statistically significant value.when compared with length of condyle with C2 and C3 statistically significant value was shown in C3. at the same time length of mandible with C2 and C3 showed statistically significant value.

Comparison of mean BMD values in C2 & C3 areas between Pre and Post Functional Therapy time intervals using Student Paired t test						
Areas	Time	N	Mean	SD	Mean Diff	P-Value
C2	Pre Rx	9	338.94	60.12	-52.67	0.003*
	Post Rx	9	391.61	52.97		
C3	Pre Rx	9	344.11	85.20	-55.72	0.01*
	Post Rx	9	399.83	53.88		

Table 3 shows the comparison of mean and SD of BMD values in C2 and C3 areas between pre and post functional therapy treatment time intervals using Wilcoxon Signed Rank test

Karl Pearson's correlation test to assess the relationship b/w BMD values at C2 & C3 Areas and Mandibular, TMJ parameters during Post Functional Therapy period								
t C2 & C3 Are	Values	Height of condyle	Length of condyle	Ht. Condylar process	Height of Ramus	Ln Mand. Body	Mandible length	Gleniod fossa depth
C2	rho	0.67	0.20	0.08	0.07	0.62	0.30	-0.27
	P-Value	0.04*	0.61	0.83	0.87	0.04*	0.43	0.49
C3	rho	0.68	0.13	0.68	0.41	0.74	0.57	-0.17
	P-Value	0.04*	0.74	0.04*	0.28	0.02*	0.08	0.67

Table 4 shows the correlation test to assess the relationship b/w BMD values at C2 & C3 areas and mandibular, TMJ parameters during post functional therapy period using KarlPearson's test

IV. DISCUSSION

Many research has been conducted to date in order to establish the influence of functional appliances on skeletal structure. Wadhawan, N., et al. conducted an MRI study on temporomandibular joint adaptations after two-phase therapy and found that forward condylar position within the glenoid fossa and articular disc retrusion with respect to the condylar head were statistically significant after functional appliance therapy.

Treatment time is critical for getting the best results from functioning appliances. Ten patients treated with functional appliances were explored in one of the studies whose parameters and findings were comparable to the current study. Four patients got therapy before the pubertal peak in skeletal growth, whereas six patients' treatment encompassed the pubertal peak. In all peak samples, the amount of genuine additional mandibular growth caused by treatment (measured by Co-Gn or Co-Pg). During the pre-peak period, none of the samples were treated had a clinically significant amount of supplementary mandibular growth

In order to establish treatment scheduling in orthodontic and orthognathic surgery patients, it is vital to know their bone age. Biological indications such as chronological age, dental development, sexual maturation, voice alteration, and body height have all been proposed by several studies. Regrettably, chronological age alone is not a good indication of bone maturation.

Skeletal maturation markers that employ hand-wrist radiographs are common and reliable in orthodontia clinics. This procedure, however, necessitates the use of hand-wrist radiography film. The use of cervical vertebral maturation (CVM) as a substitute for the hand-wrist evaluation has gained popularity.

Gabriel et al., on the other hand, have voiced concerns about CVM's low inter- and intra-observer reliability, which is below 50% and 62%, respectively. They argued that staging has inherent bias, and that in order to make the CVM analysis clearer, easier, and more applicable to the majority of patients, it would be necessary to use fewer vertebral bodies, use more sensitive parameters, and avoid estimating stage based on a comparison of changes between stages. Chen et al. proposed using factors from the second, third, and fourth cervical vertebrae to attain these circumstances. The concavity of the vertebral body, height, and form of the vertebral body were taken into account as morphologic characteristics of CVM[10]

The accuracy of CBCT imaging of the TMJ was tested by certain researchers. CBCT readings were shown to be much more trustworthy than lateral cephalometric, posteroanterior, and submentovertex values when Hilgers et al. compared them to digital cephalometric radiographs. Various authors conducted studies to compare the accuracy of 3D CBCT with various 2D imaging methods. The diagnostic accuracy of CBCT, OPG, and linear tomography was compared by Honey et al.

The researchers discovered that CBCT pictures were more reliable and accurate than linear tomography and TMJ panoramic projections.So, by comparing the effectiveness of accuracy of CBCT over other 2D imaging technique we decided to use this advanced imaging technique for the present study to determine the alterations in the skeletal parameters i.e., height of condyle, length of condyle, depth of glenoid fossa, height of ramus, length of mandibular body, mandible length, height of condylar process after orthopaedic treatment

Many clinical investigations have shown that CBCT scans may be utilised to measure BMD volumetrically. Combining the findings of these prior investigations, it is possible to assume that clinical CBCT-based 3D morphologic and volumetric BMD assessments for the cervical vertebrae can give quantitative data to determine a patient's skeletal maturity.

The patients in this study were chosen using the previously described inclusion and exclusion criteria. Patients in the pre-pubertal and pubertal stages were sampled. They ranged in age from 9 to 14 years old and were of both sexes. To check growth status, a hand wrist radiograph was done

The purpose of this study was to determine whether additional information in the form of BMD distribution would be useful in assessing skeletal maturity and growth potential. In fact, we found that the BMD does change predictably during the adolescent growth period. The Means of Gray levels, which are equivalent to average bone mineral density (BMD) of each vertebral body were assessed from the CBCT images.

At the post-treatment time-point, the difference between the mean grey values for C2 and C3 was larger than at the pre-treatment time-point. As higher gray values indicate a higher level of mineralization, this indicates that there is a greater the post-treatment time-point than at the pre-treatment time-point. As higher gray values indicate a higher level of mineralization, this indicates that there is a greater difference in mineralization between the two vertebrae after treatment than before treatment. This implies that active remineralisation took place during the observation period, i.e., adolescent growth period. We also found that the CVM level and mandibular length increased during the same period. Taken together, these results indicate that the 3D clinical CBCT-based analysis could provide information of bone mineral density distribution that is changing in concert with both skeletal maturation and TMJ,mandible.

This study presented findings of the gray values of C2 and C3 cervical vertebrae and changes in mandibular length as derived from CBCT images in 9 children of age group 9 to 14 yrs. who underwent functional appliance therapy. Diagnostic records along with handwrist radiographs were taken to assess growth status of the patient. All parameters including CVM stages, mandibular lengths and BMD significantly changed during the observation period

V. CONCLUSION:

1) During peak period of mandibular development there was increase in Bone mineral density of cervical vertebral

2) TMJ there was increase in height of condyle and condylar process pre- and post-treatment.

3) In mandible there was increase in length of mandibular body.

4) CBCT images proved to be useful to analyse the changes in gray level values of cervical vertebrae which correspond to BMD and to detect the TMJ and mandibular parameters during the pubertal growth spurt which is the optimal timing for functional jaw orthopaedics.

5) The BMD values showed a positive correlation with height of condyle, height of condylar process and length of body of mandible and CVM stages

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