"EVALUATION OF MANDIBULAR CONDYLAR POSITION USING GELB'S GRID IN PATIENTS TREATED WITH FIXED FUNCTIONAL THERAPY: A RETROSPECTIVE STUDY"

By

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Dissertation

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IN

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KLE VISHWANATH KATTI INSTITUTE OF DENTAL SCIENCES,

KAHER, BELAGAVI, KARNATAKA.

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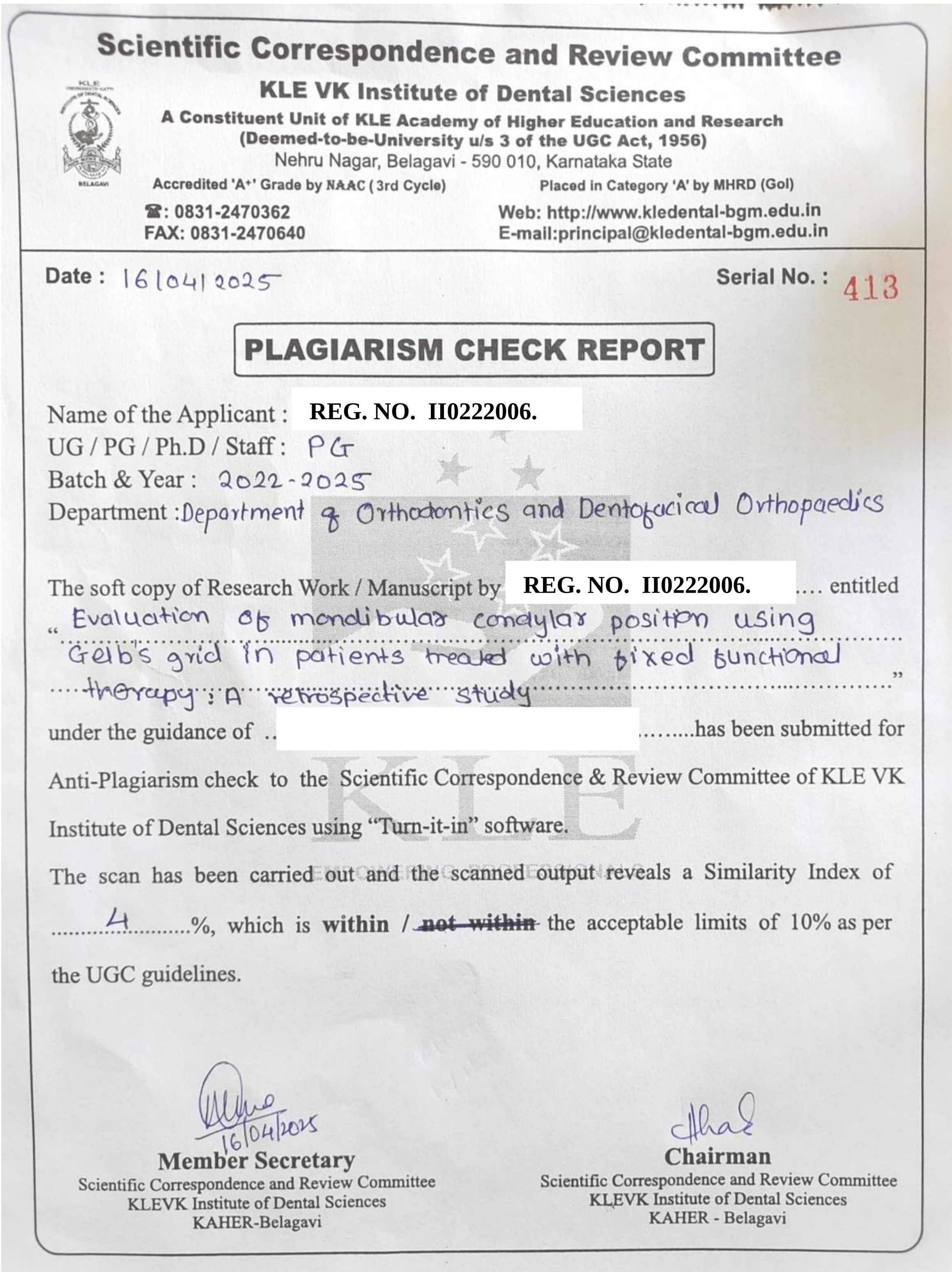

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Place: Belagavi

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ABSTRACT

INTRODUCTION: Mandibular condylar positioning is integral to maintaining occlusal harmony and temporomandibular joint (TMJ) function, particularly in patients with skeletal Class II malocclusion associated with mandibular retrusion. Fixed functional appliances are widely used to stimulate mandibular growth and induce adaptive remodeling of the condyle within the glenoid fossa. Gelb's grid, a diagnostic tool that segments the cranial base for precise evaluation of condylar positioning, offers a cost-effective and reliable means to assess these changes using lateral cephalograms.

MATERIALS AND METHODS: This retrospective study analyzed 57 patients between the ages of 14 and 20 years with skeletal Class II malocclusion who underwent fixed functional therapy. Pre- and post-treatment lateral cephalograms were standardized, digitized using Dolphin 2D Software, and manually traced on acetate sheets. Specific anatomical landmarks—including Sella, Nasion, Point A, Point B, and key dental points—were identified to construct Gelb's grid and measure sagittal skeletal parameters such as the ANB angle and Witts appraisal. Statistical analysis involved paired t-tests for continuous variables, Wilcoxon signed-rank tests for categorical data, and Pearson's correlation coefficient to examine the relationships between condylar position changes and skeletal parameters. A p value of less than 0.05 was considered statistically significant.

RESULTS: Pre-treatment evaluation revealed that majority of the condyles (84.2%) were positioned in the posterior 5/8 sector of Gelb's grid, indicative of a retro positioned condyle. Post-treatment analysis demonstrated a significant anterior shift, with 66.7% of condyles moving to the more concentric 4/7 position ($p < 0.001$).

Additionally, the mean ANB angle decreased from 4.33° to 2.45° and Witts appraisal improved from 2.59 mm to 1.24 mm, both with high statistical significance ($p < 0.001$). The frequency of Class I molar relationship increased from 0% in the pre-treatment phase to 89.5% post-treatment, further corroborating the effective anterior repositioning of the mandible. Significant positive correlations were found between the improved skeletal parameters and the anterior shift in condylar position.

CONCLUSION: Fixed functional therapy effectively induces an anterior repositioning of the mandibular condyle, as evidenced by significant changes in Gelb's grid positioning, ANB angle, and Witts appraisal values. These findings support the clinical utility of fixed functional appliances in correcting skeletal Class II malocclusions and enhancing overall occlusal and TMJ function.

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INTRODUCTION

In orthodontics and dentofacial orthopedics, the evaluation of mandibular condylar position is important for understanding the temporomandibular joint (TMJ) dynamics and occlusal relationships in patients undergoing treatment.

The spatial relationship mandibular condyle within the glenoid fossa is particularly important for maintaining occlusal harmony, TMJ function, and overall craniofacial balance, especially in skeletal Class II malocclusion, which frequently manifests as mandibular retrognathism.

Fixed functional therapy has been commonly used for the correction of mandibular deficiency aiming to enhance mandibular growth and reposition the condyle within the glenoid fossa during active skeletal growth.

The action of fixed functional appliances is thought to be mediated by adaptive alterations in the glenoid fossa and growth modulation of the condylar cartilage.[4]

Condylar cartilage is nature's synchronizer that matches maxillomandibular sagittal relationship [6] as a result, when the mandibular condyle moves out of the fossa, additional growth occurs mediated by reduced pressure on the condylar tissues or by altered muscle tension.

Even though fixed functional therapy is used extensively in orthodontics, it is crucial to comprehend how it affects the mandibular condylar position to maximize treatment results and guarantee long term stability.

One such technique is Gelb's grid, a diagnostic tool introduced by Dr. Harold Gelb used to assess mandibular condylar position and its relationship to the cranial base. This grid divides the cranial base into zones, helping clinicians to categorize the condyle's location as anterior, concentric, or posterior in relation to the glenoid fossa.

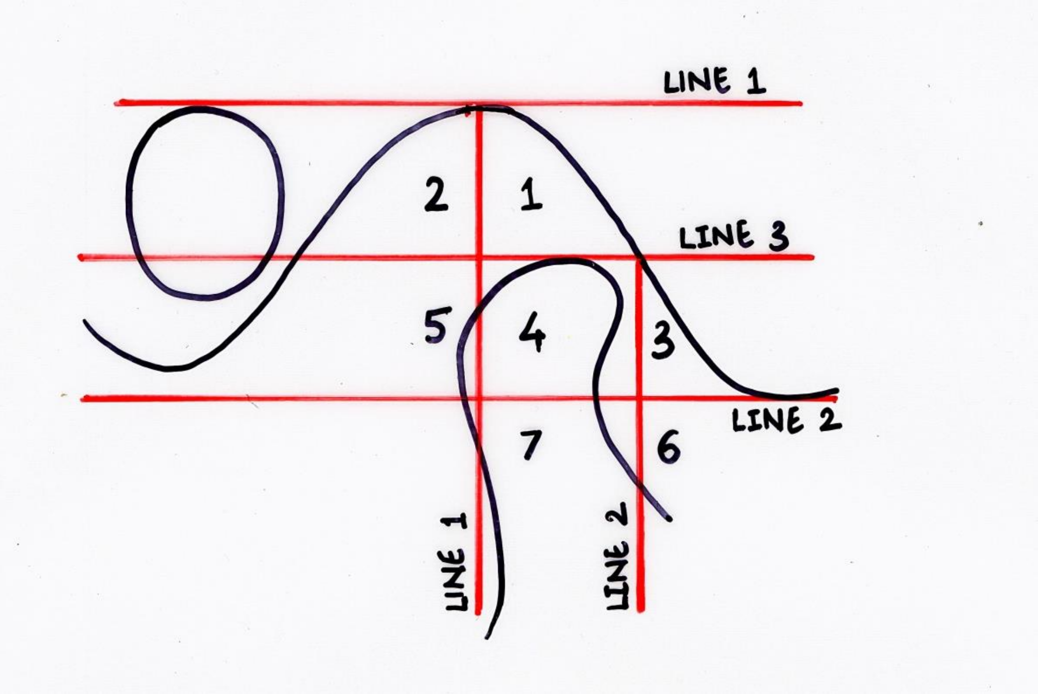

Fig. 1- Gelb's grid

Gelb's grid can be used to analyze condylar position, allowing clinicians to detect any abnormalities including anterior or posterior displacements and variations in condylar inclination.

