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RESEARCH ARTICLE

A COMPARATIVE ASSESSMENT OF MANDIBLE AND CONDYLAR POSITION IN PATIENTS WITH CLASS II DIV 2 INCISOR PATTERN AFTER ALIGNMENT AND LEVELLING PHASE- A PROSPECTIVE STUDY

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Abstract

Objectives: The aim of the study was to assess and compare the changes in mandible and condylar position in between pre and post alignment of maxillary arch in patients with class II div 2 incisor pattern.

Material and Method: CBCT and lateral cephalogram of 13 subjects of class II div 2 incisor pattern were taken in maximum dental intercuspation with the FH plane parallel to the floor. Dolphin Imaging 11.95 premium software was used to make all the tracings and measurements. All subjects were treated by non-extraction orthodontic therapy and were analyzed at two points of time i.e pre-treatment and post-levelling and alignment of maxillary arch. Angular and linear measurements were analyzed (5 CBCT parameters and 7 Lateral cephalogram parameters) in both vertical and horizontal plane.

Result: With the increase of inclination of upper incisors and opening bite, a statistically significant positional change was noted in the condylar position both in the vertical and sagittal directions. Statistically significant increase was also observed in effective mandibular length and mandibular plane angle.

Conclusion: Better condylar position and mild to moderate skeletal discrepancies associated with class II div 2 malocclusion can be addressed only by correcting the maxillary labial segment.

Introduction:-

Class II division 2 incisor pattern is characterized with excessive lingual inclination of the maxillary central incisors overlapped on the labial by the maxillary lateral incisors in combination with deep overbite[1]. In this type of incisor pattern when the mandible is brought from postural rest position to habitual occlusion the path of closure is influenced by the lingually inclined maxillary incisors and infraocclusion of the posterior teeth. During closure of the mouth the combination of these two factors results in an abnormal mandibular path as well as overclosure[2].

Altered incisal guidance and abnormal mandibular path affects the complex morphological structure of the Temporomandibular joint (TMJ). Several researchers have studied the TMJ in diverse malocclusion and reported that the morphological structure and positional relationship between the condyle and articular fossa may be different in various types of malocclusion. Occlusal factors, including incisal guidance (IG), are commonly altered during prosthetic and orthodontic treatment. IG influences condylar guidance, which in turn modifies TMJ

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morphology.Tinastepe et al. found that patients with increased vertical overlap and minimal horizontal overlap had more clinical symptoms associated with temporomandibular disorders (TMDs) than patients with normal mandibular anatomy. These findings suggest that IG may affect the function of the TMJ and anatomy[3].

Thus, it can be affirmed that in class II div 2 cases orthodontists should not only restore tooth alignment and occlusal interferences, but also develop condylar positions that are harmonic with the dentition[4].

Accurate visualization of the anatomic features of the TMJ is limited while using conventional radiograph because of its complex morphology and superimposition of adjoining bony structures. The other available tool to evaluate the ginglymoarthroidal joint is cone beam computed tomography (CBCT).CBCT can deliver submillimeter spatial high-resolution images that have good diagnostic quality. Also, measurements in CBCT were reproducible and substantially more accurate in all three possible orthogonal planes[5]

Literature shows few studies on comparative assessment of condylar position in Class II Division 2 malocclusion between pre- and post-alignment and levelling phase and most of them have used 2-D radiographs[6]. For the above reason this study was undertaken to see how orthodontic treatment affects mandibular and condylar position in patients with class II div 2 incisor relation using CBCT.

Materials and Method:-

Ethical approval

Ethical approval for this investigation was obtained from the Institutional Ethics Committee of the Institute of Dental Sciences, Bareilly (No. IEC/103/2021). The purpose of the study was explained to, and informed consent was obtained from, all the participants.

Sample- size calculation

Sample size has been scientifically estimated using G power 3.1(Franz fauliniversitat, kiel, Germany) software. This resulted in a minimal sample size of 13 subjects.

Subjects

This study was conducted from May 2022 to April 2023 with the cooperation of 13 subjects aged between 16-28 years who had reported to the Department of Orthodontics and Dentofacial Orthopedics at Institute of Dental Sciences for orthodontic treatment. Subjects with any gross deformity of the facial skeleton due to trauma or congenital anomalies were excluded from the study. CBCT scans and lateral cephalogram were taken at 2-time intervals, i.e at pre-treatment (T0) and after alignment and levelling (T1).

Study design

CBCT of the TMJ.

The CBCT scans of bilateral TMJs were performed usingCS 9300 Select Carestream Imaging system (10 × 10 cm field of view, 120kV, 5 mA, 14s exposure, voxel size of 0.2 mm). The subjects were standing and biting their teeth in to maximum intercuspal position. Their heads were positioned with the Frankfort horizontal plane (FH) parallel to the floor.

Morphological evaluation of the TMJ.

