ORIGINAL RESEARCH

Evaluation of Changes in Soft and Hard Tissues of TMJ among Class II Division 2 Patients after Prefunctional Orthodontics and Twin Block Functional Appliance Therapy: A Prospective MRI Study

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Abstract

Introduction: No study has been conducted to explore soft and hard tissue changes brought by functional appliances within the temporomandibular joint (TMJ) after correction of class II division 2 (div 2) malocclusion. Hence, we planned this study to evaluate the mandibular condyle disk-fossa relationship before and after prefunctional and twin block therapy using a magnetic resonance imaging (MRI) scan.

Methodology: This prospective observational study was conducted among 14 males treated with prefunctional appliances for 3–6 months, followed by 6–9 months of fixed mechanotherapy. MRI scan was evaluated for changes in the TMJ at baseline after completion of prefunctional phase and after completion of functional appliance therapy.

Results: At pretreatment, there was a flat contour on the posterosuperior surface of the condyles and a notch-like projection on its anterior surface. After functional appliance therapy, slight convexity appeared on the posterosuperior surface of the condyle and the prominence of the notch was reduced. There was a statistically significant anterior shift of condyles both after prefunctional and twin block treatment. The meniscus on both sides had significantly shifted posteriorly over three stages with respect to the posterior condylar (PC) plane and Frankfort horizontal (FH) plane. The superior joint space had significantly increased with significant linear glenoid fossa displacement between pre and posttreatment stages.

Conclusion: Prefunctional orthodontics induced favorable changes in TMJ soft and hard tissues of patients, but they were not sufficient to place the soft and hard tissues in their normal positions. A functional appliance phase is needed to place the TMJ in their respective normal positions.

Keywords: Class II malocclusion, Magnetic resonance imaging, Myofunctional.

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Introduction

Angle's class II div 2 is characterized by retroclined maxillary incisors along with the distal placement of the mandible in relation to the maxilla. There is downward and inward tipping of maxillary incisors along with lingual tipping of mandibular incisors and severe deep bites in a few cases. The altered gnathodynamics and prominent incisal guidance during the closure of the mandible, pushes mandible backward, resulting in structural and morphological changes in soft and hard tissues of TMJ and craniofacial structures.[1–4] Mandible gets locked posteriorly in patients having div 2 malocclusion, leading to unfavorable bone remodeling, posterior displacement of the condyle, and anterior positioning of meniscus within the TMJ complex.[5,6] However, Gianelly et al., and Pullinger et al., reported that no association exists between deep bite and posterior condyle placement in this malocclusion.[7,8]

Three systematic reviews conducted also failed to establish the precise changes within the TMJ complex, thereby pointing toward insufficiency of literature, especially in patients with div 2.[9–11]

The mandible div 2 mandible is backwardly placed due to mechanical obstruction of retroclined maxillary incisors in the path of the growing mandible, which has otherwise normal growth potential. The findings of studies conducted on div 1[12,13] cannot be applied directly to div 2, as there is a

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fundamental difference in mandibular gnathodynamics in patients with div 1 and div 2.

As per the best of our knowledge, there is no study that has documented the TMJ soft and hard tissue changes associated with div 2 malocclusions before and after correcting the maxillary incisor and using a functional appliance with advanced imaging techniques like MRI. The precise studies on patients with div 2 can help to understand the fundamental changes brought by prefunctional orthodontics (unlocking treatment) and twin block (functional appliances) on underlying soft and hard tissues of TMJ. This will help in developing better treatment options and, therefore, patient-friendly clinical outcomes.

Considering the above scenario, this study was planned to evaluate the changes in soft and hard tissues of TMJ among div 2 patients treated with prefunctional orthodontics and twin block functional appliance.

Methodology

Study setting and Participants

This hospital-based prospective observational study was conducted in the Department of Orthodontics and Dentofacial Orthopedics in collaboration with the Department of Oral Medicine and Radiology at the Postgraduate Institute of Dental Sciences (Govt. Dental College and Hospital, Rohtak), Rohtak, Haryana, India. Adolescent male patients presenting with div 2 malocclusions, accompanied by mild crowding of <3 mm, who were in the prepubertal growth spurt phase (representative case Fig. 1). Div 2 malocclusion was assessed by clinical examination, and eligibility for functional appliance was assessed by lateral cephalogram. The patients with the retro-positioned mandible [angle formed by point A, point N, point B (ANB) angle of 5° or more], horizontal growth pattern (sella nasion-mandibular plane angle between 24° and 32°), and residual skeletal growth (cervical maturation stage CS2-CS4) stage were included in the study. Patients with any TMJ pathology, internal disk derangement, contraindications for functional appliance therapy, with a previous history of orthodontic treatment, or any systemic diseases like endocrinal abnormality affecting bone metabolism were excluded from the study. Out of 20 patients who reported with div 2, 15 patients were found to be eligible for this study. Ethical clearance was taken from Institute Ethical Board, and informed consent was obtained from the patients and their parents before enrolment.