Various imaging studies have further validated this correlation by documenting condylar asymmetries and displacement patterns across different malocclusions using Cone-Beam Computed Tomography (CBCT) [2,3]

While 3-D imaging is more precise, lateral cephalograms are the cornerstone of orthodontic diagnosis and offer sufficient diagnostic clarity for evaluating sagittal condylar relationships while maintaining lower radiation exposure, greater accessibility, and reduced cost compared to CBCT.

Thus, this retrospective study aims to evaluate the mandibular condylar position using Gelb's grid in patients treated with fixed functional therapy. By analyzing pre- and post-treatment cephalometric radiographs, this study seeks to assess the changes in condylar position and their correlation with treatment outcomes.

AIMS AND OBJECTIVES

AIM:

Evaluation of mandibular condylar position using Gelb's grid in pre and post-treatment lateral cephalograms of patients treated with fixed functional therapy.

OBJECTIVES:

- To assess the pre-treatment condylar position
- To assess the changes in the condylar position post completion of fixed functional therapy
- To compare pre and post treatment condylar position using Gelb's grid on the traced lateral cephalograms

RESEARCH HYPOTHESIS

Null hypothesis – There will not be any change in the condylar head position of subjects undergoing fixed functional orthodontic treatment when assessed using pre and post treatment lateral cephalograms

Research hypothesis – There will be a change in the condylar head position of subjects undergoing fixed functional orthodontic treatment when assessed using pre and post treatment lateral cephalograms.

REVIEW OF LITERATURE

1) Soni D, et al. (2022) [1] conducted a study to evaluate the mandibular condylar position in different malocclusions using Gelb's grid. The study included 45 pre-treatments lateral cephalograms of patients aged above 18 years, categorized into three groups: skeletal Class I, Class II, and Class III malocclusions. The condylar position in relation to the glenoid fossa was analyzed using Gelb's grid. The results indicated that 86.66% of Class I subjects had a normal condylar position, while 13.33% showed posterior displacement. Among Class II subjects, 86.66% had posterior displacement, and the remaining had a normal condylar position. For Class III malocclusion, 66.66% of subjects exhibited posterior displacement, while the others maintained a normal condylar position. The study concluded that condylar displacement is strongly associated with skeletal malocclusion.

2) Stasiuk AA, et al. (2020) [2] performed a CBCT-based assessment of temporomandibular joint positioning in patients with various malocclusions. The study examined 70 patients with dentofacial abnormalities and analyzed their CBCT scans. The findings revealed that only 17.65% of Class I patients had optimal condylar positioning in segment 4/7, while this percentage was reduced to 6.67% in Class II cases. No Class III patients demonstrated optimal condylar positioning. The study emphasized the impact of condylar asymmetry and rotational displacement on TMJ function, highlighting the importance of evaluating these variations in orthodontic treatment planning.

3) Kaur A, et al. (2016) [3] conducted a CBCT study to visualize and compare condylar positions in different occlusions. A total of 45 subjects were analyzed, with their condylar positions evaluated across three planes. The study found that in the sagittal plane, the condyle was positioned anterio-superiorly in Class I and III occlusions but posterior-superiorly in Class II cases. In the frontal plane, the condyle remained centrally positioned mediolaterally across all occlusion types. The study concluded that significant differences exist in condylar positioning among different malocclusions, reinforcing the necessity of three-dimensional imaging for accurate assessments.

4) Kumawat RK, et al. (2022) [4] conducted a comparative in vivo CBCT study assessing changes in condylar positioning following fixed functional appliance therapy. The study included 20 adult patients with Class II Division 1 malocclusion, divided into two groups treated with Forsus and PowerScope appliances. Pre- and post-treatment CBCT scans were analyzed, revealing an average forward shift of the mandibular condyle by 0.85 mm in the Forsus group and 0.79 mm in the PowerScope group. The study concluded that Forsus appliances produced a greater forward condylar shift, demonstrating their effectiveness in mandibular advancement therapy.

5) Sairam Vankadara, et al. (2021) [5] conducted a study to assess and compare condylar position based on joint space dimensions and Gelb 4/7 grid using CBCT. The study included patients with temporomandibular disorders and aimed to evaluate condylar positioning within the glenoid fossa through joint space measurements in anterior, superior, and posterior compartments. CBCT scans of patients were analyzed using Gelb’s 4/7 grid method, and joint space dimensions were measured. The findings revealed that the condylar position varied significantly based on skeletal classifications, with Class II patients exhibiting posteriorly displaced condyles and increased joint space asymmetry. The study also confirmed that CBCT is a reliable tool for assessing joint morphology, emphasizing its role in diagnosing TMJ disorders and guiding orthodontic treatment planning.

6) Tariq S, et al. (2020) [6] analyzed condylar changes in skeletal Class II patients who underwent treatment with functional orthopedic appliances. The study included patients aged 11 to 15 years, with a mean age of 12.02 ± 1.05 years. The findings indicated significant positional changes in the condyle, with an average shift of 2.20 ± 2.97 mm ($p<0.001$) in relation to the midface and 2.09 ± 1.23 mm ($p<0.001$) in relation to the anterior cranial base. Additionally, the condyle's long axis became more upright post-treatment, signifying skeletal adaptation due to functional appliance therapy.

7) Ruf S, Pancherz H. (2004) [7] conducted a study comparing fixed functional appliances and mandibular sagittal split osteotomy in the treatment of adult Class II Division 1 patients. The findings indicated that while both treatments resulted in mandibular advancement, functional appliances primarily induced condylar remodeling rather than direct displacement. The study concluded that fixed functional appliances provide an effective non-surgical alternative for Class II correction while promoting adaptive changes in the temporomandibular joint.

8) Pancherz H, et al. (1999) [8] employed MRI imaging to assess condylar repositioning following Herbst appliance therapy. The study revealed that condylar remodeling was a key factor in the successful treatment of mandibular advancement. The results aligned with findings from Gelb's grid-based studies, further validating its clinical application.

9) Baccetti T, et al. (2000) [9] **and Marsico E, et al. (2011)** [10] conducted systematic reviews to assess the effectiveness of CBCT imaging in evaluating functional appliance therapy outcomes. Their findings indicated that treatment-induced condylar changes were significantly more pronounced when therapy was initiated during prepubertal growth phases, underscoring the importance of early intervention in orthodontic treatments.

10) McNamara JA. (1981) [11] and Proffit WR, et al. (2018) [12] explored the etiology of Class II malocclusion, emphasizing mandibular retrusion as the primary contributing factor. Their studies provided a foundation for understanding how condylar positioning affects skeletal discrepancies and highlighted key considerations in orthodontic treatment strategies.

11) Pancherz H. (1985) [13] and Pancherz H, Anehus-Pancherz M. (1993) [14] conducted long-term studies on Herbst appliance therapy and its impact on condylar remodeling. The results demonstrated that adaptive skeletal changes occur in response to mandibular advancement rather than simple positional shifts, reinforcing the stability and effectiveness of Herbst appliances in orthodontic corrections.

MATERIALS AND METHODS

SOURCE OF DATA

- The study has been conducted in the Department of Orthodontics and Dentofacial Orthopaedics, KLE Academy of Higher Education and Research (KAHER), KLE VK Institute of Dental Sciences, Belagavi.

INCLUSION CRITERIA:

Lateral cephalograms of-

- Patients in the age group of 14-20 years
- Patients with skeletal Class II malocclusion
- Patients of either gender
- Pre- and post-treatment lateral cephalograms in which the condylar head and glenoid fossa can be identified and traced

EXCLUSION CRITERIA:

Lateral cephalograms of-

- Patients with skeletal Class I and Class III malocclusion
- Patients with history of TMJ disorders or associated syndromes
- Patients with history of any TMJ injury or surgery
- Patients who have undergone Myofunctional, Orthopaedic, and Orthodontic treatment

SAMPLE SIZE ESTIMATION

$$n = \frac{(Z_{1-\alpha/2})^2 \times (pq)}{d^2}$$

Where,

- $p = 0.87$
- $q = 0.13$
- d = 10 % of p
- $\alpha = 5\%$
- $z_{1-\alpha/2} = 1.96$ at 95% C.I.

Final Sample Size (n) = 57

For an α value equal to 0.05 and $Z1\text{-}\alpha/2 = 1.96$, The sample size was estimated to be 57.

METHODOLOGY

INSTRUMENTS AND MATERIALS:

- Pre-treatment lateral cephalograms of orthodontic patients
- Post treatment lateral cephalograms of orthodontic patients
- Acetate tracing sheets
- Stationery materials

FLOW CHART OF METHODOLOGY

Pre-treatment lateral cephalograms of patients who underwent Fixed functional therapy obtained

⬇

Digitization and standardization of lateral cephalograms done using Dolphin 2D Software

⬇

Lateral cephalograms adjusted in 1:1 ratio and printed

⬇

Lateral cephalograms were hand traced and points necessary to draw the Gelb's Grid as well as those needed to measure parameters-ANB and Witts were marked.

⬇

The Gelb's Grid was constructed and the position of condyle noted. The ANB angle and Witts appraisal value was measured

⬇

Similarly, the post treatment lateral cephalograms were standardized and traced.

⬇

Gelb's Grid was drawn and the new position of condyle noted along with post treatment values of ANB and Witts appraisal

⬇

The position of condyle was then compared in the pre and post treatment lateral cephalograms along with its correlation to the ANB angle and Witts appraisal and conclusion was drawn regarding any change or discrepancy.

Details of the procedures conducted during the research

- The study included a total of 57 patients who underwent fixed functional therapy in the Department of Orthodontics and Dentofacial Orthopaedics, KLE VK Institute of Dental Science, KLE Academy of Higher Education and Research, Belagavi.
- Lateral cephalograms of the patients meeting inclusion criteria were obtained. The cephalograms which had magnification other than 135% were scanned using the Epson perfection V800 photo scanner (Fig 1.)