The FH plane, which was constructed by Orbitale on the right side and by Porion on both sides, was used as the horizontal reference plane for the reconstructed images. The left and right joints were evaluated separately. Dolphin Imaging Version 11.9 (Chatsworth, CA) was used to digitize landmarks. Morphological evaluation of the TMJ was performed using linear and angularmeasurements. In the sagittal view, slice was selected in which the condyle, glenoid fossa and sigmoid notch were clearly noticed. **Anterior joint space (AJS)** The shortest distance between the most anterior point of the condyle and the posterior wall of the articular tubercle (figure1). **Posterior joint space (PJS)** The shortest distance between the most posterior point of the condyle and the posterior wall of the mandibular fossa (figure1). **Superior joint space (SJS)** The shortest distance between the most superior point of the condyle and the deepest point of the mandibular fossa (figure2). **Mandibular fossa depth (MFD)** Distance between the deepest point of the mandibular fossa and the plane formed by the most inferior point of the articular tubercle to the most inferior point of the auditory meatus (figure3). **Articular eminence angle (AEA)** Line1 was constructed as horizontal line, parallel to the FH passing through the uppermost point of the glenoid fossa, Line 2 was constructed along the posterior slope of articular eminence, connecting the lowermost and most posterior point of the articular eminence and the uppermost and most anterior point of the glenoid fossa on the temporal bone, the angle measured between the two lines (figure4).

Condylar position assessment[7]
Condylar position was determined by the following formula according to the method of Pullinger and Hollender.

$$\textbf{Condylar ratio} = \frac{PJS - AJS}{PJS + AJS} \times 100$$

The position of the condyle was considered concentric if the ratio was within ±12%, posterior if the ratio was smaller than −12%and anterior if the ratio was greater than +12%.

Lateral cephalograms.
Lateral cephalograms were taken using the Allengers Smart PAN 2K150330009-D9. All images were taken by the same radiographer. The patients were imaged in maximum dental intercuspation with theFH plane parallel to the floor. The cephalostat machine set at 80 KVp, 10mA for 0.8s. Fujifilm FCR FUJI IP cassette type CC of 8 x 12 in (20.1 x 25.2 cm) was used and processed by the Fujifilm FCR Primax T2 Automatic X-ray film processor.

These records were then transferred in the Dolphin Imaging 11.95 premium software for cephalometric tracing and analysis (figure5). Parameters evaluated were **SNB, ANB, Mandibular plane Angle** (FH-Go-Me), Effective mandibular length(Co-Gn) and **U1 to SN**.

Two additional reference planes were constructed,the Horizontal reference plane (HRP) by drawing a line through nasion (N) -7° from SN plane and Vertical reference plane (VRP) was drawn perpendicular to HP plane through sella.Linear parameters (HRP-Co), (VRP-Co)were measured to calculate the position of the condyle.

All parameters were measured three times by two researchers at 2-week interval. The average values of the six measurements were taken for statistical analysis.

Statistical Analysis:
Descriptive statistics were calculated as mean and standard deviation (SD) for all the parameters. The paired t-test was used to compare the mean values of all the parameters between pre and post with in the scores. Intra and inter-observer reliability were analysed using Pearson correlation coefficient analysis. Alpha error was set at 0.05 and 'p' value less than 0.05 ($p<0.05$) was considered statistically significant and highly significant as ($p<0.001$) for all the analysis. All the analysis were performed on IBM SPSS 20 (Statistical package for Social Science) software (Appendix VII).

Method:-
After case selection (figure6), fixed orthodontic treatment was decided for all the patientsstarting with bonding of retruded incisors and by placing a 2 x 2 appliance to intrude and procline the retroclined incisors (figure7). After 3-4 months, complete maxillary arch was bonded and 0.014 NiTi arch wire was placed (figure8). Alignment and levelling of the maxillary teeth was continued till a 0.016 x 0.022 NiTi wire fitted in to the bracket slot.

Results:-
A final analysis of 13 patients (5 males and 8 females) was included. The age ranged from 16 to 22 yrs. In our study a statistically significant decrease was found in the AJS from 1.862 ± 0.338 mm (T0) to 1.715 ± 0.2996 mm (T1)on the Right and from 1.854 ± 0.2876 mm (T0) to 1.7 ± 0.2614 mm (T1) on the Left (P= 0.002). Statistically significant increase in the PJSat T1, both on the right and left, from 2.392 ± 0.3616mm to 2.508 ± 0.4153mm (p=0.033) and 2.431 ± 0.4151mm to 2.562m ± 0.3709mm (p=0.007) respectively was observed. A statistically insignificant increase in theSJS at T1 from 3.192 ± 0.7455mm to 3.231 ± 0.6588mm on the Right (p=0.579) and statistically significant increase from 3.208 ± 0.5823mm to 3.362 ± 0.5867mm on the left (p= 0.000) were observed. A statistically significant increase in theMFD at T1 from 7.000 ± 0.7735mm to 7.162 ± 0.6959mm on the right (p=0.003) and from 7.077 ± 0.6710mm to 7.254 ± 0.6578 mm on the left (p= 0.001) were obtained. A statistically insignificant increase in the AEA at T1 from 46.62º ± 4.419º to 47.00 ± 4.916º on the right (p=-0.506) and from 46.69º ± 4.608º to 47.23º ± 5.464º on the left (p= -0.538) was observed (Table I, Graph 1A and B).