Phases of Treatment

The orthodontic treatment was carried out in three phases: prefunctional phase (3–6 months), functional appliance phase (6–9 months), and multibracket phase. During the first phase, a two-fourth orthodontic appliance was used to correct maxillary anterior. A twin block appliance was used to achieve class I occlusion (Fig. 1). One patient did not wear the appliance, so he was dropped from the final analysis. Hence, the final sample size achieved was 14 patients. Figures 2 and 3 show representative patients after incisor correction and twin block therapy, respectively.

Correspondingly, the MRI scan [by Nova Gradiant 1.5 Tesla Phillips (Netherlands)] and other records were collected at three stages: S1 (before starting of the prefunctional phase), S2 (at the completion

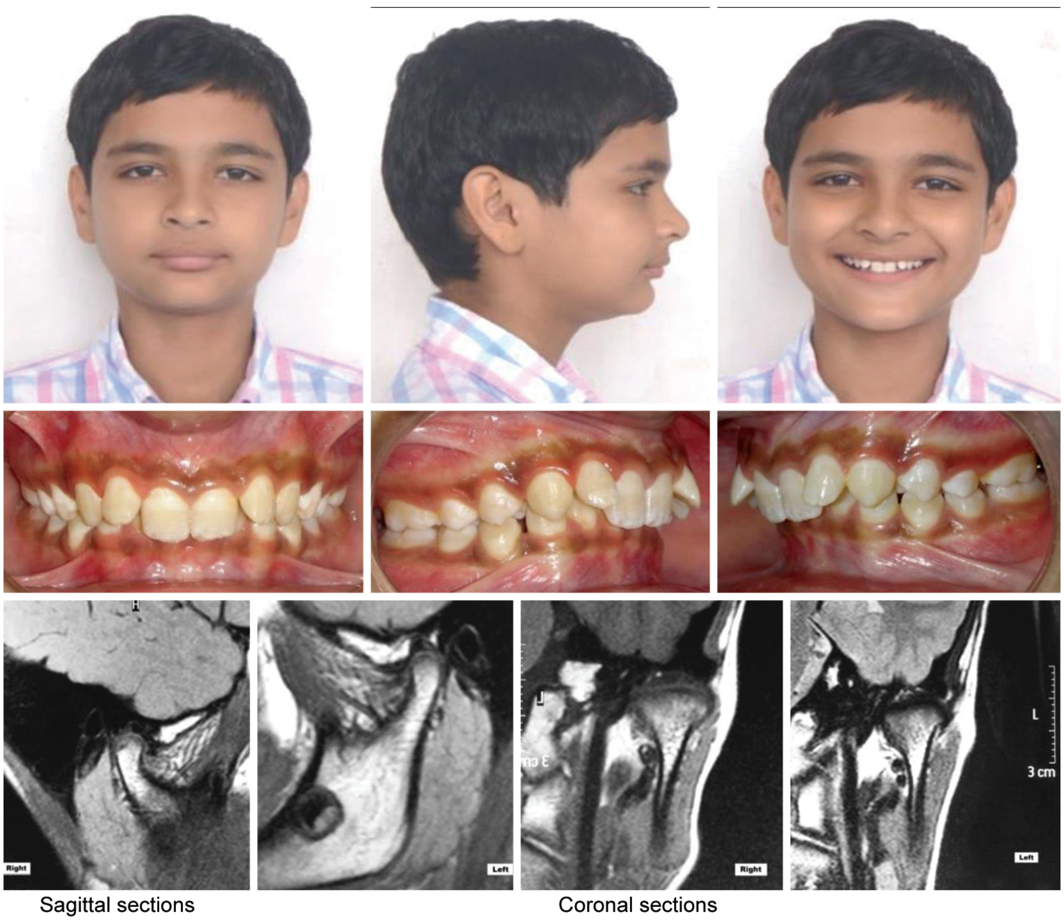


Fig. 1: Extraoral and intraoral photographs and MRI records at pretreatment (stage S1)

