Impact of Occlusal Plane on Facial Soft Tissue Profile in Different Malocclusions: A Cephalometric Study in the Solan Population

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ABSTRACT : Background: Malocclusion poses both esthetic and functional challenges, with the inclination of the occlusal plane having a direct influence on the facial soft tissue profile. While skeletal parameters have been extensively studied, there is limited evidence on how occlusal plane orientation specifically affects soft tissue characteristics such as lip position and facial esthetics. **Objectives:** To evaluate the association between occlusal plane inclination and selected soft tissue parameters—upper lip position, lower lip position, nasolabial angle, and Z-angle—in Class II and Class III sagittal malocclusions in the Solan population. **Materials and Method:** A total of 100 pretreatment lateral cephalometric radiographs (50 Class II, 50 Class III) of patients aged 18–35 years were retrospectively analyzed. Patients were selected using convenience sampling. Exclusion criteria included prior orthodontic treatment, craniofacial anomalies, systemic conditions affecting growth, and incomplete records. Cephalometric analysis assessed skeletal discrepancies, occlusal plane inclination, and soft tissue parameters. Data were statistically analyzed to identify correlations. **Results & Conclusion:** Class II patients showed significantly higher SNA and ANB angles, while Class III had greater SNB, FMA, and Z-Angle values. Strong correlations between skeletal and occlusal parameters suggest occlusal plane orientation plays a critical role in facial profile assessment and treatment planning.

Keywords: occlusal plane, soft tissue profile, sagittal malocclusions.

INTRODUCTION

Class II malocclusions are often characterized by a retrusive mandible, whereas Class III malocclusions involve a protrusive mandible relative to the maxilla, leading to an underbite. Both conditions can significantly impact the soft tissue profile, influencing facial aesthetics profoundly.[1] The occlusal plane is an imaginary surface defined by the incisal edges of the incisors and the cusp tips of the posterior teeth, serving as a critical reference for the relationship between skeletal structures and soft tissue contours.[3]

The orientation of the occlusal plane is crucial in defining jaw positioning and consequently the facial profile .The spatial position and inclination of the occlusal plane in the lower face influences the functional position of the mandible.[4]

Variations in this plane can lead to significant changes in both hard and soft tissue structures, which are particularly pronounced in individuals with different classes of sagittal malocclusion. For instance, an altered occlusal plane angle in Class III malocclusion, typically characterized by a prognathic mandible, can influence the soft tissue profile, leading to aesthetic and functional discrepancies.[5] Recent studies highlight the impact of occlusal plane orientation on the soft tissue profile. For instance, a study by **Mahmood (2023)** demonstrates how orienting the occlusal plane using high-tech orthodontic appliances can improve dental, skeletal, and soft tissue parameters, emphasizing the need for precise control in orthodontic planning.[6] **Alqahtani et al., (2020)**, found that patients with bimaxillary protrusion who underwent extraction of the four second premolars and subsequent retraction of the anterior teeth exhibited profound soft tissue alterations.[6]

In the field of orthodontics, the manipulation of the occlusal plane is emerging as a crucial technique for improving facial aesthetics, particularly in patients with sagittal malocclusions. Remarkably, with the booming progression of computer technology, machine learning has gained reputation for its characteristics as self-adaptive, self-learning and high accuracy, which could not only outweigh traditional tactics by its effectiveness.[7] Notably, a recent study by **Cai et al. (2024**) utilized a back-propagation artificial neural network (BP-ANN) to assess how occlusal plane rotations can lead to aesthetic improvements, showcasing significant results especially among diverse skeletal types.[7]

Despite these advances, most existing data are derived from non-Indian populations. Craniofacial morphology and soft tissue responses vary across ethnic groups and geographic regions, and findings from other populations cannot always be generalized. The Solan population is of particular interest because of its distinct ethnic composition and skeletal patterns, which have not yet been systematically studied. Establishing baseline cephalometric data for this population will provide valuable insights for region-specific diagnosis and orthodontic treatment planning.

Therefore, the present study aims to evaluate the effect of occlusal plane orientation on soft tissue parameters in Class II and Class III sagittal malocclusions in the Solan population, using cephalometric analysis.

MATERIALS AND METHOD

This retrospective study was conducted in a postgraduate orthodontics and dentofacial orthopedics department located in Himachal Pradesh. The study focused on investigating the effects of occlusal plane adjustments on the soft tissue profiles of individuals diagnosed with Class II and Class III malocclusions from the Solan region. The study included a total of 100 patients who had visited the orthodontic department. These patients were chosen according to predefined inclusion and exclusion criteria.