At T0, 15 (56.69%) of the total 26 condyles were posteriorly positioned, 1(3.84%) was centred and 10(38.46%) were anteriorly positioned. At T1, 18 (69.2%) were now anteriorly positioned, 5 (19.23%) were now centred and 3 condyles (11.5%) were posteriorly positioned. The change in the condylar position were found to be statistically significant (p=0.044)(Table II, Graph 2).

In the cephalometric parameters, there was a highly significant increase for U1-SN (-20.7308º), SNB (-0.9231º) and FH-Go-Me (-1.7538º) was observed. A highly significant decrease in the ANB (0.8769º) was noted.A highly significant increase in Co- Gnwas observed (-2.0769).A highly significant decrease of 1.5385mm was observed for HRP-CO, while a highly significant increase in VRP-CO (-0.2846mm) was noted(Table III, Graph 3).

Discussion:-

Palatal tipping of the maxillary incisors in class II division 2 incisor pattern results in the final part of the mandibular closing movement in the dorsal direction, possibly also affecting the location of the condyle in the articular fossa.[8] **Ricketts** believed that it was important to "unlock" the deep bite by advancing and intruding the upper incisors in div 2 incisal pattern, that could have also inhibit the habitual forward movement of the mandible.Hence the mandibular and temporomandibular joint changes can be expected after the leveling and alignment phase of maxillary arch in patients having retroclined maxillary incisors. Surprisingly there are limited number of studies in the literature that examine the morphology of the TMJ in different occlusal anomalies and none whatsoever discuss the changes in TMJ morphology after orthodontic correction.[9]Therefore, the goal of this study was to see how initial alignment and levelling affected condylar position, TMJ and mandible in patients with class II div 2 incisor relation using CBCT and Cephalogram.

A statistically significant difference was observed in linear parameters between T0 and T1 scores of AJS, PJS, SJS and MFD($p<0.05$).

In our study, a statistically significant decrease was found in the AJS on the right and on the left. Statistically significant increase in the PJS at T1, both on the right and leftwas observed. A statistically insignificant increase in the SJS at T1on the right and statistically significant increase on the left were observed. In the present study Statistically significant increase in theMFD at T1on the right and on the left were obtained.

It has been reported that TMJ undergoes a continuous morphologic alteration, and that this alteration is mediated by dental occlusion and also that it adapts to altered functions. In present study and in other studies which are done to evaluate TMJ changes after correction of maxillary incisors inclination and deep bite in class II div 2 patients, joint spaces have shown significant changes supporting the belief of possible mandibular functional displacement. Results of the present study are also suggestive of anterior and inferior displacement of condyle after alignment and levelling of maxillary arch. **Ricketts**also noted that in many class II div2 malocclusions subjects, the mandible followed the maxillary incisors teeth after they were tipped labially in the initial phase of treatment.[9]

However, few studies did not validate the finding of mandibular repositioning after correction of incisal interference in class II div 2 subjects. **Demish et al(1992)[10]**did not find any spontaneous anterior mandibular repositioning after proclination of the maxillary incisors. In this study, age range for subjects were from 8 to 12 yrs, with growth potential and significant growth of maxilla was also reported in study, a factor that may have masked detection of any mandibular anterior repositioning. **Coskuner et al (2015)[11]** did not find significant changes which was probably due to the fact that CBCT records were obtainedafter considerable maxillary arch correction. Hence, condylar remodelling could have camouflaged the changes in joint space.

Therefore, it can be inferred from the above results that temporomandibular joints is highly adaptable to functional needs but statistically appreciable changes were dependent on time interval between consecutive records.

Statistically insignificant increase in theAEAat T1was observed. **Katsavrias et al[12]** has suggested that inclination of AE completes its70%-72% maturation by the age of 10yrs and it was 90%-94% completed by the age of 24 years. He also reported the normal value in adults ranges between 30º-60º. **Raghav P et al[6]**had taken the similar parameters in cephalogram and naming it as condylar inclination and showed a statistically significant increase of 6.45º post alignment of maxillary arch in class II div 2 patients and it was also mentioned that condylar inclination may be an important prognostic variable for assessing mandibular relocation, where as in the present study statistically insignificant increase was observed in the AEI.Taking in to account the wide range of AEI and completion of its growth at an earlier age justifies the insignificant changes in its inclination with treatment.