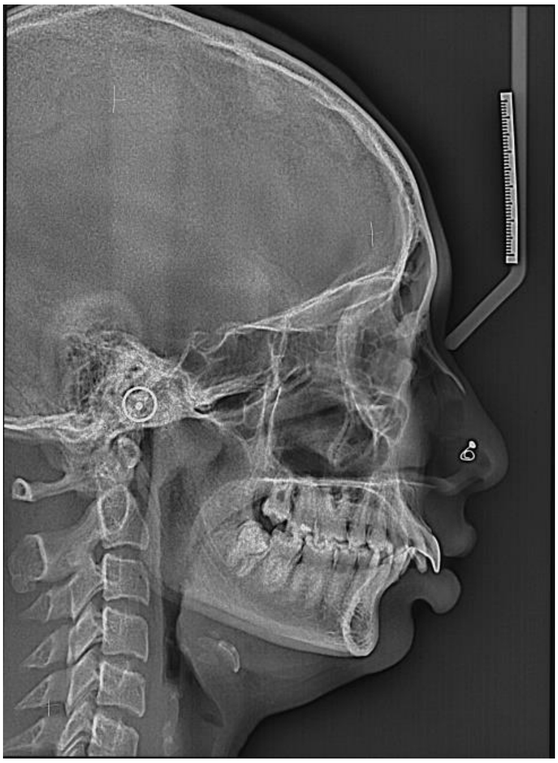

Fig -2-Scanned lateral cephalogram

- The lateral cephalograms were then uploaded to the computer and then fed to into the dolphin imaging software where they were digitized and standardized using the measuring ruler points in the lateral cephalograms. (fig 2)

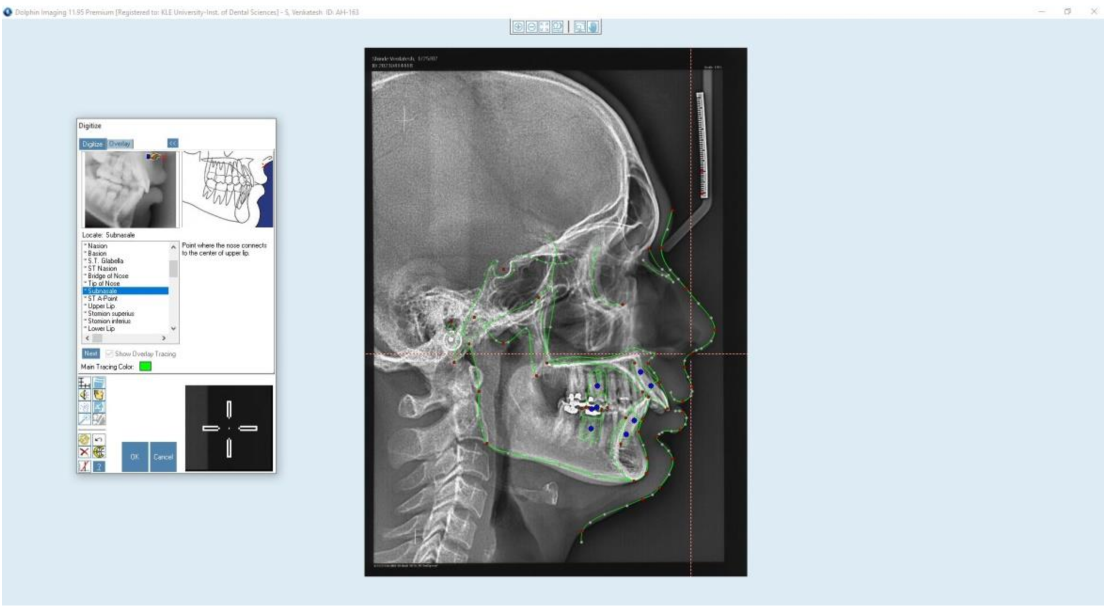

Fig 3-Uploaded and digitized lateral cephalogram

- The lateral cephalograms were then hand traced on acetate tracing sheets and landmarks were marked on the tracing.

- The landmarks marked were Sella, Nasion, Subspinale (Point A), Supramentale (Point B) for measurement of ANB along with U1, U6, L1, L6 for Witts appraisal. Head of Condyle, Articular eminence, and Glenoid fossa for construction of the Gelb's grid. (fig.3)

- The Gelb's grid was then constructed on the tracing and the position of the condyle was noted. Also, the pre-treatment values of ANB Angle and Witts Appraisal were recorded. (fig.4)

- Same procedure was repeated for post treatment lateral cephalograms and the values were recorded (fig.5) The pre-treatment and post functional measurements were then compared