Inclusion Criteria

- Individuals diagnosed with Class II malocclusion (ANB $\geq 4^0$).
- Individuals diagnosed with Class III malocclusion (ANB $\leq 0^0$).
- Ages between 18 and 35 years
- High-quality lateral cephalograms.

Exclusion Criteria

- Previous history of orthodontic treatment.
- Craniofacial syndromes, congenital anomalies, or severe systemic diseases that could affect craniofacial growth.

The lateral radiographs of the patients were taken in natural head position (NHP).The radiographs were traced on standard cephalometric sheets by a single operator. All the landmarks and planes were identified and marked. (TABLE 1, 2) Various parameters to check the occlusal plane in all the 2 groups. (TABLE 3). (Figure 1) Reference planes evaluated are shown in Figure 2. (See Figure 3 for measured parameters)

Reliability check: To assess intra-examiner reliability, 20 cephalograms were randomly re-traced and re-measured after two weeks. Intra-class correlation coefficients (ICC) exceeded 0.90 for all parameters, confirming excellent measurement consistency.

Statistical Analysis

Statistical analyses were conducted using SPSS software (Version 26, IBM Corp). Descriptive statistics, including means and standard deviations, were calculated for each parameter to provide a summary of the data collected. An Independent T-test was employed to compare the means of the cephalometric parameters between the 2 Classes.

RESULTS

A total of 100 pretreatment cephalograms (50 Class II, 50 Class III) were analyzed. Descriptive statistics (mean ± SD) and group comparisons are presented in Tables 4 and 5.

Skeletal Parameters:

Class II patients exhibited significantly higher SNA (84.73 ± 3.52) compared to Class III patients (79.88 ± 4.81, $p < 0.001$), reflecting maxillary protrusion. Conversely, SNB was significantly greater in Class III (82.70 ± 4.36) than Class II (78.55 ± 3.47, $p < 0.001$), indicating mandibular prognathism. The ANB angle was also significantly higher in Class II (6.29 ± 1.69) versus Class III (-2.82 ± 2.26, $p < 0.001$), confirming sagittal discrepancies.

Vertical Parameters:

FMA was significantly higher in Class III (26.88 ± 6.82) compared to Class II (22.88 ± 5.98, $p = 0.012$), suggesting a more hyperdivergent growth pattern. Similarly, IMPA was significantly higher in Class II (99.61 ± 9.04) compared to Class III (88.26 ± 7.38, $p < 0.001$), reflecting differences in lower incisor inclination.

Soft Tissue Parameters:

The Z-Angle was significantly greater in Class III (79.97 ± 6.76) than Class II (70.32 ± 7.03, $p < 0.001$), indicating a more concave soft tissue profile in Class III patients.

Non-Significant Parameters:

No statistically significant differences were found for OCC-SN, OCC-FH, OCC-MP, Go-Angle, Y-Axis, or Facial Axis ($p > 0.05$), suggesting relative stability of occlusal plane orientation across sagittal malocclusion types.

Correlations:

Pearson correlation analysis revealed that in Class II malocclusions, SNA correlated positively with SNB ($r = 0.673$, $p < 0.001$) and ANB ($r = 0.413$, $p = 0.044$). In Class III malocclusions, SNA strongly correlated with SNB ($r = 0.848$, $p < 0.001$) and ANB ($r = 0.428$, $p = 0.031$). Additional correlations between vertical and dental parameters are detailed in Tables 6 and 7.

Discussion

This study evaluated the influence of occlusal plane orientation on soft tissue parameters in Class II and Class III malocclusions in the Solan population. Significant differences were observed in SNA, SNB, ANB, FMA, IMPA, and Z-Angle between the two groups, whereas occlusal plane parameters relative to cranial planes (OCC-SN, OCC-FH, OCC-MP) showed no statistically significant differences.