Joint space index was evaluated to assess the condylar position at T0 and T1 whether it is centric, anterior or posterior. A statistically significant change in condylar position was observed at T1 as greater percentage of condyles were now either centeredor anteriorly positioned than atT0. **Moataz A et al**[13]observed a significant difference in the condylar position. Initially, out of the total 22 condyles, 2 (9.1%) were positioned posteriorly, 8 (36.4%) were centred, and 12 (54.5%) were anteriorly positioned. Following the levelling process, 5 condyles (22.7%) became centred, and 17 (77.3%) were anteriorly positioned, demonstrating a highly significant difference (p=0.001).**Zheng et al**[14] **also** reported a highly significant difference,initially 34 (68.00%) of the total 50 condyles (25 subjects) were posteriorly positioned, 16(32.00%) were centred and 0 were anteriorly positioned. In the post treatment 12 condyles (24.00%) were posteriorly positioned, 38 (76.00%) were centred and none was anteriorly positioned (p=0.001). **Parker et al**[15]has also suggested a potential association between occlusal changes and changes in the condylar position.Increased frequency of condyles in anterior or central position in post alignment phase suggest a likely association between condylar position in mandibular fossa and incisal relationship.

Treatment changes in craniofacial structures were assessed with various linear and angular cephalometric parameters. A statistically significant difference was observed in all the angular parameters between pre and post alignment and levelling scores. In our study a statistically significant increase was found for the (U1-SN) from T0-T1 by 20.7º (P-value =0.000). This is in accordance to the result obtained by**Shaik et al**[16]**, Raghav P et al**[6]**.**Correcting the inclination of the upper central incisors was a foremost requirement to unlock the mandible from its distal position and for correction of deep bite. Bjork, Burzin and Nanda, Kim and Little had also reported that deep bite depends on the relation between the upper and lower incisors and was believed to play a critical role in overbite correction.

In our study, the mean increase for SNB was 0.92º, which was statistically significant. A statistically significant decrease was also observed in ANB (0.87º, P< 0.005). A significant increase in SNB and a decrease in ANB entailed a notable reduction in skeletal class II pattern and this findings were consistent with the result of various other studiesdone by **Raghav P et al**[6]**, Parker et al**[15].To put it briefly class II div 2 malocclusion often have skeletal patternssimilar to class I than class II division I but due to unique incisor relationship acquirement of same remains problematic. Once that constraint isovercame, skeletal pattern approaches towards class I as depicted by increased SNB and decreased ANB in the present study.

There was an increase in Co-Gn by 2.07mm (p=0.000) observed in our study, which was statistically significant. This finding was similar to the results of **Raghav P et al**[6] who also found an insignificant increase by 4.5mm (p=0.11) in the Co-Pog. **Parker et al**[15]also found an increase in mandibular length during deep bite correction by 6.09mm (p=0.0001). **Coskuner et al**[11] evaluated 3D changes in mandibular position after elimination of occlusal interferences in class II div 2 patients and found a statistically significant increase of 2.14mm in effective mandibular length i.e Co-Gn (p=0.001). It was also mentioned statistically significant increase in mandibular dimensions resulted due to elimination of maxillary interference in class II div 2 patients.

Statistically significant increase in the mandibular plane angle (Go-Me-FH) at T1by 1.75º (P 0.013) was observed. Our findings are in accordance with the study done by **Ghobashy**[17] who has also reported an increase of 2.5º±0.5º in the mandibular plane angle in patients with class II division 2 cases treated without extraction. In a study done by **Parker et al**[15]**,** FMA has shown a significant increase of 0.91± 1.89 in treated class II div 2 cases. Similar findings were also reported by **Shaik Set al**[16]who found an increase in mandibular plane angle by 1.7º.The reason for the same can be attributed to the increase in intermaxillary divergence associated with deep bite correction.

There was a statistically significant decrease in distance from HRP–Co by -0.2846mm (p=0.045) and also an increase in distance from VRP-Co by 1.5385mm (p=0.005) from T0 to T1.So, it can be inferred that condyle was shifted in forward and downward direction after correcting the retroclined central incisors. In agreement with our study, **Raghav P et al**[6] also concluded that there is a downward and forward shift of condyle during the unlocking phase in class II div 2 subjects. This is also in accordance to the observational study conducted by **Shaik K et al**[16]who reported an average horizontal shift of the condyle was -1.62 mm in forward direction, an average vertical shift of the condylewas 1.68 mm in downward direction which was statistically significant (p= 0.0001). **Nimri K et**

al[18] also reported that there is forward sagittal movement of articulare point by 1.88mm in growing individuals and in non-growing groups by 1.39mm in treated class II div 2 cases.