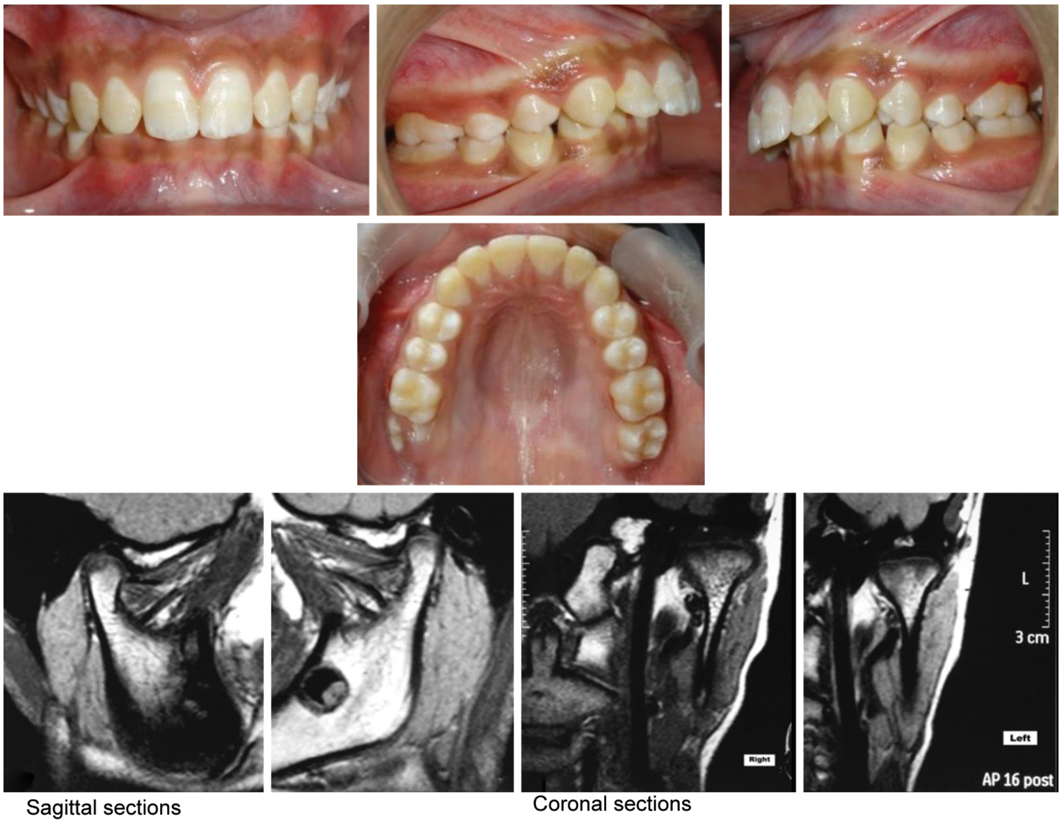


Fig. 2: Intraoral photographs and MRI records after prefunctional orthodontics (stage S2)

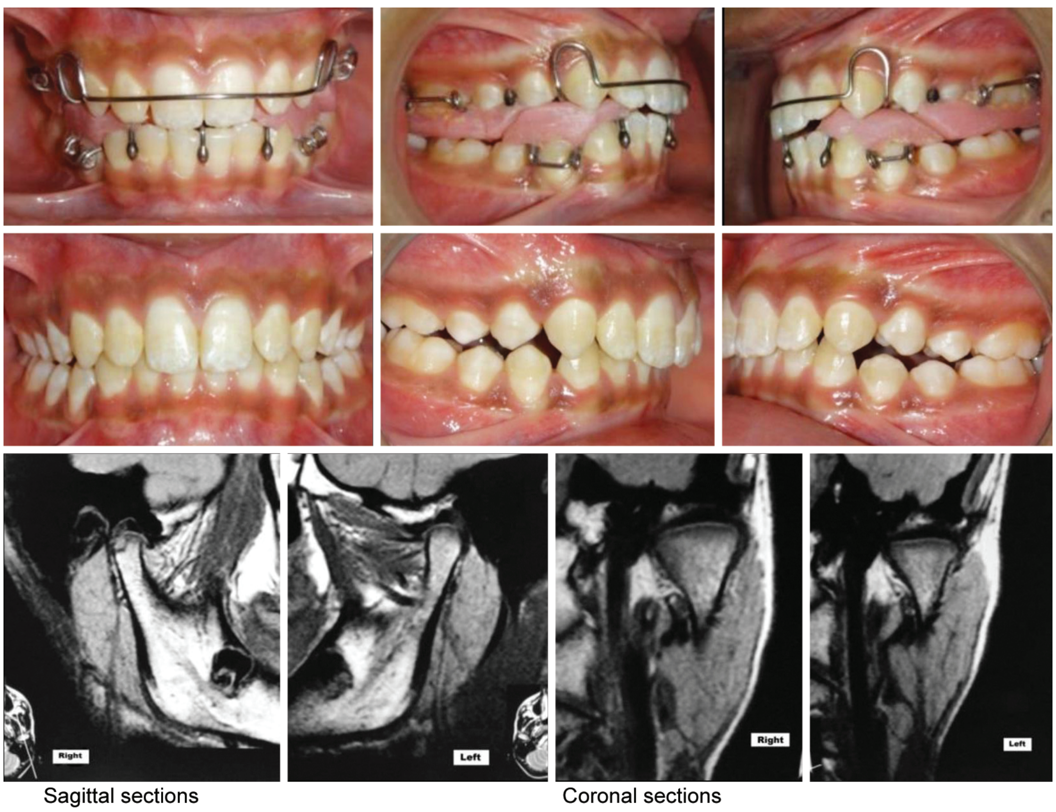


Fig. 3: Intraoral photographs with twin block, after class II correction and MRI records (stage S3)

of prefunctional phase and before initiation of twin block appliance phase), and S3 (minimum 6 months of twin block wear or after dental corrections of class II molar relation, whatsoever was achieved earlier).

Angular and Linear Measurements

Eight paired angular parameters were recorded for each patient, sagittal concentricity and glenoid fossa angle for both condyles, respectively. The eminence angle for both sides in relation to the PC plane and FH plane was measured. The PC plane was drawn according to the method described and transfer of the FH plane was done accordingly.[14] Similarly, anterior and posterior bands of the meniscus on both sides were recorded in relation to the PC plane and FH plane. There were four pairs of linear measurements corresponding to both sides of TMJ in terms of superior joint space, linear glenoid fossa displacement, with respect to the center of condylar head (c-CH) and linear distance from center of posterior glenoid spine (PGS), and mean coronal meniscus position. The operational definitions considered for measuring these parameters are elaborated in Table 1.[7,12,15,16] The representative drawings of various landmarks and angles are illustrated in Figure 4.

