# Comparative evaluation of fixed twin block versus mandibular protraction II appliance on condylar position using Gelb's grid: a Cephalometric Study

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*Abstract*—Introduction: Functional appliances play a pivotal role in the orthopaedic correction of skeletal Class II malocclusions during growth. Assessing their impact on skeletal parameters and condylar position is essential for determining treatment efficacy and appliance selection. Objectives: To compare skeletal changes and condylar repositioning following treatment with Fixed Twin Block and Mandibular Protraction Appliance (MPA II) using Gelb's grid on lateral cephalograms. Materials and Methods: This retrospective study analysed pre- and post-treatment lateral cephalograms of 40 growing Class II patients treated with either Fixed Twin Block (n = 20) or MPA II (n = 20). Skeletal changes were assessed using ANB angle and Witts appraisal, while condylar position was evaluated using Gelb's grid. Descriptive statistics, paired and independent t-tests, and percentage comparisons were performed using SPSS v23.0, with $p < 0.05$ considered statistically significant. Results: Both groups showed significant improvement in sagittal parameters. The Twin Block group demonstrated greater mean reductions in ANB (–2.35° ± 0.88) and Witts (–1.65 ± 0.93 mm) compared to the MPA group (–1.85° ± 0.81; –1.40 ± 0.82 mm). Anterior condylar shift was more frequently observed in the Twin Block group (50%) than in the MPA group (30%). Conclusion: Both appliances were effective, but the Fixed Twin Block demonstrated more significant skeletal and condylar changes. Conclusion: Both appliances effectively enhanced mandibular positioning, but the Fixed Twin Block produced more pronounced skeletal and condylar changes. It may be the preferred option in cases requiring significant orthopaedic correction.

*Index Terms*—Class II malocclusion, Fixed Twin Block, MPA II, Condylar position, Gelb's grid

## I. INTRODUCTION

Fixed functional appliances are a cornerstone in the non-surgical management of skeletal Class II malocclusion, exerting continuous sagittal orthopaedic forces to advance the mandible and stimulate adaptive remodelling of the temporomandibular joint (TMJ) complex [1]. By positioning the lower jaw forward, these appliances enhance condylar cartilage mitotic activity and promote endochondral ossification, leading to both positional and structural changes that improve maxillomandibular relationships and long-term stability [1,2]. Recent cone-beam computed tomography (CBCT) studies have compared various systems—such as the Forsus and PowerScope—to evaluate differences in condylar shifts and sagittal skeletal correction; Kumawat et al. found a slightly greater forward condylar shift with Forsus compared to PowerScope, highlighting subtle inter-appliance variability in skeletal response [3]. Meanwhile, Mandibular Protraction Appliance (MPA II) and Fixed Twin Block therapy remains less documented.

Gelb's grid is a validated, reproducible method for assessing sagittal condylar position on lateral cephalograms, dividing the cranial base into standardized zones that correspond to concentric (4/7), posterior (5/8), or anterior condylar locations [6]. Its simplicity and low radiation exposure make it especially valuable in retrospective studies where CBCT data may not be available. By overlaying a transparent grid on cephalometric tracings, clinicians can categorize the condylar head's spatial relationship within the glenoid fossa and detect subtle positional shifts following functional therapy. Previous research has demonstrated high intra- and inter-examiner