In our opinion, these results substantiate the view that the posteriorly displaced mandible holds true for many class II div 2 malocclusion cases, if not valid as a general statement for the whole population belonging to the same malocclusion.Results of the present study can be inferred as thebetter condylar position and mild to moderate skeletal discrepancies associated with class II div 2 malocclusion can be addressed only by correcting the maxillary labial segment.A limitation of the study was that only sagittal and axial images were evaluated for mandibular condyle assessment with CBCT. Future studies should evaluate the condylar position in all 3 planes i.e sagittal, axial as well as coronal view. Another limitation of the study was the potential for cephalometric errors as the craniofacial structures were evaluated with the use of lateral cephalogram which is a 2- dimensional representation of the 3-dimensional structures.Simultaneously the increased sample size segregating in male and female subjects could have enhanced the accuracy of the results.

Comparison Of Post-Treatment From Pre- Treatment For Cbctmeasurements

Table I:- Comparison of post-treatment from pre- treatment for CBCT Measurements.

Variable		Pre-Treatment		Post-Treatment		Treatment Change	p-Value
		Mean	**S.D.**	**Mean**	**S.D.**		
1. AJS	**RT**	1.862	0.338	1.715	0.2996	0.1462	0.002**
	LT	1.854	0.2876	1.7	0.2614	0.1538	0.002**
2.PJS	**RT**	2.392	0.3616	2.508	0.4153	-0.1154	0.033**
	LT	2.431	0.4151	2.562	0.3709	-0.1308	0.007**
3. SJS	**RT**	3.192	0.7455	3.231	0.6588	-0.0385	0.579
	LT	3.208	0.5823	3.362	0.5867	-0.1538	0.000**
4. MFD	**RT**	7.000	0.7735	7.162	0.6959	-0.1615	0.003**
	LT	7.077	0.6710	7.254	0.6578	-0.1769	0.001**
5.AEA	**RT**	46.62	4.419	47.00	4.916	-0.385	0.506
	LT	46.69	4.608	47.23	5.464	-0.538	0.266

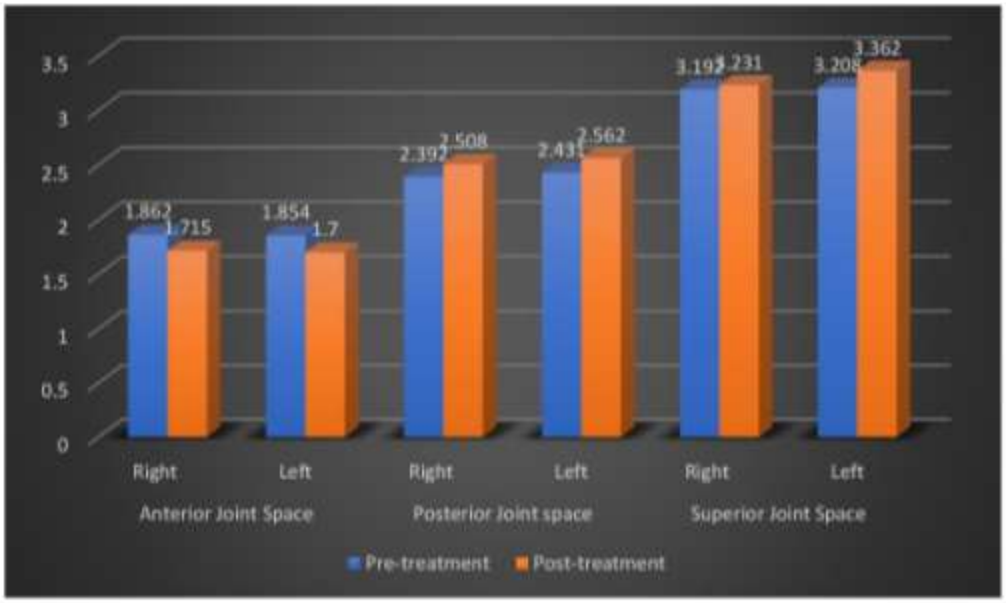
**p<0.05 (significant), ¶p value of paired t test.