Data Analysis

The data were analyzed using the Statistical Package for Social Sciences (SPSS) for Windows, Version 20.0 (SPSS Inc., Chicago, USA). Shapiro–Wilk test was used for testing the normal distribution of the data. For comparing the mean or median of linear and angular measurements at three stages, either repeated measures of analysis of variance (ANOVA) or Friedman ANOVA was used depending upon the type of variable distribution. p-value of <0.05 was considered to be significant for rejecting the null hypothesis. Cronbach's α was calculated to assess the interrater reliability of measurements made for each variable at three stages of treatment by two researchers.

Results

Basic Data Characteristics

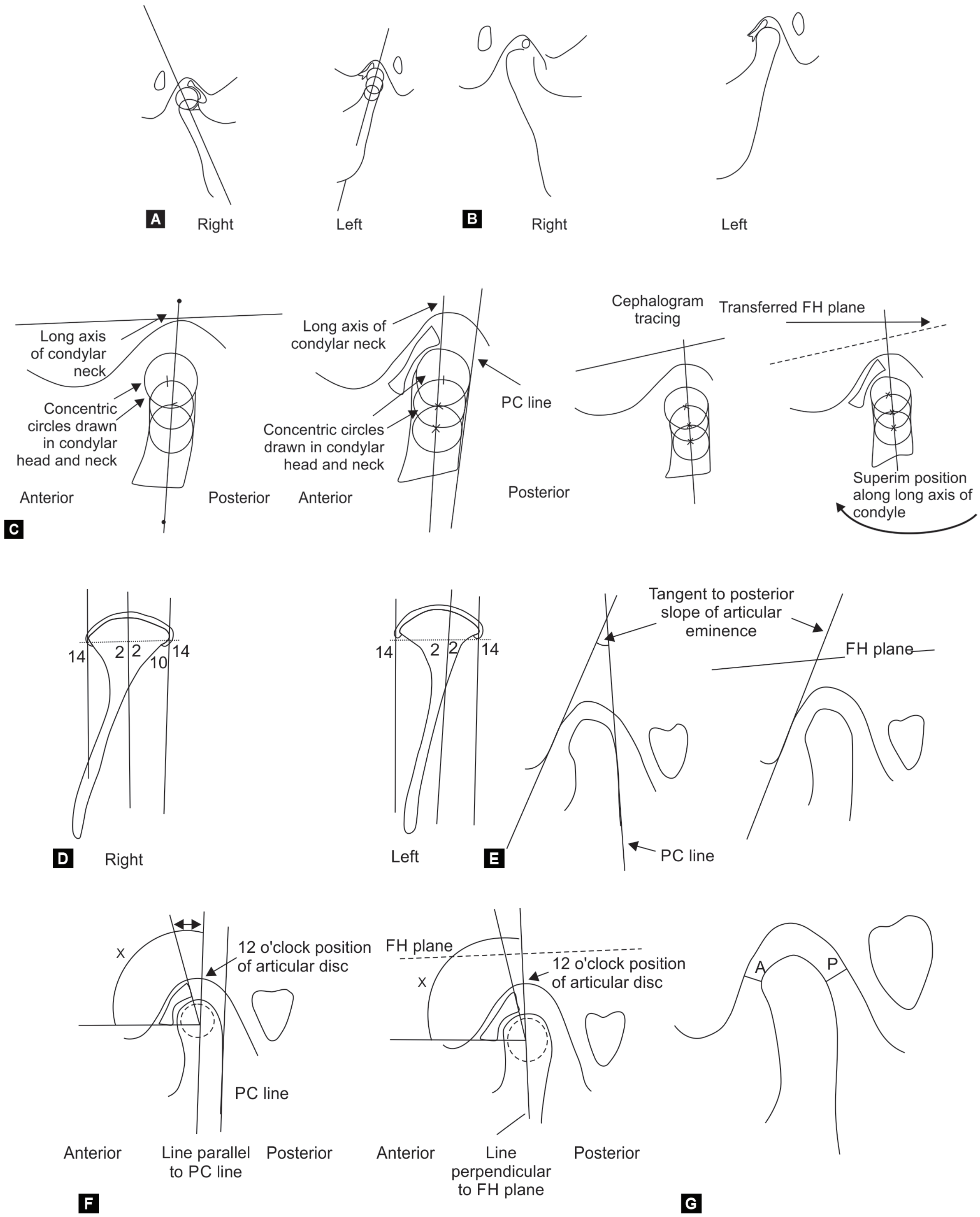
The age of all patients ranged from 11 to 13 years. All cases were diagnosed to have deep bites. All the measurements were recorded and analyzed at three stages, that is, S1, S2, and S3. Out of 16 angular parameters, five were non-normally distributed, as shown by the asterisk mark in Table 2. And out of eight linear parameters, only two were normally distributed (shown by an asterisk mark in Table 3). The Cronbach's α varied from 0.997 to 1, indicating an excellent interrater reliability coefficient among the two observers (Table 4).