reliability for Gelb's grid assessments, and its findings correlate well with three-dimensional imaging modalities, thereby justifying its use in this study to quantify condylar adaptations induced by Fixed Twin Block versus MPA II treatment [4,7].
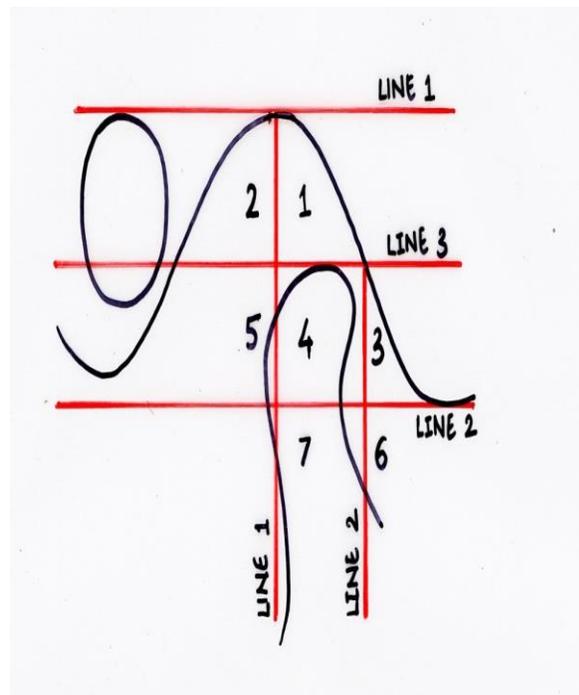


Fig. 1- Gelb's grid

Vankadara et al. reported CBCT-based condylar position assessments using Gelb's grid but did not directly compare MPA outcomes to those of Herbst or other rigid appliances [4]. Furthermore, although changes in ANB angle and Wit's appraisal are well-established metrics for quantifying sagittal correction, the correlation between condylar repositioning and improvements in these angular and linear parameters has not been fully elucidated for MPA therapy [5].

Given the retrospective availability of lateral cephalograms in routine clinical archives, this study seeks to perform a comparative analysis of Fixed Twin Block and MPA interventions by assessing pre- and post-treatment ANB angle, Wit's appraisal, and condylar zone shifts on Gelb's grid. Such an investigation will clarify whether the rigid Herbst appliance confers superior sagittal and TMJ adaptations compared to MPA, and will inform appliance selection tailored to individual growth patterns and treatment goals. Therefore, this study aims to retrospectively evaluate and compare condylar position changes, ANB angle reduction, and Witts's appraisal improvements in growing Class II patients treated with Fixed Twin Block and MPA II therapy.

## II. MATERIALS AND METHODS

The sample consisted of 40 growing patients (mean age $12.8 \pm 2.8$ years) with skeletal Class II malocclusion who were treated with Fixed twin block therapy (n=20) and MPA II (n=20) were retrospectively selected from the archives of KLE VK Institute of Dental Sciences.

INCLUSION CRITERIA:
Patients with skeletal Class II malocclusion aged 11–14 years at appliance insertion, with an ANB angle greater than 4° and Witts's appraisal exceeding 2 mm and having high-quality pre- and post-functional lateral cephalograms

EXCLUSION CRITERIA:
Patients with skeletal Class I or Class III malocclusion, craniofacial syndromes, systemic growth disorders, history of TMJ pathology, incomplete records, or use of any other functional appliances were excluded.