Comparison Of Condylar Position Of Post-Treatment From Pre- Treatment

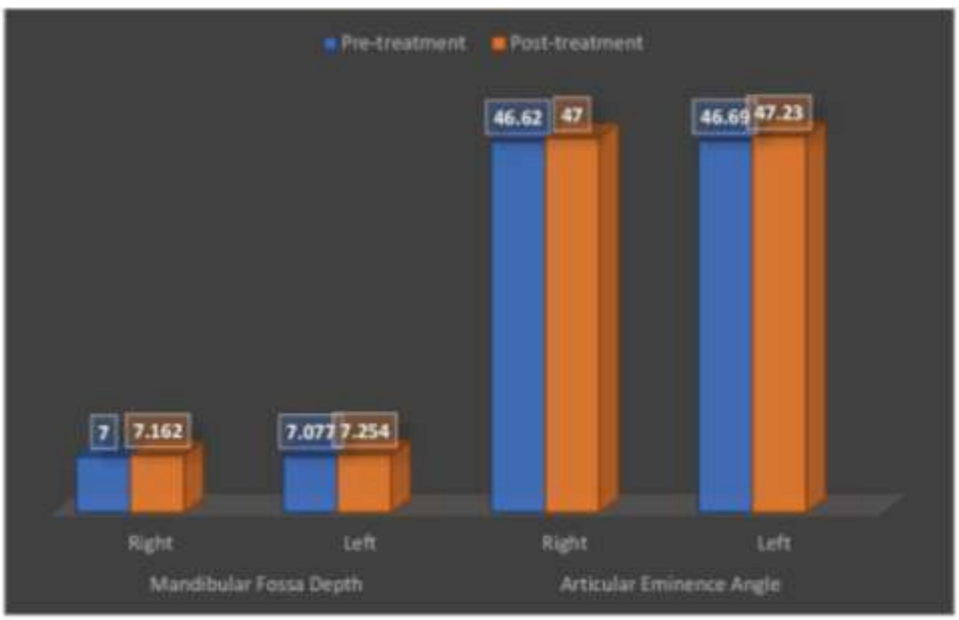
Table II:- Comparison of post-treatment from pre- treatment for CBCT Measurements.

Group	**CONDYLAR POSITION**			**p-value**
	Posterior	**Concentric**	**Anterior**	
PRE-TTREATMENT	15 (56.69%)	1(3.84%)	10(38.46%)	0.044
POST-TTREATMENT	3 (11.5%)	5 (19.23%)	18 (69.2%)	

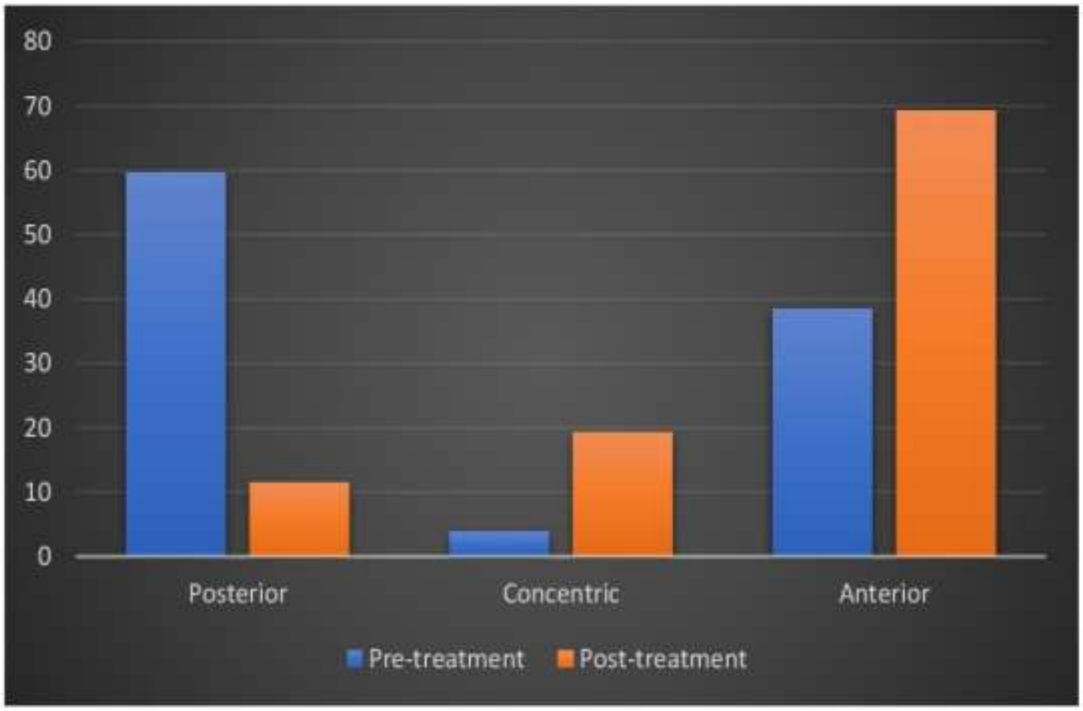
**p<0.05 (significant), ¶p value of paired t test