Visual Inspection Findings

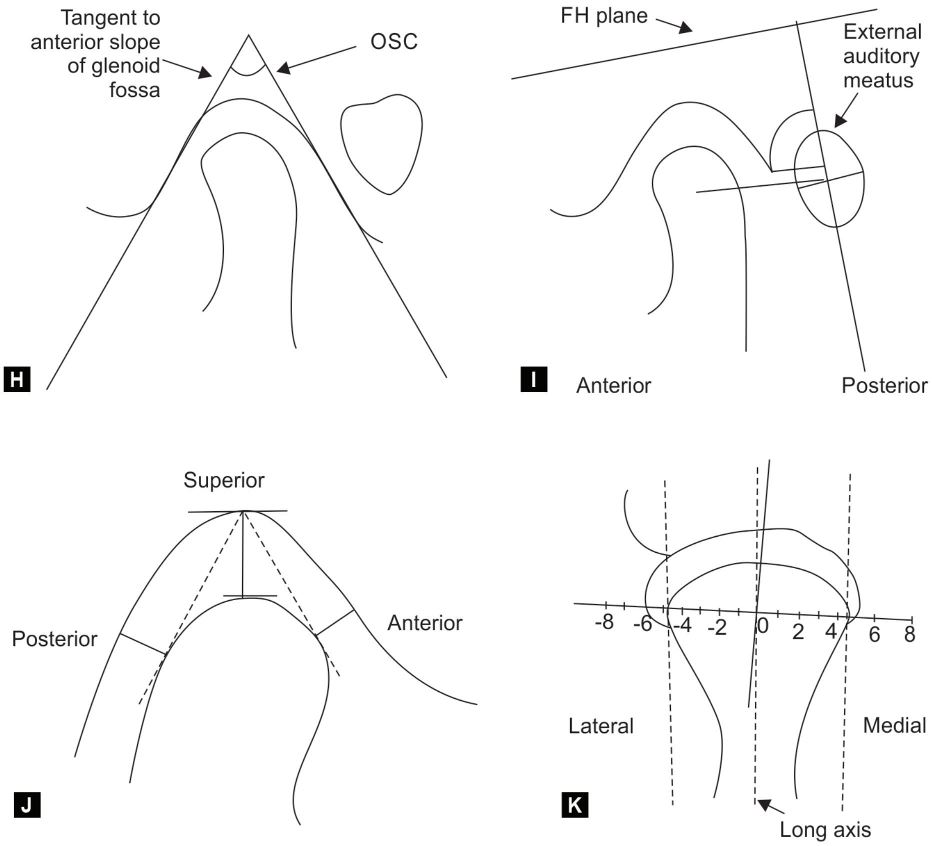
The glenoid fossa was observed as bell-shaped, indicative of the normal anatomy in div 2 patients. There was no change in the eminence of the notch on the anterior surface at S2, as compared to S1. However, there was a noticeable decrease in the eminence of the notch at S3, as compared to S1. There were no major changes in condyle or glenoid fossa at S2. At S3, we found a convexity that appeared on the posterosuperior surface of the condyle. The visual evidences of alteration in the shape of the mandibular condyle were observed among nine (64.3%) out of the 14 patients.

Table 1: Operational definitions for linear and angular measurements

Variables	*Operational definitions*
Angular measurements	
Sagittal concentricity	A positive value indicated an anterior position of the condyle, while a negative value indicated a posterior position of condyle, and zero value was referred to as concentric
Eminence angle with respect to PC plane Eminence angle with respect to FH plane	Angle formed by a line tangential to the posterior slope of the articular eminence relative to PC line and FH plane
Anterior band of disk with respect to PC plane Anterior band of disk with respect to FH plane Posterior band of disk with respect to PC plane Posterior band of disk with respect to FH plane	The intersecting point between a line parallel to the PC line passing through the condylar center and the roof of the fossa was constructed and was referred to as the 12 o'clock position in the glenoid fossa. The line perpendicular to the FH plane through the condylar center and the roof of the articular fossa was constructed and referred to as the 12 o'clock position. The position of the anterior and posterior band of the disk was measured as angles relative to the 12 o'clock position
Glenoid fossa angle	Angle between the tangents to the anterior and posterior slopes of the glenoid fossa as measured on sagittal view
Linear measurements	
Superior joint space	Shortest distance between the most superior point of the condyle and the most superior point of the mandibular fossa
Linear glenoid fossa displacement (c-CH)	One point was marked at the c-CH and the linear distance of the c-CH from the linear distance from center of external auditary meatus (c-EAM) was evaluated as the shortest distance from the constructed FH perpendicular
Linear glenoid fossa displacement (PGS)	One point was marked at the crest of the post-glenoid spine (c-PGS) and the linear distance of the c-PGS from the c-EAM was evaluated as the shortest distance from the constructed FH perpendicular
Mean coronal disk position	The line across the maximum width was then divided into tenths. The position of the disk was recorded in relation to the 1/10 divisions of the condylar width. Negative value represented the lateral side, while positive value represented the medial side