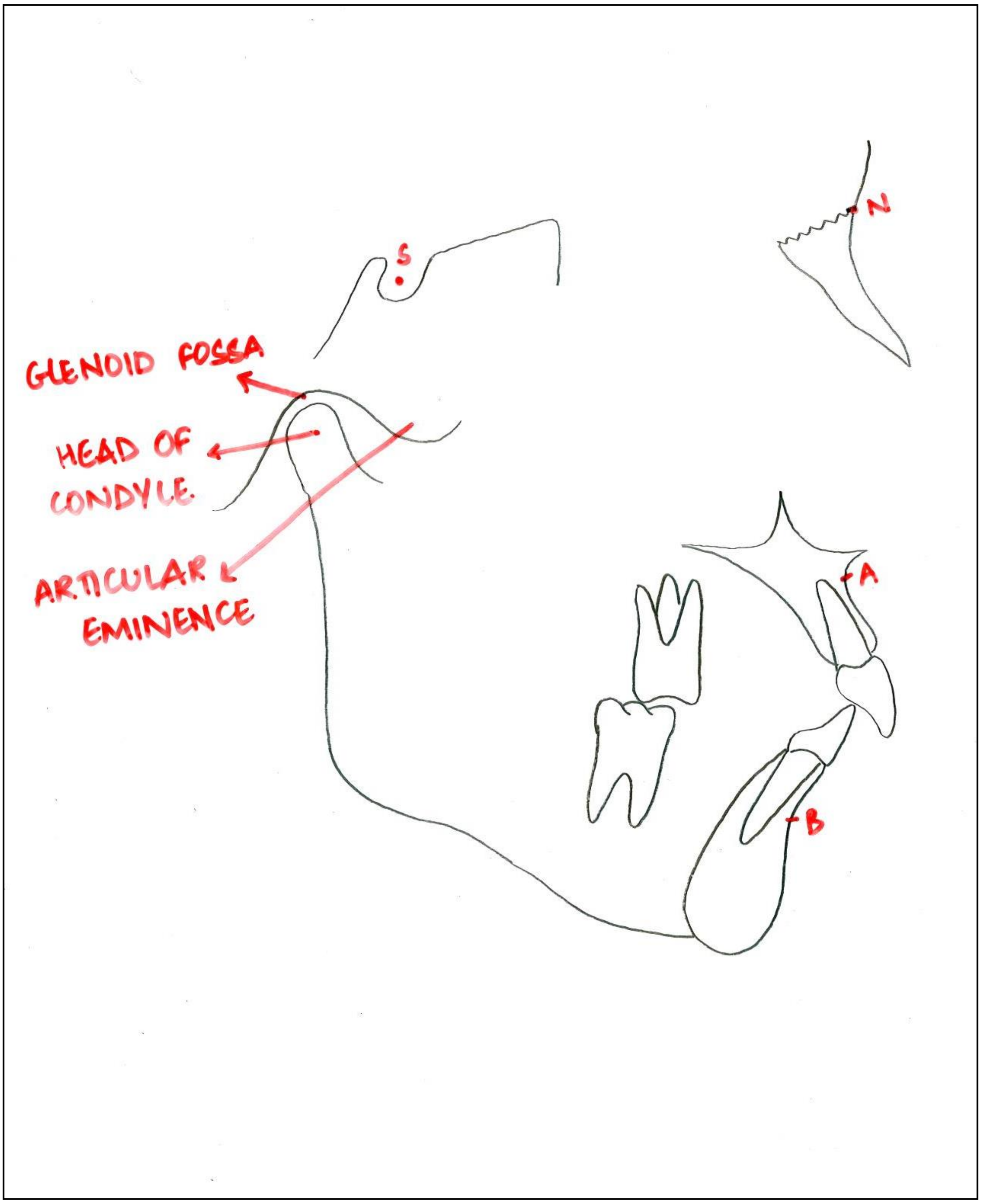

Fig 4-Landmarks

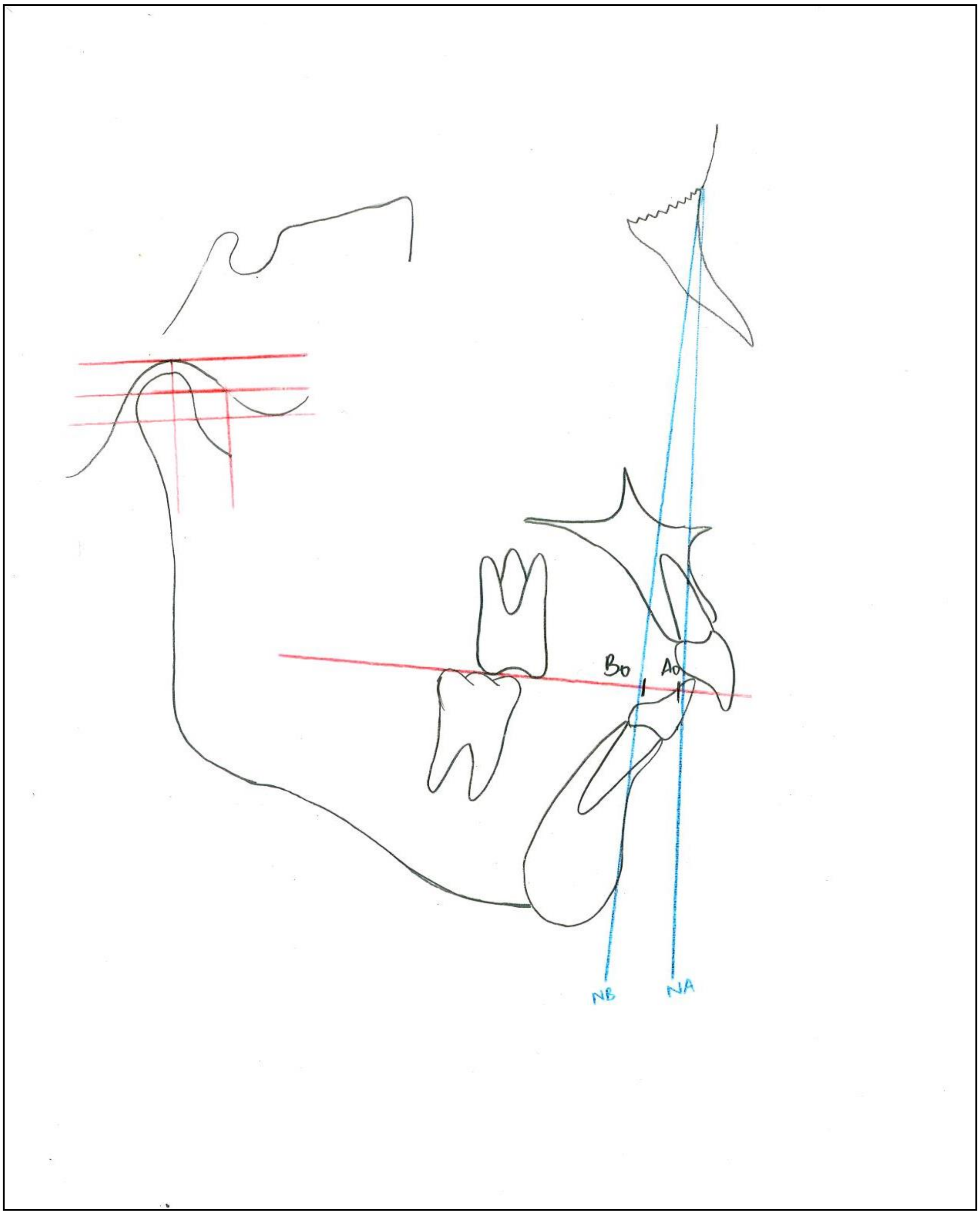

Fig 5-Pre-treatment tracing with Gelb's grid

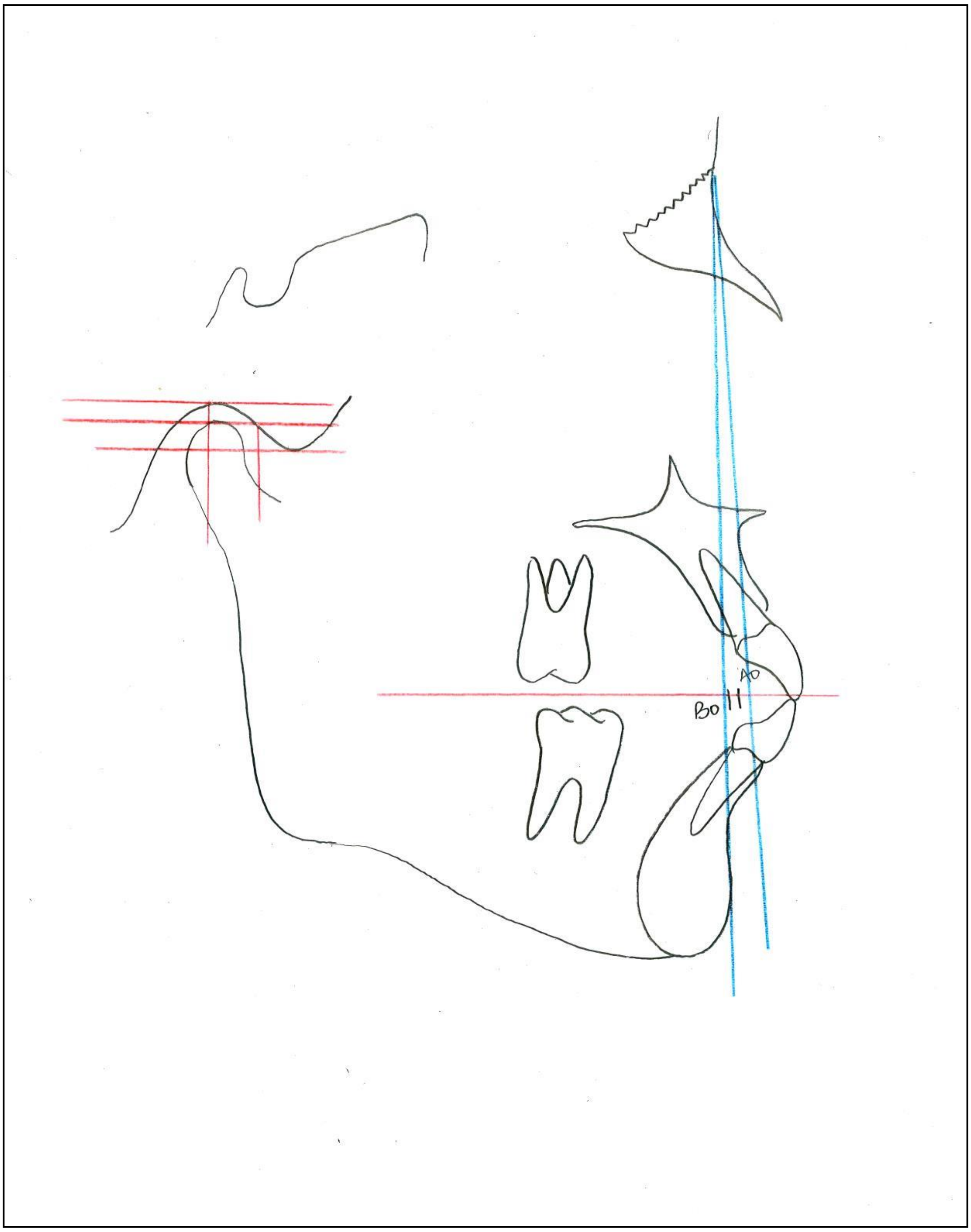

Fig 6-Post functional tracing with Gelb's grid

STATISTICAL ANALYSIS

STATISTICAL TEST:

- Data obtained was entered and sorted in Microsoft Excel (v.2017).
- Statistical analysis was performed using Statistical package for social sciences (SPSS) software (IBM Corp) (v.26.0).
- Descriptive and inferential statistics was performed for all the different parameters assessed in the study.
- Data normality test was performed to determine normal distribution of the data.
- Intragroup pre and post treatment comparison for continuous variables was performed using Student Paired t-test to assess significant differences.
- Intragroup pre and post treatment comparison for categorical variables was performed using Wilcoxon's sign rank test to assess significant differences.
- Pearsons's correlation coefficient was used to assess significant correlation between different angles and condylar position and molar relation of the study participants.
- All statistical tests were performed at 95% confidence intervals.
- A p value of less than 0.05 was considered as statistically significant in the study.

RESULTS

- This study was done to evaluate the mandibular condylar position using Gelb's grid in pre and post-treatment lateral cephalograms of patients treated with fixed functional therapy.
- Lateral cephalograms of 57 patients who had been treated with fixed functional therapy were taken from the Department of Orthodontics and Dentofacial Orthopaedics, KLE VK Institute of Dental Sciences, Belagavi
- The pre and post treatment lateral cephalograms were traced and the values for ANB, Witts's appraisal and condylar position change were compared.

Table 1 - Descriptive statistics of Age (in years) of the study participants

	N	Minimum	Maximum	Mean	Std. Deviation
Age (in years)	57	12.00	19.00	14.77	1.65

Graph 1: Mean Age (in years) of the study participants

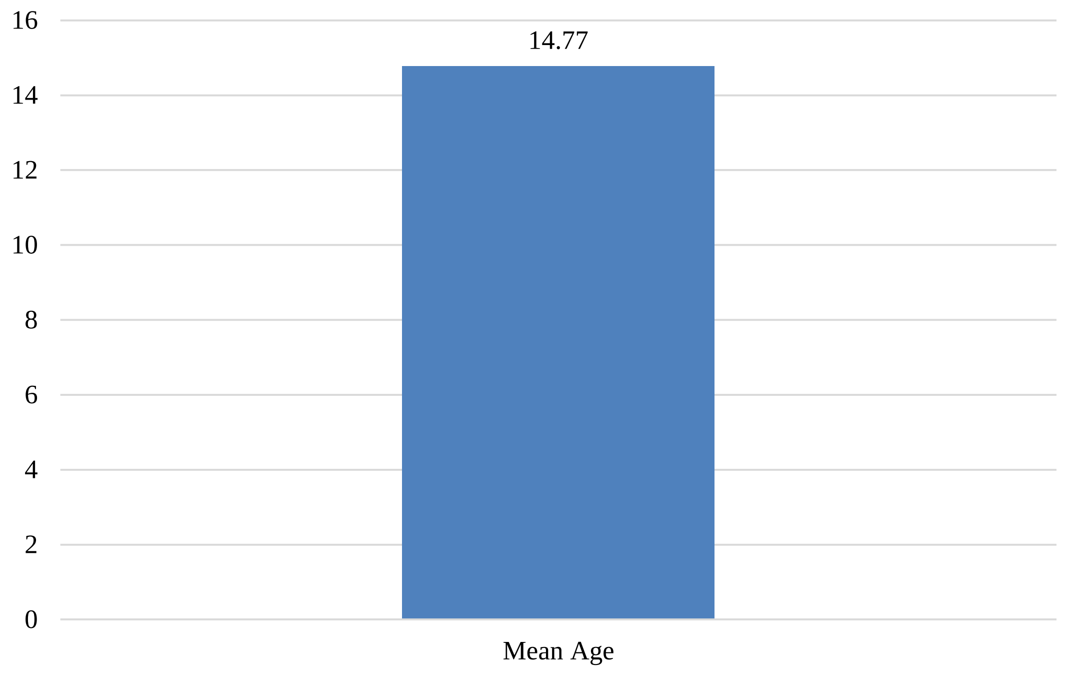

Table 1 shows the descriptive statistics of age of patients included in the study

Table 2 – Frequency statistics of Gender distribution amongst the study participants

Gender	Frequency (n)	Percent (%)
Male	20	35.1
Female	37	64.9
Total	57	100.0

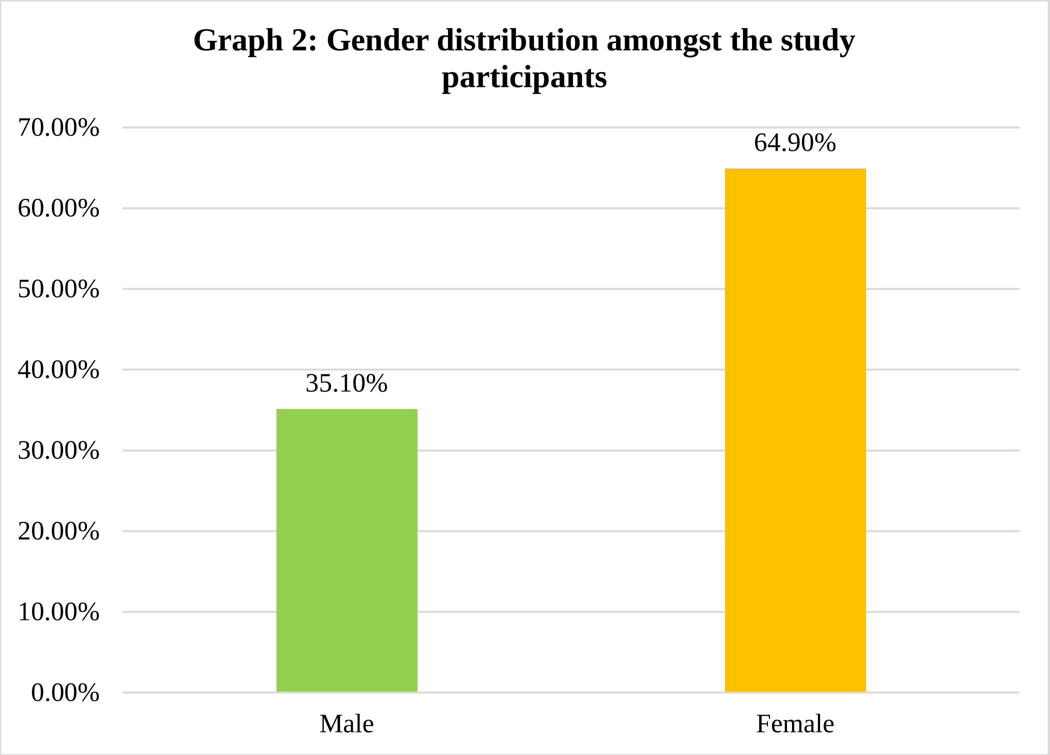

Table 2 describes the frequency of gender distribution among the participants included in the study