Graph 1A: Comparison of post-treatment from pre- treatment for CBCT Measurements



Graph 1B: Comparison of post-treatment from pre- treatment for CBCT Measurements

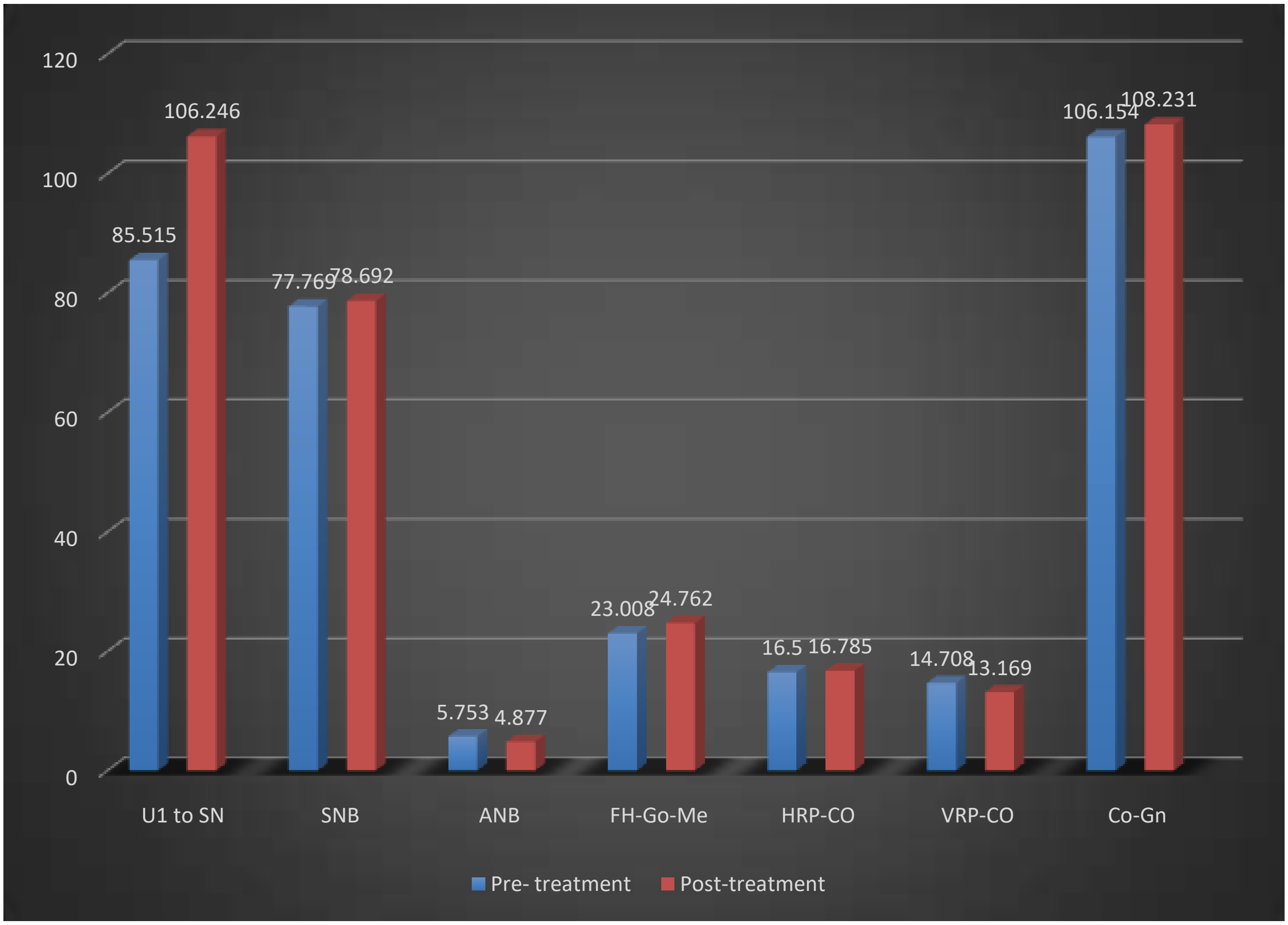


Graph 2: Comparison of condylar position of post-treatment from pre- treatment

Comparison Of Post-Treatment From Pre- Treatment Scores For Cephalometric Parameters

Table III:- Comparison of post-treatment from pre- treatment for CBCT Measurements.

Variables	Pre-Treatment		Post-Treatment		Treatment Change	p-value
	Mean	S.D.	Mean	S.D.		
1. U1 - SN	85.515	9.7385	106.246	9.7357	-20.7308	0.000**
2. SNB	77.769	1.9615	78.692	2.3475	-0.9231	0.000**
3. ANB	5.753	2.5683	4.877	2.2398	0.8769	0.005**
4. FH-Go-Me	23.008	6.1734	24.762	5.3879	-1.7538	0.013**
5. HRP-CO	16.500	2.0817	16.785	1.819	-0.2846	0.045**
6. VRP-CO	14.708	2.0962	13.169	1.5343	1.5385	0.005**
7. CO-Gn	106.154	5.986	108.231	6.1322	-2.0769	0.000**



Graph 3: comparison of post-treatment from pre- treatment scores for cephalometric parameters