The pre- and post-treatment cephalograms were scanned at 1:1 magnification and imported into Dolphin 2D software for standardization before hand-tracing on acetate by a single calibrated examiner. 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. The Gelb's Grid was then constructed and the pre- and post-treatment condylar positions were recorded, and changes were correlated with ΔANB and ΔWitts. Intra-examiner reliability was confirmed by re-tracing 10% of radiographs after two weeks (ICC > 0.90), and institutional review board approval with a waiver of consent was obtained for this anonymized retrospective analysis.
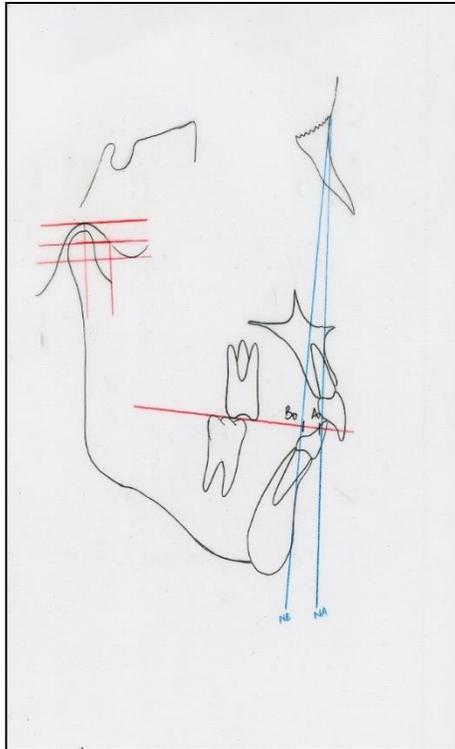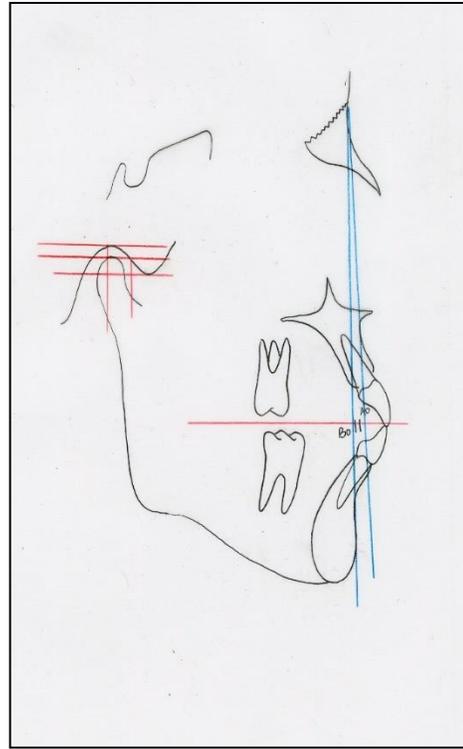
Fig 5-Pre-treatment tracing with Gelb's grid



Fig 6-Post functional tracing with Gelb's grid

## III. RESULTS

The study included 20 subjects in each appliance group. The Fixed Twin Block group had a mean age of $13.55 \pm 1.61$ years, whereas the MPA group had a mean age of $15.55 \pm 1.39$ years.

Table 1: Group Summary Statistics

| Appliance Type | N | Mean Age (years) | SD Age | Mean ΔANB (°) | SD ΔANB | Mean ΔWITTS (mm) | SD ΔWITTS |
|---|---|---|---|---|---|---|---|
| Fixed Twin Block | 20 | 13.55 | 1.61 | -2.35 | 0.88 | -1.65 | 0.93 |
| Mandibular Protraction Appliance (MPA) | 20 | 15.55 | 1.39 | -1.85 | 0.81 | -1.4 | 0.82 |

Table 2 show the skeletal changes seen in terms of ANB and Witts Appraisal. The Fixed Twin Block group (mean age $13.55 \pm 1.6$ years) achieved significantly greater sagittal skeletal correction than the Mandibular Protraction Appliance (MPA) group (mean age $15.55 \pm 1.4$ years). Specifically, Twin Block therapy produced an average ANB angle reduction of $2.35° \pm 0.88$ and a Wits appraisal improvement of $1.65 \pm 0.93$ mm, whereas the MPA group demonstrated more modest changes (ANB $-1.85° \pm 0.81$; Wits $-1.40 \pm 0.82$ mm).

Table 2: Skeletal parameter changes

| Parameter | Fixed Twin Block (Mean ± SD) | MPA (Mean ± SD) |
|---|---|---|
| ΔANB (°) | −2.35 ± 0.88 | −1.85 ± 0.81 |
| ΔWITTS (mm) | −1.65 ± 0.93 | −1.40 ± 0.82 |

Table 3 shows Condylar Head Shift Distribution (%) Gelb's grid analysis of condylar position paralleled these results: 50% of Twin Block patients exhibited a significant anterior condylar shift, reflecting significant TMJ adaptation, compared to just 30% in the MPA group. Slight anterior shifts occurred in 20% of Twin Block versus 30% of MPA cases, while stable condylar positioning was noted more frequently among MPA patients (40% vs. 30%).

Table 3: Condylar head shift distribution (%)

| Appliance Type | Significant Anterior Shift (%) | Slight Anterior Shift (%) | Stable (%) |
|---|---|---|---|
| Fixed Twin Block | 50.0 | 20.0 | 30.0 |
| Mandibular Protraction Appliance (MPA) | 30.0 | 30.0 | 40.0 |

These findings suggest that, although both appliances effect favourable skeletal change, the Twin Block appliance not only yields greater sagittal correction but also induces more pronounced remodelling of the mandibular condyle.