Figs 4A to G: MRI tracings, (A) tracing of condyle glenoid fossa complex (sagittal section); (B) Determination of long axis of the condyle; (C) Transfer of FH plane; (D) Tracing of condyle glenoid fossa complex (coronal section); (E) Eminence angle; (F) Sagittal disk position; (G) Sagittal condylar concentricity



Figs 4H to K: (H) Glenoid fossa angle; (I) Linear measurements; (J) Superior joint test; and (K) Coronal disk position

Angular Parameters

The mean sagittal concentricity values corresponding to S1, S2, and S3 stages for the right condyle were 14.92, −6.07, and 18.00, respectively, and for the left condyle −17.64, −8.92, and 17.07, respectively (Table 2). Measurement for sagittal concentricity showed that there was a statistically significant anterior shift among both right and left condyles within the TMJ from S1 to S2, S2 to S3, and S1 to S3. The position of both the bands of the meniscus on both sides moved posteriorly from S1 to S2, S2 to S3, and S1 to S3 as observed in relation to both the PC plane and FH plane, and the shift was found to be statistically significant. For the rest of the angular parameters like eminence angle and glenoid fossa angle on both sides of TMJ, the intergroup comparison showed no statistically significant differences over the three measurement stages.

Linear Parameters

The superior joint space on both sides showed no statistically significant differences between the S1 and S2 stages, while it was significantly increased between S2 and S3 stages, and correspondingly between S1 and S3 stages.

The mean linear glenoid fossa displacements (c-CH) at stages S1, S2, and S3 for the right condyle were 10.60, 10.89, and 11.67, respectively, and for the left condyle 10.39, 10.67, and 11.45, respectively. This indicates that statistically significant linear glenoid fossa displacement (c-CH) had occurred over three stages for both condyles. However, for mean linear glenoid fossa displacement (PGS), the interstage comparison showed no statistically significant differences between S1 and S2 stages, but it was statistically significant between S1 and S3 stages.

The mean coronal meniscus position measurements at S1, S2, and S3 for the right condyle were −0.42, −0.42, and −0.42, respectively and for the left condyle −0.42, −0.42, and −0.42, respectively (Table 3). There was no statistically significant difference in coronal meniscus position on both sides over three treatment stages (Table 3).

Discussion

Posteriorly positioned condyle in 10 (71.4%) of the total 14 patients indicated posterior displacement/locking of mandibular condyle within the glenoid. Our findings are supported by Pullinger AG et al. and Gianel ly AA et al. Many researchers found no correlation between the posterior placement of condyles and correction of deep bite, zero overjet, or backward shift of mandible due to incisal guidance.[7,8,17] However, all these comparative studies were guided by cephalometric and computed tomography findings.

The flat contour on the sagittal scans at S1 is suggestive of osseous remodeling due to forceful backward displacement of the condyle in div 2 patients. At S2 though, the condyle moved anteriorly but with a similar flat contour, which suggests that 3–6 months is not a sufficient time period for osseous changes. Loss of the flat contour at the S3 stage could be attributed to osseous augmentation in condyle in this region.[18]

We found that there was a statistically significant anterior shift of the mandible between stages S1 and S2, S2 and S3, and S1 and S3, as indicated by the measurements of sagittal concentricity (Table 2). The number of patients with posterior mandibular position reduced from 10 at S1 to eight at S2. The anterior movement in only two patients is indicative that prefunctional orthodontics alone is not

Table 2: Comparison of angular parameters among 14 class II div 2 patients at three stages