Table 3 –Descriptive statistics of different parameters at Pre (T1) and Post treatment (T2) amongst the study participants

Parameter	Time interval	N	Minimum	Maximum	Mean	Std. Deviation
ANB angle	**PRE (T1)**	57	2.00	6.00	4.33	1.02
	POST (T2)	57	0.00	5.00	2.45	0.96
WITTS	**PRE (T1)**	57	1.00	4.00	2.59	0.72
	POST (T2)	57	.00	3.00	1.24	0.80

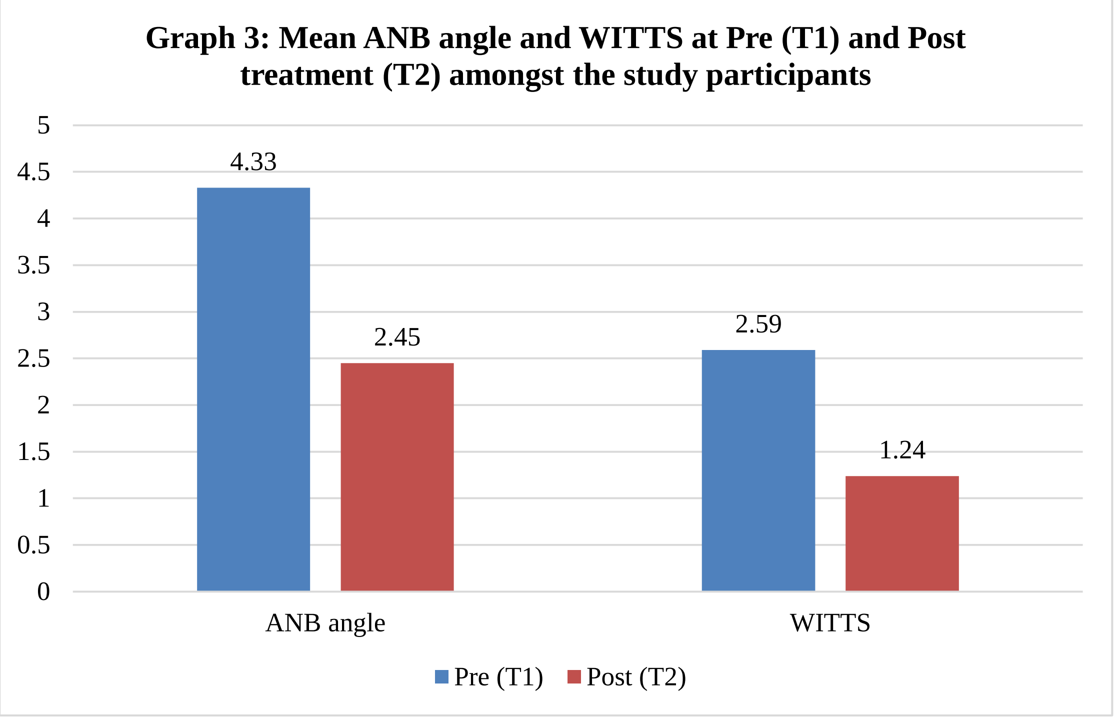

Table 3 describes the mean ANB angle and WITTS appraisal values of the study participants at 2 different time points

Table 4 – Frequency distribution of the study participants according to Molar relation at Pre (T1) and Post treatment (T2)

MOLAR RELATION	PRE (T1)		POST (T2)	
	Frequency (n)	Percent (%)	Frequency (n)	Percent (%)
Class I	0	0	51	89.5
Class II	47	82.5	3	5.3
Class II (End-on)	10	17.5	3	5.3
Total	57	100.0	57	100.0

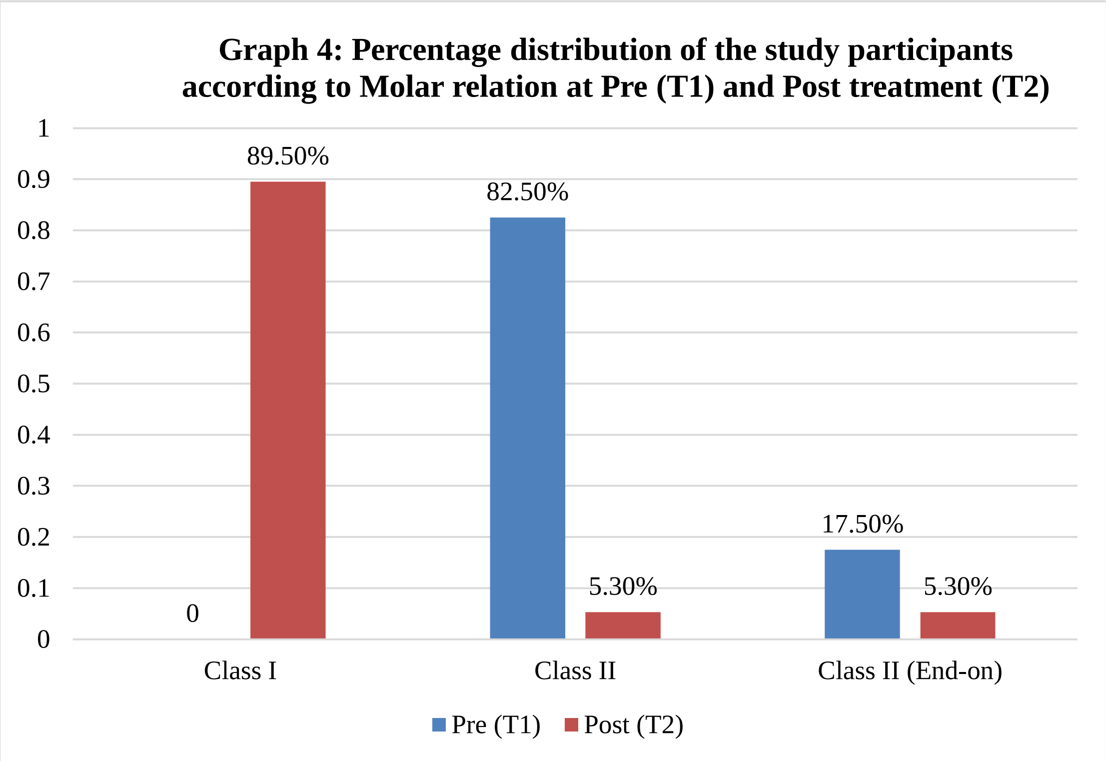

Table 4 describes the frequency distribution of participants according to their molar relation as 2 different time points

Table 5 – Frequency distribution of the study participants according to Condylar position at Pre (T1) and Post treatment (T2)

CONDYLAR POSITION		PRE (T1)		POST (T2)	
		Frequency (n)	Percent (%)	Frequency (n)	Percent (%)
	4/7 position	9	15.8	38	66.7
	5/8 position	48	84.2	19	33.3
	Total	57	100.0	57	100.0

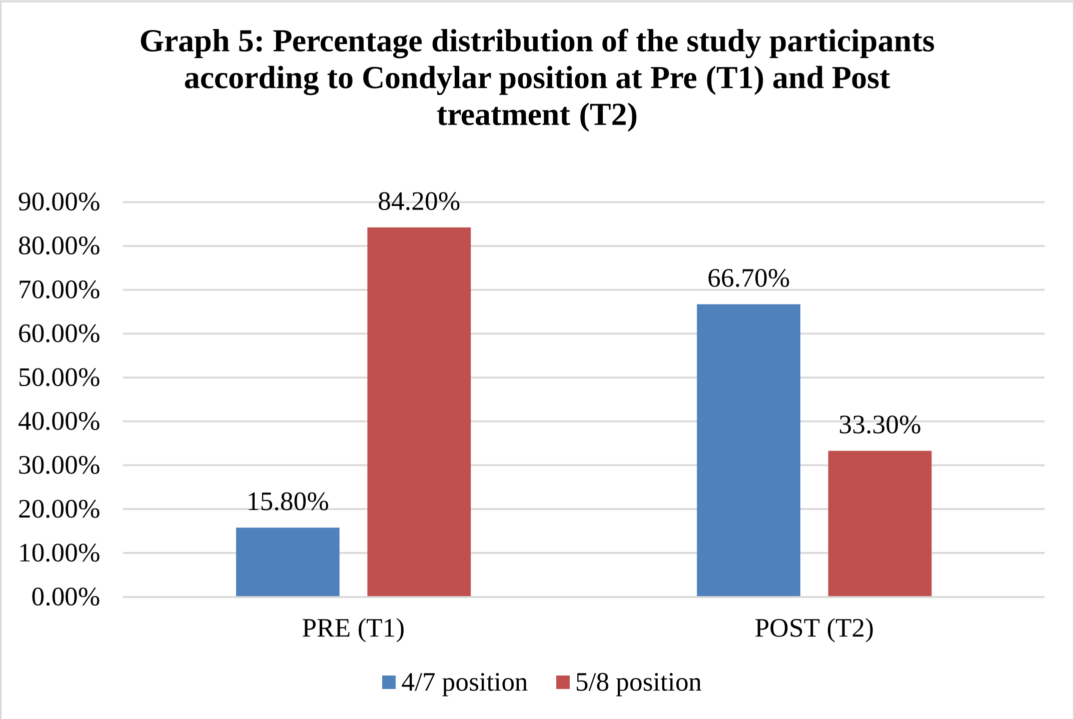

Table 5 describes the frequency distribution of study participants according to the condylar head position at 2 different time points

Table 6 – Frequency distribution of the study participants according to Condylar head shift

CONDYLAR HEAD SHIFT		Frequency (n)	Percent (%)
	Significant Anterior shift	16	28.1
	Slight Anterior shift	16	28.1
	Shift Posterior shift	1	1.8
	Stable	24	42.1
	Total	57	100.0