## IV. DISCUSSION

The present retrospective analysis confirms that Fixed Twin Block therapy produces more substantial sagittal and temporomandibular adaptations than Mandibular Protraction Appliance (MPA) treatment in growing Class II patients. The Fixed Twin Block group showed a greater mean reduction in ANB angle (2.35°) and Wits appraisal (1.65 mm) than the MPA group (1.85° and 1.40 mm, respectively), indicating more pronounced skeletal correction. These findings are consistent with earlier studies by Baccetti et al. and Marsico et al., which demonstrated that functional appliances are most effective when initiated during the peak pubertal growth spurt, leading to enhanced skeletal remodelling and mandibular advancement [8,9]. Pancherz's foundational work on the Herbst appliance also supports these results, emphasizing its skeletal effects via adaptive condylar remodelling rather than dentoalveolar changes alone [1].

In the present study, Gelb's grid analysis revealed a significant anterior condylar shift in 50% of Twin Block patients versus 30% in the MPA group, consistent with CBCT-based findings by Kumawat et al. and Vankadara et al., who reported measurable condylar repositioning following fixed functional therapy [3,4]. Ruf and Pancherz further validated these adaptations with MRI, demonstrating that functional appliances like the Herbst and Twin Block can induce favourable TMJ remodelling [2]. The higher frequency of stable condylar positioning in the MPA group (40% vs. 30%) suggests that MPA may act more through dentoalveolar effects and neuromuscular adaptation than skeletal transformation—an observation echoed by Tariq et al. and Souki et al. [5,10].

Notably, the younger mean age of the Fixed Twin Block group (13.6 years) likely contributed to greater growth responsiveness, in agreement with McNamara's and Proffit's etiological explanations that highlight the importance of early skeletal intervention in mandibular retrusion [11,12]. Long-term studies by Pancherz and Anehus-Pancherz have also shown that early functional treatment not only advances the mandible but contributes to sustained skeletal corrections and improved TMJ harmony [13,14]. Additionally, studies by Al-Hadad et al. and Zhang et al. underscore that significant condylar changes occur primarily during active skeletal growth, with minimal risk of relapse if timing and appliance selection are appropriate [15,16].

The current study employed Gelb's grid to assess sagittal condylar position changes using standardized lateral cephalograms. Despite being a two-dimensional method, Gelb's grid has demonstrated high reproducibility and clinical reliability in previous investigations, with our study also yielding excellent intra-examiner agreement (ICC > 0.90). Soni et al. and Durão et al. have supported its application for large-

scale studies where CBCT may not be feasible, particularly when ethical constraints limit radiographic exposure in growing patients [7,17].

In clinical terms, these results suggest that the Twin Block appliance is more effective than MPA in producing favourable skeletal and TMJ outcomes when used at the optimal growth phase. For future research, prospective randomized controlled trials with larger, multi-centre cohorts, and integration of three-dimensional imaging modalities (such as CBCT or MRI) are recommended to further validate the diagnostic sensitivity of Gelb's grid, assess its accuracy in multiple planes, and examine long-term post-treatment condylar stability.

## V. CONCLUSION

The findings of this retrospective study demonstrate that both Fixed Twin Block and Mandibular Protraction Appliance (MPA II) therapies effectively contribute to sagittal correction in growing Class II malocclusion patients. However, Fixed Twin Block therapy resulted in significantly greater improvements in ANB angle and Witts's appraisal.

Furthermore, Gelb's grid analysis revealed a higher incidence of anterior condylar repositioning in the Fixed Twin Block group, suggesting a more pronounced adaptive response at the temporomandibular joint level.

These outcomes highlight the clinical advantage of early intervention with Fixed Twin Block appliances during peak growth periods to maximize skeletal and condylar adaptations. While both appliances are viable options, the Fixed Twin Block may offer enhanced orthopaedic effects and TMJ remodelling potential.

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