Angular parameter	*Stage*	*Mean ± standard deviation (SD)/median (IQR)*]*	*Standard error (SE)/ rank*	*p-value*	*Interpretation*
	S1	−14.92 ± 12.42	3.32	S1–S2 = 0.026	S
	S2	−6.07 ± 13.14	3.51	S2–S3 = 0.001	S
Sagittal concentricity-right	S3	18.00 ± 7.53	2.01	S3–S1 = 0.001	S
Sagittal concentricity-left*	S1	−17 (−33 to 0.0)	1.3	<0.01	S
	S2	−12.5 (−20.0 to 0.0)	1.7		
	S3	20 (10.5–20)	3.0		
Eminence angle with respect to PC plane-right*	S1	30 (28–32)	2	NA	NA
	S2	30 (28–32)	2		
	S3	30 (28–32)	2		
Eminence angle with respect to PC plane-left*	S1	29.5 (27.8–30.0)	2	NA	NA
	S2	29.5 (27.8–30.0)	2		
	S3	29.5 (27.8–30.0)	2		
Eminence angle with respect to FH plane-right	S1	49.71 ± 3.40	0.91	S1–S2 = 1.00	NS
	S2	49.71 ± 3.40	0.91	S2–S3 = 1.00	NS
	S3	49.71 ± 3.40	0.91	S3–S1 = 1.00	NS
Eminence angle with respect to FH plane-left	S1	49.64 ± 4.30	1.15	S1–S2 = 1.00	NS
	S2	49.64 ± 4.30	1.15	S2–S3 = 1.00	NS
	S3	49.64 ± 4.30	1.15	S3–S1 = 1.00	NS
Anterior band of disk with respect to PC plane-right	S1	126.14 ± 11.29	3.01	S1–S2 = 0.023	S
	S2	124.71 ± 11.71	3.13	S2–S3 = 0.001	S
	S3	118.35 ± 10.86	2.9	S3–S1 = 0.001	S
Anterior band of disk with respect to PC plane-left	S1	125.92 ± 11.85	3.16	S1–S2 = 0.023	S
	S2	124.50 ± 12.15	3.24	S2–S3 = 0.001	S
	S3	118.14 ± 11.40	3.04	S3–S1 = 0.001	S
Anterior band of disk with respect to FH plane-right	S1	109.21 ± 9.00	2.4	S1–S2 = 0.023	S
	S2	107.78 ± 9.43	2.52	S2–S3 = 0.001	S
	S3	101.42 ± 8.56	2.28	S3–S1 = 0.001	S
Anterior band of disk with respect to FH plane-left	S1	109.00 ± 9.71	2.59	S1–S2 = 0.023	S
	S2	107.57 ± 9.99	2.67	S2–S3 = 0.001	S
	S3	101.21 ± 9.26	2.47	S3–S1 = 0.001	S
Posterior band of disk with respect to PC plane-right	S1	26.28 ± 6.77	1.81	S1–S2 = 0.023	S
	S2	24.85 ± 7.19	1.92	S2–S3 = 0.001	S
	S3	18.50 ± 6.38	1.7	S3–S1 = 0.001	S
Posterior band of disk with respect to PC plane-left	S1	26.00 ± 7.39	1.97	S1–S2 = 0.023	S
	S2	24.57 ± 7.63	2.04	S2–S3 = 0.001	S
	S3	18.21 ± 6.97	1.86	S3–S1 = 0.001	S
Posterior band of disk with respect to FH plane-right*	S1	9 (5–12.3)	2.7	<0.01	S
	S2	6.5 (3.5–10.8)	2.3		S
	S3	1(−2.3–4.3)	1.0		S
Posterior band of disk with respect to FH plane-left*	S1	7.5 (5–10.5)	1.0	<0.01	S
	S2	6.5 (2.8–10.0)	2.3		S
	S3	1.0 (−3.3 to 2.0)	1.0		S
Glenoid fossa angle-right	S1	66.35 ± 4.55	1.21	S1–S2 = 1.00	NS
	S2	66.35 ± 4.55	1.21	S2–S3 = 1.00	NS
	S3	66.35 ± 4.55	1.21	S3–S1 = 1.00	NS
Glenoid fossa angle-right	S1	66.14 ± 4.12	1.1	S1–S2 = 1.00	NS
	S2	66.14 ± 4.12	1.1	S2–S3 = 1.00	NS
	S3	66.14 ± 4.12	1.1	S3–S1 = 1.00	NS

Table 3: Comparison of linear parameters among 14 class II div 2 patients at three stages

Linear parameter	*Stage*	*Mean ± SD/median (IQR)*	*SE*	*p-value*	*Interpretation*
Superior joint space—right*	S1	2.5 (2–3)	3	<0.01	NS
	S2	2.5 (2–3)	3		S
	S3	4 (3.4–4)	4		S
Superior joint space—left*	S1	2.5 (2–3)	3	<0.01	NS
	S2	2.5 (2–3)	3		S
	S3	4 (3.5–4)	4		S
Linear glenoid fossa displacement (c-CH)—right*	S1	10 (9–13)	1.3	<0.01	S
	S2	10.3 (9.5–13.0)	1.8		S
	S3	11.3 (10.4–13.6)	3.0		S
Linear glenoid fossa displacement (c-CH)—left	S1	10.39 ± 1.09	0.29	S1–S2 = 0.011	S
	S2	10.67 ± 0.93	0.24	S2–S3 = 0.001	S
	S3	11.45 ± 0.83	0.22	S3–S1 = 0.001	S
Linear glenoid fossa displacement (PGS)—right*	S1	4.8 (4.0–6.1)	1.5	<0.01	NS
	S2	4.8 (4.0–6.1)	1.5		S
	S3	5.5 (5.0–6.6)	3.0		S
Linear glenoid fossa displacement (PGS)—left	S1	4.96 ± 0.79	0.21	S1–S2 = 1.00	NS
	S2	4.96 ± 0.79	0.21	S2–S3 = 0.001	S
	S3	5.82 ± 0.79	0.21	S3–S1 = 0.001	S
Coronal disk position—right**	S1	−0.42 ± 4.50	1.2	S1–S2 = 1.00	NS
	S2	−0.42 ± 4.50	1.2	S2–S3 = 1.00	NS
	S3	−0.42 ± 4.50	1.2	S3–S1 = 1.00	NS
Coronal disk position—left**	S1	−0.42 ± 4.50	1.2	S1–S2 = 1.00	NS
	S2	−0.42 ± 4.50	1.2	S2–S3 = 1.00	NS
	S3	−0.42 ± 4.50	1.2	S3–S1 = 1.00	NS

*Distribution is non-normal; **we computed mean ± SD for these variables instead of median (IQR) as it was coming to be 0

sufficient enough to relieve the condyle from its backward position. An augmented effort in the form of a functional appliance is also needed to position the condyle in a normal position. At S3, all the patients showed the anterior movement of the condyle, indicating that the mandible had shifted anteriorly after twin block functional appliance therapy.