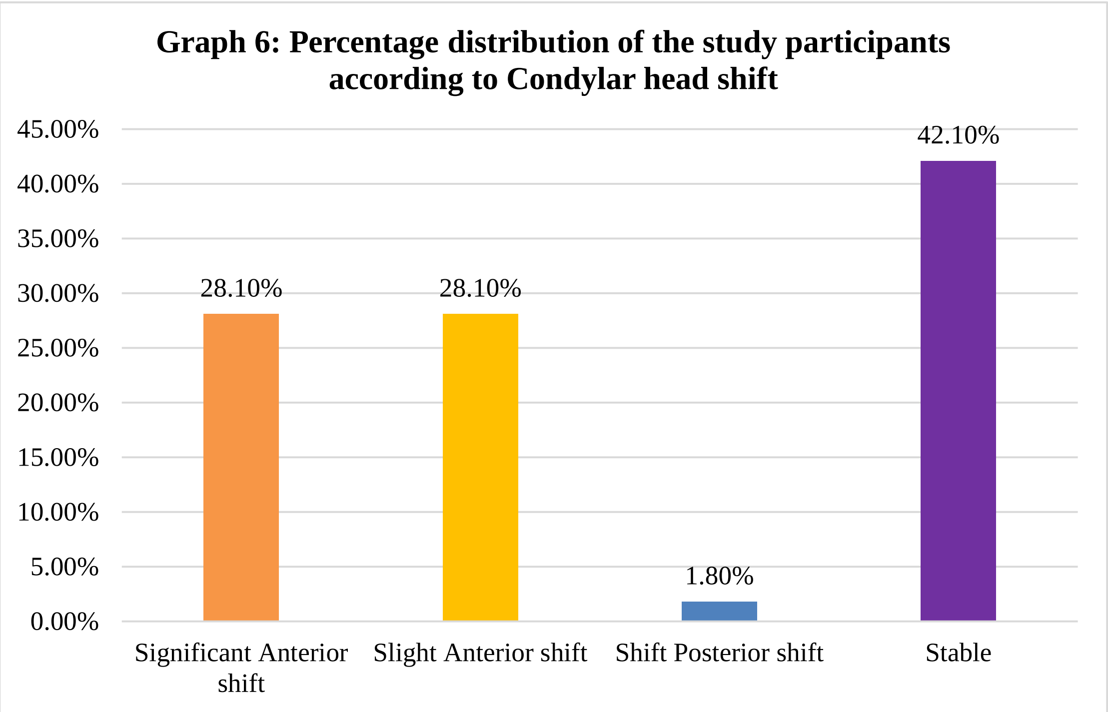

Table 6 describes number of participants having significant anterior shifted, slight anterior shifted, slight posterior shifted and stable condylar head position

Table 7 – Frequency distribution of the study participants according to Appliance type

APPLIANCE TYPE		Frequency (n)	Percent (%)
	ADVANSYNC 2	1	1.8
	EUREKA SPRING	1	1.8
	FIXED TWIN BLOCK	15	26.3
	Forsus	19	33.3
	Herbst	12	21.1
	MPA	9	15.8
	Total	57	100.0

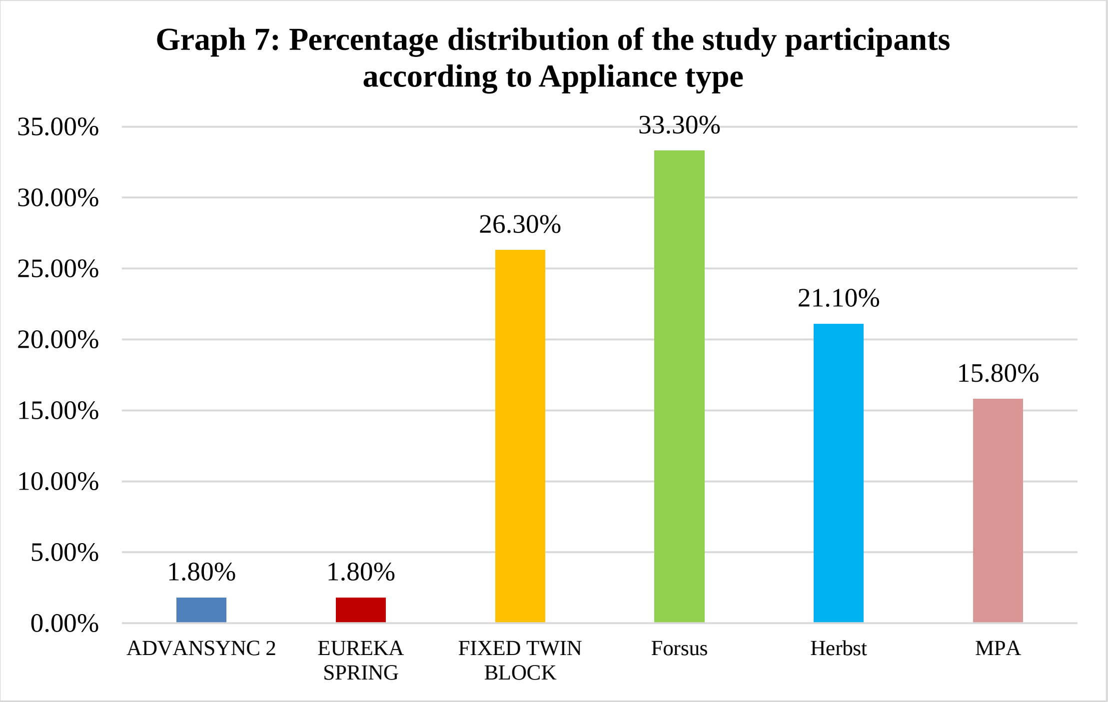

Table 7 describes the different types of appliances used among study population

Table 8 – Intragroup pre and post comparison of ANB angle and WITTS in study participants

Pre (T1) and post comparison (T2)	Mean difference	t value	df	p value
ANB PRE (T1) vs ANB POST (T2)	1.87719	16.338	56	.000*
WITTS PRE (T1) vs WITTS POST (T2)	1.35088	11.380	56	.001*

*p value <0.05 statistically significant, <0.001 highly significant, <0.001 very highly significant

Table 8- The intragroup pre and post comparison of ANB angle and WITTS appraisal of study participants was performed using Paired t-test. This comparison showed a very high statistically significant difference (p=0.000) between ANB angle at Pre (T1) and Post (T2) treatment; and a high statistically significant difference (p=0.001) between WITTS at Pre (T1) and Post (T2) treatment.

Table 9 – Intragroup pre and post comparison of Molar relation and condylar position in study participants

Pre (T1) and post comparison (T2)		N	Mean Rank	Sum of Ranks	p value
MOLAR RELATION POST (T2) vs MOLAR RELATION PRE (T1)	Negative Ranks	10[a]	7.00	70.00	0.912
	Positive Ranks	6[b]	11.00	66.00	
	Ties	41[c]			
	Total	57			
CONDYLAR POSITION POST (T2) vs CONDYLAR POSITION PRE (T1)	Negative Ranks	33[d]	17.76	586.00	0.000*
	Positive Ranks	1[e]	9.00	9.00	
	Ties	23[f]			
	Total	57			

*p value <0.05 statistically significant, <0.001 highly significant, <0.001 very highly significant

Table 9- The intragroup pre and post comparison of Molar relation and condylar position was performed using Wilcoxon sign rank test

The molar relation showed improvement from Class II to Class I post treatment (T2) in about 51 participants in comparison with pretreatment (T1) This difference was highly statistically significant (p<0.001).

The condylar position showed improvement in 33 participants, worsening in 1 participant and 23 participants showed no change at Post treatment (T2), respectively which was highly statistically significant (p<0.001).

Table 10 – Correlation between different angles and molar relation and different angles and condylar position at Pre (T1) and Post treatment (T2)

		MOLAR RELATION PRE (T1)	MOLAR RELATION POST (T2)	CONDYLAR POSITION PRE (T1)	CONDYLAR POSITION POST (T2)
ANB PRE (T1)	**Pearson Correlation**	-.379**	-.035**	.443	.110**
	p value	.004*	.794	.001*	.416
	N	57	57	57	57
ANB POST (T2)	**Pearson Correlation**	-.172	.071	.263**	.616
	p value	.201	.599	.048*	.000*
	N	57	57	57	57
WITTS PRE (T1)	**Pearson Correlation**	-.253	.231	.175**	-.024
	p value	.057	.084	.192	.860
	N	57	57	57	57
WITTS POST (T2)	**Pearson Correlation**	-.199**	.215*	.067	.724**
	p value	.138	.108	.618	.000*
	N	57	57	57	57

*p value <0.05 statistically significant, <0.001 highly significant, <0.001 very highly significant

Table 10- Pearson's correlation analysis between different angles and molar relation and different angles and condylar position at Pre (T1) and Post treatment (T2) indicated a highly significant positive correlation between ANB angle Pre (T1) and Condylar Position Pre (T1), ANB angle Post (T2) and Condylar Position Post (T2), WITTS Post (T2) and Condylar Position Post (T2) ($p < 0.001$); a significant positive correlation between ANB angle Post (T2) and Condylar Position Post (T2) ($p<0.05$).

DISCUSSION

The position of the mandibular condyle within the glenoid fossa is fundamental in understanding craniofacial growth, skeletal malocclusion patterns, and temporomandibular joint (TMJ) dynamics. This becomes particularly relevant in skeletal Class II malocclusions, where the mandibular condyle is frequently displaced posteriorly due to mandibular retrusion, thereby altering the maxillomandibular relationship and predisposing the patient to occlusal and articular discrepancies [1-3]

The functional matrix theory and Moss's hypothesis claim that growth of the craniofacial skeleton is significantly influenced by the surrounding functional environment, including the neuromuscular and articular components such as the TMJ [4]. Therefore, any intervention such as fixed functional therapy that aims to modulate mandibular growth inherently affects the condylar position, which may subsequently induce morphological and positional changes in the TMJ [5].

Fixed functional appliances such as Forsus, Herbst, Fixed Twin Block, MPA, and Advansync 2 are designed to advance the mandible anteriorly by positioning the lower jaw forward, thereby encouraging adaptive growth of the condylar cartilage and remodelling of the glenoid fossa [7–9].

The mechanism of these appliances is dual-fold:

- They apply continuous sagittal orthopaedic force that displaces the condyle forward within the glenoid fossa.
- They stimulate compensatory condylar remodelling and/or condylar cartilage growth in response to altered joint loading and muscle activity.

Histological studies have shown that such forward posturing increases mitotic activity in the condylar cartilage, facilitating endochondral ossification and growth stimulation [10,11]. Moreover, TMJ remodelling occurs because of biomechanical adaptation to new occlusal forces, often producing clinically observable improvements in skeletal harmony and occlusal function.

The purpose of the current study was to evaluate the mandibular condylar position using Gelb's grid in pre- and post-treatment lateral cephalograms of patients treated with fixed functional therapy. A sample of 57 patients with skeletal Class II malocclusion was selected, and comparisons were drawn between the condylar positions, ANB angle, and Witts appraisal values before and after therapy.

The Gelb's 4/7 grid provides a practical method for assessing the sagittal position of the condylar head using lateral cephalograms. It categorizes condylar positions into:

- Zone 4/7 (Central Position): Physiologically concentric and stable.
- Zone 5/8 (Posterior Position): Indicative of retropositioned condyles, often seen in skeletal Class II cases.
- Zone 3/6 or anterior to 4/7: Rare, may indicate anterior displacement or hyperplastic growth.