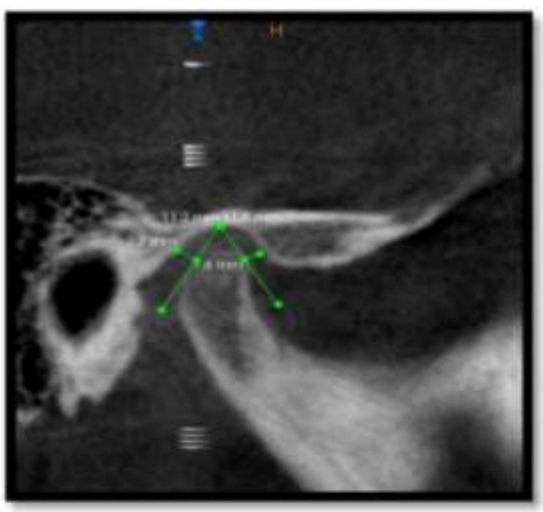


Figure 1: Anterior (A) and posterior (B) joint space

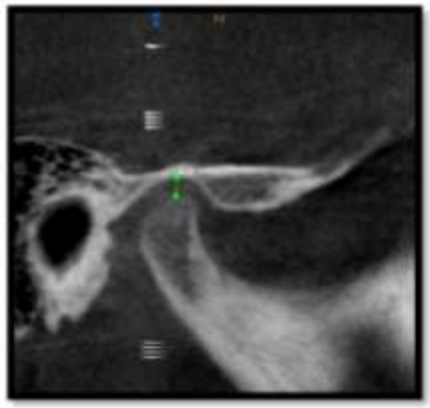


Figure 2: Superior joint space

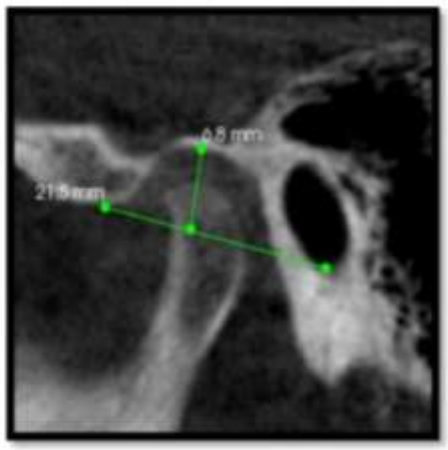


Figure 3: Depth of the mandibular Fossa

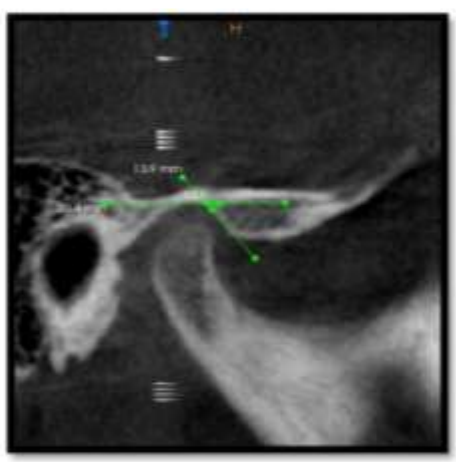


Figure 4: Articular Eminence Angle

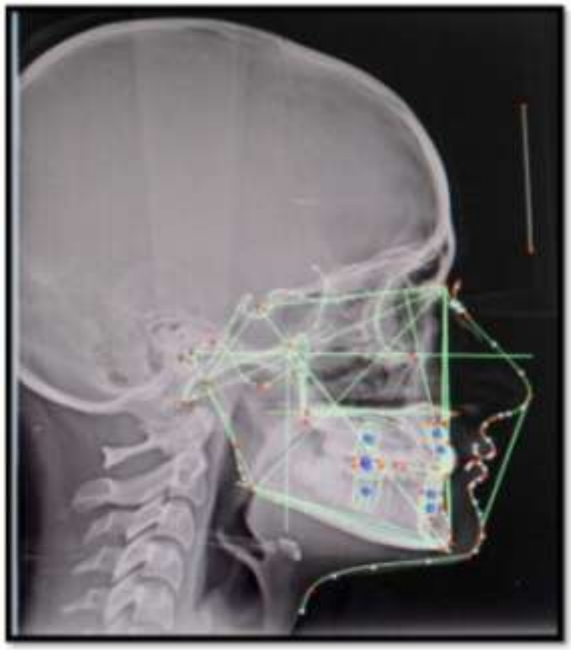


Figure 5: Tracing for Cephalometric analysis

Figure 6: Pre-treatment intra oral photograph

Figure 7: 2 X2 Appliance

Figure 8: Complete bonded maxillary arch

Conclusion:-

1. Condylar displacement in the forward and downward direction after correction of maxillary incisor inclination in class II div 2 malocclusion.
2. Greater number of condyles were posteriorly positioned in pre treatment, out of them many became centred or anteriorly positioned in the post alignment phase.
3. Upper incisors were considerably proclinedand mandible was anteriorly positioned eliminating class II tendency in the post alignment phase.Effective mandibular length has also been significantly increased.

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