In the present study, SNA angle was found to be significant when compared between Class II and Class III. Class II patients had a higher SNA than Class III patients, an increased SNA suggests a more protrusive maxilla. ***Ardani et al. (2020)***[2] underscore the importance of this angle in diagnosing maxillary protrusion characteristic of Class II. A study by ***Taloumtzi et al. (2020)***[8]on skeletal growth in Class II malocclusion from childhood to adolescence found that the SNA angle generally increases slightly over time, but this change is often minor compared to the more significant changes in the SNB angle. This suggests that while the SNA angle is an important diagnostic measure, its changes are less pronounced during growth phases than other parameters like SNB. Conversely***, Halimi et al. (2011)***[9] caution that relying solely on the SNA might overlook other crucial craniofacial structures, advocating for a more comprehensive assessment to avoid diagnostic oversights. The SNB angle was found to be significant when compared between 2 Classes. Class III patients had a higher SNB .This elevation in the SNB angle suggests a more protrusive mandible, which is crucial for evaluating the mandible's anteroposterior positioning and differentiating between Class II and Class III malocclusions. ***Zere et al. (2018)***[1]delve into the clinical consequences and management approaches for higher SNB angles in Class III malocclusion cases. A study by ***El-Huni et al. (2023)***[10] comparing Twin Block and Myobrace appliances for treating Class II malocclusions noted significant changes in the SNB angle, especially with growth-promoting appliances. This highlights the importance of the SNB angle in evaluating and planning orthodontic interventions for Class II malocclusions The ANB angle was found to be significant and was higher in Class II than in Class III indicating a maxillary protrusion relative to the mandible. This finding aligns with ***Ardani et al. (2020),*** who reported a strong association of high ANB with more severe Class II discrepancies. ***McNamara (1984)***[11]***,*** however, warns that the ANB angle's sensitivity to nasion positioning can lead to misleading assessments, recommending additional parameters for a more reliable diagnosis. The FMA angle was found to be significant and Class III had a higher value than Class II suggesting a more pronounced downward and backward mandibular growth pattern typical of this malocclusion. ***Tanaka and Sato (2008)***[4] confirm the correlation between increased FMA and hyperdivergent growth patterns in Class III malocclusion. Research by ***Li et al. (2023)***[12] focusing on the classification and characterization of Class III malocclusions in a Chinese population found that different subtypes of Class III malocclusion showed varied FMA angles, which correspond to different growth patterns. This study emphasized that the FMA angle is crucial for understanding vertical growth patterns and making informed treatment decisions. The IMPA was found to be significant and was higher in Class II than in Class III, measuring the orientation of the lower incisors relative to the mandibular plane. Lower IMPA values in Class III malocclusions indicate less protrusive lower incisors, integral to aesthetic and functional outcomes in orthodontics, as discussed by ***Gandhi et al. (2017).***[13] ***Yet, Cai et al. (2024)*** argue that a sole focus on IMPA overlooks the complex three-dimensional interactions of dental and skeletal components, advocating for a more holistic approach to orthodontic modeling. The Z-Angle, which assesses skeletal discrepancies through the relationship of the zygomatic bone to the maxillary and mandibular structures, is significantly higher in Class III, indicating severe skeletal discrepancies**.** ***Jacobson (2006)*** highlights the diagnostic value of the Z-angle in assessing the skeletal framework. However, ***Cai et al. (2024***) note that interpretations of the Z-angle can vary greatly with racial and ethnic differences, suggesting a careful consideration of these factors in clinical assessments. Similarly, the FMIA showed significant differences between Class II and Class III malocclusions, with Class III patients exhibiting a higher FMIA. This indicates a greater proclination of the lower incisors in Class III malocclusions, which may serve as a compensatory adjustment to the prognathic mandible typically observed in these patients. Moreover, the study by ***Li et al. (2023)*** emphasizes the variability of FMIA among different subtypes of Class III malocclusion, suggesting that individualized treatment approaches are essential based on specific FMIA readings, Conversely, ***Cai et al. (2024***) argue for a broader consideration of FMIA within the context of three-dimensional cephalometric analysis to better understand its role in facial aesthetics and orthodontic treatment outcomes.The OCC-SN was found to be non-significant when compared between groups because despite different anteroposterior relationships of the jaws in Class II and Class III malocclusions, the overall orientation of the occlusal plane relative to the cranial base remains similar across these classes, suggesting that the occlusal plane maintains a relatively stable position. Research by ***Şenışık and Hasipek (2015)*** supports that variations in occlusal cant are influenced more by individual anatomical adaptations than by the specific class of malocclusion. The OCC-FH was found to be non-significant when compared between groups because the orientation of the occlusal plane relative to the Frankfort Horizontal Plane is stable across malocclusion types, likely due to similar compensatory mechanisms across different skeletal patterns, a finding supported by machine learning studies in orthodontics (***Cai et al., 2024***). The OCC-MP was found to be non-significant when compared between groups because the relationship between the occlusal and mandibular planes remains consistent, influenced by uniform mandibular growth patterns as noted by ***Tanaka & Sato (2008)***[4]. The Go-Angle was *found to be non-significant when compared between groups because the variation in the gonial* angle, which primarily reflects the mandibular shape and overall facial growth, is not distinct enough to differentiate between the malocclusion classes, as observed by ***Zere et al. (2018)***. The Y-Axis was found to be non-significant when compared between groups because it represents the direction of mandibular growth, which is influenced more by individual vertical growth patterns than by the sagittal classification, though ***Cai et al. (2024)*** suggest further investigation into its impact on facial profiles. Lastly, Facial-Axis was found to be non-significant when compared between groups because the overall direction of facial growth, influenced by a complex interplay of factors, remains similar in both Class II and Class III malocclusions, with ***McNamara (1984)*** noting the stability of the facial axis across different facial types, while ***Zere et al. (2018)*** argue that distinct growth patterns in different malocclusion types could lead to significant findings in other studies. These findings suggest that while these parameters are essential for understanding malocclusion, they may not be critical in differentiating between Class II and Class III malocclusions, as also supported by Malkoc et al. (2005), who examined occlusal plane variations across skeletal growth patterns. This is further supported by the findings of ***Yohana et al. (2020)***[14] who demonstrated significant occlusal plane inclination changes during Class II treatment.