The pre-treatment analysis of condylar positioning using Gelb's grid revealed that majority of condyles were in the 5/8 position (84.2%), indicating a tendency towards posterior displacement. This finding aligns with previous studies that emphasized the prevalence of posterior condylar positioning in Class II malocclusion patients. Soni et al. reported that 86.66% of Class II subjects had posterior condylar displacement when evaluated with Gelb's grid, reinforcing the notion that malocclusion is frequently associated with condylar misalignment [1].

Further corroboration is provided by Stasiuk et al., who in a CBCT-based study found only 6.67% of Class II patients exhibited optimal condylar positioning in the 4/7 segment [2]. Similarly, Kaur et al. identified that condyles in skeletal Class II individuals were typically located posterosuperior in the sagittal plane [3]. These observations support the anatomical predisposition towards posterior condylar displacement in Class II malocclusions.

Post-treatment findings revealed a significant anterior shift in condylar positioning for many patients (66.7% in the 4/7 position), suggesting effective repositioning of the condyle after fixed functional appliance therapy. The Wilcoxon test confirmed that this shift was statistically significant ($p < 0.001$), in-keeping with the findings of Kumawat et al., who demonstrated an average anterior shift of 0.85 mm using CBCT in patients treated with Forsus appliance [4].

Additionally, 28.1% of participants demonstrated a significant anterior shift, while others exhibited a slight anterior repositioning, consistent with functional adaptation. Only 1.8% showed a posterior shift, which may be attributed to individual variability in response to therapy or poor appliance compliance. These observations are in concordance with findings by Vankadara et al., who demonstrated variability in condylar shifts depending on skeletal classification and the nature of functional orthopaedic intervention [5].

Adaptation of the condyle to altered functional loading occurs via two mechanisms:

- Positional remodelling, where the condyle repositions within the glenoid fossa due to mechanical shifts.
- Structural remodelling, involving histological changes in the condylar cartilage and subchondral bone architecture [16].

Longitudinal MRI studies by Pancherz and Ruf have highlighted that functional appliance therapy does not merely reposition the condyle but also initiates biological remodelling of the TMJ components, enhancing stability and joint congruence [17,18].

Further, the increase in joint space anteriorly and superiorly post-treatment, as demonstrated in studies using CBCT [19,20], suggests unloading of posterior joint components, which can potentially alleviate TMJ-related symptoms and reduce internal derangement risk in predisposed individuals.

The mean ANB angle showed a notable reduction from 4.33° pre-treatment to 2.45° post-treatment, and Witts appraisal also improved significantly (from 2.59 mm to 1.24 mm). These changes were highly statistically significant ($p = 0.000$ and $p = 0.001$, respectively), indicating successful skeletal correction. These findings are supported by Tariq et al., who reported average condylar shifts of 2.20 mm in response to fixed functional orthopaedic appliances, confirming adaptive skeletal remodelling (6).

The Pearson's correlation results further affirm the impact of condylar repositioning on sagittal skeletal parameters. A significant positive correlation was observed between ANB (T2) and condylar position (T2) ($r = 0.616$, $p < 0.001$), and between Witts (T2) and condylar position (T2) ($r = 0.724$, $p < 0.001$). These correlations highlight the influence of condylar repositioning on achieving improved skeletal balance and occlusal harmony, which is consistent with Ruf and Pancherz's findings on adaptive remodelling of the condyle in response to Herbst appliance therapy [(7).]

The findings of this study also substantiate the theoretical framework proposed by Pancherz et al., who emphasized condylar remodelling as a central factor in mandibular advancement during Herbst appliance treatment [(8)]. These results reflect the long-standing view that growth modulation rather than mere positional shift is the underlying mechanism of correction in Class II treatment, as elaborated by Baccetti et al. and Marsico et al., who noted greater efficacy when treatment coincides with periods of active growth [(9,10).]

The role of condylar cartilage, which serves as a growth-modulating and load-bearing structure, is crucial in this context. As emphasized in the introduction, the remodeling response of condylar cartilage under altered functional loads contributes significantly to positional adaptation[(6)]. This is consistent with McNamara and Proffit's etiological insights into Class II malocclusion, where mandibular retrusion is closely linked to condylar disposition [(11,12).]

Finally, the long-term impact of fixed functional therapy as a stable and non-invasive alternative to surgical correction was underscored by long-term studies conducted by Pancherz[(13)] and Pancherz & Anehus-Pancherz[(14).] These studies documented the biologic effects of appliances like the Herbst and demonstrated their ability to induce and maintain skeletal correction via condylar remodelling, findings that are reflected in the positive outcomes of this current research.

Despite its two-dimensional limitations, the use of Gelb's grid in lateral cephalograms remains a cost-effective, reproducible, and low-radiation diagnostic modality for condylar assessment. This is particularly valuable in resource-limited settings or in serial longitudinal assessments where repeated CBCT exposure is ethically constrained [20,21].

The current findings also validate its clinical utility and demonstrate that when used meticulously, it can yield insight into TMJ adaptations with acceptable diagnostic reliability.

LIMITATIONS OF THE STUDY

Despite the significant findings observed in this study, there are a few limitations that must be acknowledged:

- The primary limitation of this study lies in the use of lateral cephalograms, a two-dimensional imaging modality, for assessing condylar position. While Gelb's grid provides a practical and standardized framework for evaluating sagittal condylar relationships, it does not allow for visualization of the condyle in the coronal or axial planes.
- In this study pre- and immediate post-treatment lateral cephalograms were analyzed. No long-term follow-up was conducted to assess the stability or relapse of the observed condylar changes. Longitudinal studies extending into the post-retention phase are required to determine whether the changes in condylar positioning are maintained over time or prone to regression.
- Although standardization techniques were employed, the use of manual cephalometric tracing introduces the potential for inter- and intra-operator variability in landmark identification and measurement.
- This was a retrospective study conducted at a single institution, limiting the external validity and generalizability of the findings to broader, more diverse populations.

FUTURE SCOPE

Considering the limitations of the current study, there is a scope for further research which should be prospective, multi-center studies with larger and more heterogeneous samples are necessary to strengthen the clinical applicability of the results.

CONCLUSION

The present study investigated the effects of fixed functional therapy on mandibular condylar position using Gelb's grid analysis in pre- and post-treatment lateral cephalograms of patients with skeletal Class II malocclusion.

The findings contribute valuable insights into the sagittal repositioning of the condyle following functional intervention, reinforcing the therapeutic role of fixed functional therapy in facilitating mandibular advancement and remodelling.

A significant anterior shift in the position of the mandibular condyle was observed in a substantial proportion of patients post treatment. The condylar relocation from a predominantly posterior (5/8) to a more concentric and physiologic (4/7) position was accompanied by notable improvements in sagittal skeletal parameters, including a statistically significant reduction in the ANB angle and Witts appraisal values.

From a biological standpoint, the anterior repositioning of the condyle is likely a result of adaptive remodelling processes within the temporomandibular joint (TMJ), mediated by altered neuromuscular and articular forces generated by functional appliance therapy. These positional changes not only support improved occlusal relationships as demonstrated by the high rate of transition to Class I molar occlusion but also potentially enhance TMJ balance and stability.

In conclusion, fixed functional therapy serves not only as a dentoalveolar corrective modality but also as a skeletal remodelling agent capable of inducing measurable changes in condylar position. These changes are of considerable clinical relevance for orthodontists aiming to achieve stable, functional, and esthetic outcomes in the management of skeletal Class II malocclusions. The study also underscores the importance of integrating condylar evaluation into diagnostic and treatment planning protocols and advocates for continued research incorporating advanced imaging and longer follow-up periods to elucidate the long-term implications of condylar adaptations on TMJ health and treatment stability.

SUMMARY

This study investigates the changes in mandibular condylar position in patients with skeletal Class II malocclusion following fixed functional orthodontic therapy, using Gelb's grid analysis on pre- and post-treatment lateral cephalograms. The condyle's position within the glenoid fossa is crucial for TMJ health, occlusal balance, and facial harmony. In skeletal Class II cases, posteriorly positioned condyles are commonly observed due to mandibular retrusion. Fixed functional appliances aim to advance the mandible, potentially repositioning the condyle and encouraging adaptive growth.

The research was conducted on 57 patients aged 14–20 years who received fixed functional therapy. Lateral cephalograms were digitized, standardized, and manually traced to mark anatomical landmarks. Gelb's grid, a diagnostic tool that segments the glenoid fossa into zones, was applied to assess the condylar position as anterior, concentric (central), or posterior. Alongside this, ANB angle and Wits appraisal were measured to evaluate skeletal relationships.

Results showed a significant anterior shift in the mandibular condyle post-treatment. Initially, 84.2% of condyles were in a posterior (5/8) position; after treatment, 66.7% moved to a concentric (4/7) position. These positional changes were statistically significant and corresponded with a reduction in ANB angle from 4.33° to 2.45°, and Wits appraisal from 2.59 mm to 1.24 mm. Additionally, most patients shifted from Class II to Class I molar relationships. Pearson's correlation analysis revealed a strong association between improved skeletal parameters and the new condylar position.

The study emphasizes that fixed functional appliances do more than dental correction—they contribute to skeletal remodelling by inducing biological changes in the TMJ. The condyle adapts not only positionally but also structurally through cartilage remodelling in response to altered muscular forces and joint loading.

Despite using two-dimensional imaging, the study demonstrates that Gelb's grid is a reliable, low-cost, and reproducible tool for monitoring condylar shifts, particularly where CBCT is not feasible. The limitations include lack of long-term follow-up, absence of three-dimensional data, and potential variability from manual tracing. Nevertheless, the findings support integrating condylar evaluation into orthodontic planning to better predict outcomes and enhance treatment stability.

In conclusion, fixed functional therapy effectively induces anterior repositioning of the mandibular condyle, contributing to improved skeletal alignment and occlusal relationships. These results highlight the therapeutic and diagnostic value of assessing condylar position during orthodontic treatment, particularly in managing skeletal Class II malocclusions.