We couldn't find significant alteration in the eminence angle throughout all the stages of treatment (Table 2). A possible explanation could be the short time period of evaluation which was maximum of 9–15 months.

Significant posterior movement of meniscus (Table 2) with prefunctional orthodontics (S1–S2) indicates the utmost importance of this phase. Prefunctional orthodontics not only corrects incisor guidance and facial esthetics of the patients but also normalizes meniscus position, which is a largely ignored criteria of the success of this phase. Significant posterior movement of meniscus with twin block (S2–S3) indicates that the functional appliance was effective to bring favorable changes in the meniscus position, which is otherwise placed anteriorly. Meniscus was displaced en masse during therapy without losing its morphology. Comparative studies among div 1 patients conducted by Wadhawan et al. supported our finding,[12] while Foucart et al. showed contradicted results.

The comparison of superior joint space between the S1 and S2 stages on both sides did not show any statistically significant differences. This finding indicates that the prefunctional orthodontics alone is not sufficient to unlock the mandible/condyle, which is superiorly placed in patients with div 2. Functional appliance (twin block in our study) is also needed for the complete unlocking of the mandible, as suggested by findings between S2 and S3 stages and correspondingly between S1 and S3 stages.

The linear measurement from c-EAM to c-CH showed anterior condylar movement (Table 3). Our observations are in sync with those reported by Wadhawan et al.[12]

The measurement from c-EAM to the c-PGS disclosed no forward movement between stages S1 and S2, while forward movement between S1 and S3 (0.86 mm) and S2 and S3 (0.86 mm) were statistically significant (Table 3). These findings are matching with those of Voudouris et al. and Wadhawan et al.[12,19,20] Thus, the anteroinferior relocation of the glenoid fossa appears to contribute to the complex biomechanics that happens during the correction of mandibular retrognathism after insertion of functional appliances.

The position of the meniscus did not change with respect to the condyle in the coronal section during prefunctional and functional, which is a concordant finding with Chintakanon et al.[15] and Wadhawan et al.[12]

As this is the first-ever longitudinal study conducted among div 2 patients using MRI scans, so we could only compare our findings between stages S2 and S3 with the existing literature on div 1. Despite of small sample size, the findings are obvious and significant. Long-term, prospective, and sufficiently powered studies should be carried out to validate the findings of our study.

In the present scenario, the first treatment line in patients with div 2 includes the opening of a deep bite along with correction of maxillary incisors, which converts div 2 to div 1 first, and then conventional correction of div 1 malocclusion is applied. Through this paper, we aim to motivate innovative treatment appliances

Table 4: Internal consistency coefficient as measure of agreement between two researchers

		Stages		
Variables		*S1*	*S2*	*S3*
Angular measurements				
Sagittal concentricity	Right	1	1	1
	Left	1	1	1
Eminence angle with respect to PC plane	Right	0.999	0.997	0.997
	Left	0.999	0.999	1
Eminence angle with respect to FH plane	Right	1	1	0.998
	Left	1	1	0.998
Anterior band of disk with respect to PC plane	Right	1	1	1
	Left	1	1	1
Anterior band of disk with respect to FH plane	Right	1	1	1
	Left	1	1	1
Posterior band of disk with respect to PC plane	Right	1	1	1
	Left	1	1	1
Posterior band of disk with respect to FH plane	Right	1	1	1
	Left	1	1	1
Glenoid fossa angle	Right	1	0.999	0.999
	Left	0.999	0.999	0.976
Linear measurements				
Superior joint space	Right	0.999	0.996	1
	Left	0.997	0.998	1
Linear glenoid fossa displacement (c-CH)	Right	0.999	0.999	1
	Left	0.999	0.998	0.999
Linear glenoid fossa displacement (PGS)	Right	0.998	0.998	0.999
	Left	0.999	0.999	0.999
Mean coronal disk position	Right	1	1	1
	Left	1	1	1

which can reduce the total treatment duration for the correction of div 2 malocclusion along with better patient outcomes.

Conclusion

Posterior condylar (PC) position and anterior meniscus position in the sagittal plane were prominent findings at baseline in class II div 2 malocclusion. Statistically significant anterior displacement had occurred in the condylar position after prefunctional orthodontics and twin block functional appliance therapy. The meniscus had significantly shifted posteriorly, relative to the condyle, with an increase in the superior joint space and an anterior shift of 1.07 mm of condyles after functional appliance therapy as compared to baseline. Linear glenoid fossa (PGS) assumed a forward position by 0.86 mm between pretreatment and postfunctional stages significantly. Within the constraints of the present study, we can conclude that prefunctional orthodontics induced favorable changes in TMJ soft and hard tissues of patients with div 2, but they were not sufficient to place the soft and hard tissues in their normal positions. A functional appliance phase is also needed to place the TMJ soft and hard tissues in their respective normal positions.

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