For *Class II malocclusion*, there was a strong positive correlation between SNA and SNB, indicating that as maxillary protrusion increases, mandibular protrusion also tends to decrease. This relationship reflects the anteroposterior discrepancies essential for understanding and correcting Class II malocclusions. In a study by ***Ardani et al. (2018)***, skeletal Class II malocclusions with anteroposterior skeletal discrepancies are characterized by a large ANB, reflecting the malrelationship between the maxilla and mandible. ***Ardani et al. (2018)*** also reported a similar strong correlation coefficient. A notable strong positive correlation was observed between SNA and ANB, suggesting that as maxillary protrusion increases, the anteroposterior discrepancy between the maxilla and mandible also tends to rise, which is crucial for devising treatment strategies to address these discrepancies. Similarly, a strong positive correlation between FMA and the Go-Angle demonstrates that changes in the mandibular plane angle are closely linked to adjustments in the Gonial angle, reflecting the relationship between mandibular rotation and overall jaw growth. Conversely, negative correlations such as between FMA and FMIA and IMPA and OCC-SN indicate that increases in the mandibular plane angle are associated with decreases in the mandibular incisor axis, impacting both the aesthetics and functionality of the occlusion.

For *Class III malocclusion*, a very strong positive correlation between SNA and SNB was observed, indicating a significant interrelationship between the maxillary and mandibular bases, which is especially pronounced in Class III cases. Furthermore, the positive correlations between FMA and both the Go-Angle and Y-Axis highlight the influence of the mandibular plane angle on vertical growth patterns and the direction of mandibular growth. Notably, a strong negative correlation between FMIA and IMPA was observed, suggesting that as the mandibular incisors become more upright (decrease in IMPA), there is a corresponding increase in the incline of the mandibular incisors relative to the mandibular plane (increase in FMIA). Additionally, the study identified a significant negative correlation between the occlusal plane (OCC-SN) and the Frankfurt horizontal plane (OCC-FH) in Class III malocclusion, recorded. ***Ardani et al. (2018)*** noted a similar negative correlation for Class II malocclusion. The Y-Axis was higher for Class II than in Class III . According to ***Ardani et al. (2018)***, an increasing Y-Axis indicates vertical growth of the mandible, with a standard Y-Axis value in normal conditions ranging between 53 and 66

This study has underscored the significant cephalometric differences between Class II and Class III malocclusions, highlighting the essential role of angles such as SNA, SNB, and ANB in diagnosing and treating these conditions. The distinct variations in these parameters are consistent with previous research, including studies by ***Ardani et al. (2020) and Zere et al. (2018)***, which have shown how these measurements are vital for understanding the relationships between the maxilla and mandible. Additionally, the strong correlations found between various parameters within each malocclusion class reveal the complexity of craniofacial growth patterns. This complexity is further supported by studies like those of ***Tanaka and Sato (2008)*** and ***Li et al. (2023)***, which stress the importance of considering both vertical and anteroposterior dimensions in orthodontic diagnosis and treatment planning

Conclusion

1. This study demonstrated that while sagittal and vertical skeletal parameters (SNA, SNB, ANB, FMA, IMPA) and soft tissue profile measures (Z-Angle) differ significantly between Class II and Class III malocclusions in the Solan population, occlusal plane orientation remains relatively stable across groups.
2. Clinically, orthodontists should recognize that skeletal and soft tissue discrepancies in this population may be more pronounced than in other ethnic groups, underscoring the importance of using population-specific cephalometric norms rather than relying solely on generalized values. Treatment planning should therefore emphasize correction of sagittal and vertical discrepancies, with less focus on altering occlusal plane inclination unless required for esthetic harmony.
3. Future studies integrating digital tools and machine learning could further refine diagnostic accuracy and improve prediction of treatment outcomes in this population

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