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ANNEXURES

ANNEXURE-I-ETHICAL CLEARANCE CERTIFICATE

Research and Ethics Committee
KLE VK INSTITUTE OF DENTAL SCIENCES
A Constituent Unit of KLE Academy of Higher Education & Research
Accredited 'A' Grade by NAAC
Placed in Category 'A' by MHRD (GoI)
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Sl. No. : 1651

CERTIFICATE

This is to Certify that the synopsis titled Evaluation of mandibular condylar position using Gelb's grid in patients treated with fixed functional therapy - A retrospective study *Submitted by* *Dr.* REG. NO. II0222006. *P. G. Student / Staff, Guided by* *from Department of* Orthodontics and Dentofacial Orthopedics *has been critically evaluated by committee members and granted ethical clearance to conduct the above mentioned study*

Date : 15/04/25

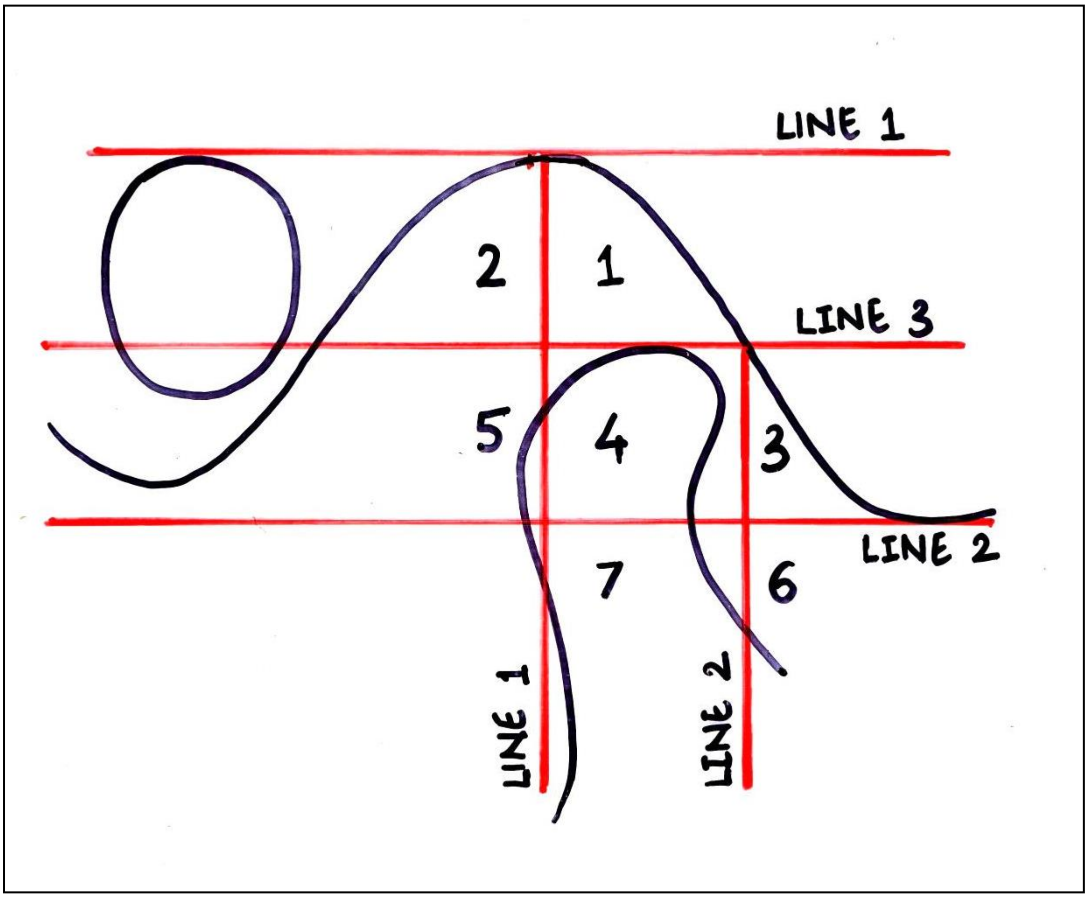
Member Secretary
Research and Ethical Committee
KLEVK Institute of Dental Sciences
Belagavi

MEMBER SECRETARY
Research & Ethical Committee
KLEVK Institute of Dental Sciences
BELAGAVI.

Chairman
Research and Ethical Committee
KLEVK Institute of Dental Sciences
Belagavi

Chairman
Research and Ethical Committee
KLE VK Institute of Dental Sciences
Belgaum

ANNEXURE II- PHOTOGRAPH OF THE CONSTRUCTED GRID



ANNEXURE III- MASTER CHART

SR. NO.	AGE	SEX	ANB PRE (T1)	ANB POST (T2)	WITTS PRE (T1)	WITTS POST (T2)	MOLAR RELATION PRE (T1)	MOLAR RELATION POST (T2)	CONDYLAR POSITION PRE (T1)	CONDYLAR POSITION POST (T2)	CONDYLAR HEAD SHIFT	APPLIANCE TYPE
1	15	Female	4	3	3	2	Class II	Class II	5,8	5,8	Stable	MPA
2	16	Female	3	1	3	1	Class II	Class I	5,8	4,7	Significant Anterior Shift	Forsus
3	14	Male	4	2	2	1	Class II	Class I	5,8	4,7	Slight Anterior Shift	Forsus
4	16	Female	3	1	2	0	Class II (End-On)	Class I	5,8	4,7	Slight Anterior Shift	Forsus
5	16	Male	4	2	3	0	Class II (End-On)	Class I	5,8	4,7	Significant Anterior Shift	Herbst
6	13	Female	5	2	4	1	Class II	Class I	5,8	4,7	Significant Anterior Shift	FIXED TWIN BLOCK
7	14	Male	4	2	3	1	Class II	Class I	5,8	4,7	Slight Anterior Shift	Forsus
8	14	Female	5	3	3	2	Class II	Class I	5,8	5,8	Stable	Forsus
9	14	Male	4	2	2	2	Class II	Class I	5,8	5,8	Stable	Forsus
10	16	Male	4	2	2	1	Class II	Class I	5,8	4,7	Slight Anterior Shift	Herbst
11	15	Female	5	3	3	2	Class II	Class I	5,8	4,7	Slight Anterior Shift	Herbst
12	14	Male	3	1	2	2	Class II	Class II	4,7	4,7	Stable	Herbst
13	17	Female	5	2	2	0	Class II	Class I	5,8	4,7	Significant Anterior Shift	Herbst
14	16	Female	2	1	3	1	Class II	Class I	4,7	4,7	Slight Anterior Shift	MPA
15	13	Female	4	3	3	2	Class II	Class II (End-On)	5,8	5,8	Stable	Forsus
16	14	Male	4	2	2	0	Class II	Class I	5,8	4,7	Significant Anterior Shift	Herbst
17	17	Female	3	0	3	1	Class II	Class I	5,8	4,7	Slight Anterior Shift	Herbst
18	17	Female	4	2	2	0	Class II (End-On)	Class I	4,7	4,7	Stable	MPA
19	15	Female	5	3	4	2	Class II	Class II (End-On)	5,8	5,8	Stable	FIXED TWIN BLOCK
20	15	Female	4	3	3	2	Class II	Class I	5,8	5,8	Stable	MPA
21	16	Female	4	3	2	2	Class II	Class I	5,8	5,8	Stable	Forsus
22	12	Female	5	2	3	0	Class II	Class II	5,8	4,7	Significant Anterior Shift	FIXED TWIN BLOCK
23	15	Female	4	1	2	0	Class II	Class I	5,8	4,7	Significant Anterior Shift	Herbst
24	14	Male	4	3	3	2	Class II (End-On)	Class I	4,7	4,7	Stable	FIXED TWIN BLOCK
25	15	Male	3	1	3	1	Class II	Class I	5,8	4,7	Slight Anterior Shift	EUREKA SPRING
26	16	Female	4	3	2	1	Class II	Class I	5,8	4,7	Slight Anterior Shift	Forsus
27	15	Female	4	3	1	1	Class II	Class I	4,7	4,7	Stable	Forsus
28	12	Female	6	2	4	1	Class II	Class I	5,8	4,7	Significant Anterior Shift	FIXED TWIN BLOCK
29	12	Female	4	2	3	1	Class II (End-On)	Class I	5,8	4,7	Significant Anterior Shift	FIXED TWIN BLOCK
30	14	Female	4	3	2	1	Class II	Class I	5,8	4,7	Slight Anterior Shift	FIXED TWIN BLOCK

31	14	Female	5	3	3	2	Class II	Class I	5,8	5,8	Stable	MPA
32	13	Male	6	2	3	1	Class II	Class I	5,8	4,7	Significant Anterior Shift	FIXED TWIN BLOCK
33	15	Female	3	3	2	2	Class II	Class I	5,8	5,8	Stable	Forsus
34	15	Male	5	3	3	2	Class II	Class I	5,8	4,7	Slight Anterior Shift	Forsus
35	17	Female	3	2	2	2	Class II (End-On)	Class I	4,7	4,7	Stable	Forsus
36	17	Male	6	5	4	3	Class II	Class I	5,8	5,8	Stable	Herbst
37	17	Female	3	2	2	1	Class II (End-On)	Class I	4,7	4,7	Slight Anterior Shift	Forsus
38	12	Female	3	1	2	0	Class II	Class I	5,8	4,7	Significant Anterior Shift	FIXED TWIN BLOCK
39	15	Male	5	3	3	2	Class II	Class I	5,8	5,8	Stable	Forsus
40	15	Female	4	3	2	2	Class II	Class I	5,8	5,8	Stable	MPA
41	12	Male	6	3	3	1	Class II	Class I	5,8	4,7	Significant Anterior Shift	FIXED TWIN BLOCK
42	14	Female	5	2	4	2	Class II	Class I	5,8	4,7	Slight Anterior Shift	Herbst
43	18	Female	6	4	3	2	Class II	Class I	5,8	5,8	Stable	Forsus
44	19	Male	3	3	2	2	Class II (End-On)	Class I	5,8	5,8	Stable	Herbst
45	16	Female	6	5	3	2	Class II	Class I	5,8	5,8	Stable	Herbst
46	12	Male	5	2	3	1	Class II	Class I	5,8	4,7	Significant Anterior Shift	FIXED TWIN BLOCK
47	13	Female	4	2	2	0	Class II (End-On)	Class I	4,7	4,7	Slight Anterior Shift	FIXED TWIN BLOCK
48	15	Female	4	3	2	1	Class II	Class I	5,8	5,8	Stable	ADVANSYNC 2
49	14	Male	5	3	2	2	Class II	Class I	5,8	5,8	Stable	FIXED TWIN BLOCK
50	14	Female	5	2	2	0	Class II	Class I	5,8	4,7	Significant Anterior Shift	Forsus
51	17	Female	4	4	3	2	Class II	Class II (End-On)	5,8	5,8	Slight Posterior Shift	Forsus
52	16	Male	5	3	2	1	Class II	Class I	5,8	4,7	Slight Anterior Shift	MPA
53	14	Female	3	2	1	1	Class II (End-On)	Class I	4,7	4,7	Stable	Forsus
54	12	Female	6	3	4	2	Class II	Class I	5,8	4,7	Slight Anterior Shift	FIXED TWIN BLOCK
55	14	Female	6	4	3	1	Class II	Class I	5,8	4,7	Significant Anterior Shift	MPA
56	14	Male	4	2	2	0	Class II	Class I	5,8	4,7	Significant Anterior Shift	MPA
57	16	Male	6	4	2	2	Class II	Class I	5,8	5,8	Stable	FIXED TWIN BLOCK