www.ajohas.com

Asian Journal of Oral Health and Allied Sciences

Original Article

A photographic evaluation of smile characteristics in different dental and skeletal patterns: A cross-sectional study

Richa Ahlawat[1], Ragni Tandon[1], Kamlesh Singh[1], Ashish Chauhan[1]

[1]Department of Orthodontics and Dentofacial Orthopedics, Saraswati Dental College, Lucknow, Uttar Pradesh, India.

***Corresponding author:**
Dr. Richa Ahlawat,
Department of Orthodontics and Dentofacial Orthopedics, Saraswati Dental College, Lucknow, Uttar Pradesh, India.

dr.richaahlawat@gmail.com

Received: 11 June 2025
Accepted: 20 July 2025
Published: 11 September 2025

DOI
10.25259/AJOHAS_18_2025

Quick Response Code:

ABSTRACT

Objectives: The aim of this study was to assess smile characteristics – maxillary incisor display, upper lip length (ULL), and gingival display – in individuals with Class I and Class II malocclusions across normodivergent, hyperdivergent, and hypodivergent skeletal growth patterns.

Material and Methods: A total of 102 participants (aged 15–25 years) were enrolled. Molar relationship determined Class I versus Class II; cephalometric measurements (Sella-Nasion to Mandibular Plane, Frankfurt Mandibular Plane angle, and Jarabak ratio) classified skeletal patterns. Videography captured posed smiles, and static frames were selected to measure (1) maxillary incisor display at rest and on smiling, (2) ULL at rest and on smiling, and (3) gingival display on smiling. Data analysis used Statistical Package for the Social Sciences (v. 20), with significance set at $P < 0.05$.

Results: Hyperdivergent individuals showed significantly greater incisor display at rest and on smiling ($P = 0.001$) and shorter ULL on smiling ($P = 0.001$) compared to normodivergent and hypodivergent groups. Gingival display was higher in hyperdivergent participants but not significantly ($P = 0.387$). No significant differences were observed between Class I and Class II malocclusions ($P > 0.05$).

Conclusion: Vertical growth patterns, particularly hyperdivergence, are associated with increased incisor display, shorter ULL on smiling, and greater gingival display. Sagittal classification alone did not significantly affect these characteristics. Orthodontic treatment planning should prioritize skeletal growth pattern assessment to optimize smile esthetics.

Keywords: Malocclusion, Orthodontics, Skeletal growth patterns, Smile analysis, Videography

INTRODUCTION

The smile, often described as a gateway to interpersonal communication and social interaction, significantly shapes facial attractiveness. In today's society, an appealing smile is seen as a valuable asset in professional and social settings, influencing facial expression and appearance.[1] Enhancing facial and dental esthetics is a major motivation for seeking orthodontic treatment.[2] Modern orthodontics goes beyond correcting malocclusion, adopting a holistic approach that considers the entire face and impacts demeanor and well-being.[3]

Smiles are categorized into posed (social) and unposed (Duchenne) types based on voluntary or involuntary orofacial muscle engagement.[4] A posed smile, being voluntary, is emotionless,

static, reproducible, and ideal for analysis.[5,6] In contrast, an unposed smile, arising from genuine joy, is fleeting and dynamic, often with greater lip elevation,[5] but less consistent for measurement.[6]

Smile esthetics are now central to orthodontic diagnosis and treatment planning.[7] Smile analysis considers patient expectations and involves dental, skeletal, and soft-tissue elements in static and dynamic positions.[8] Conventionally, static photographs were used,[9] but capturing an authentic smile in a single image is challenging due to variability of expressions.[10] Innovations in videographic and computer technologies have expanded diagnostic capabilities, advocating for videography in smile analysis, as suggested by many authors, which is complied by Maulik *et al*.[11] Videography overcomes the limitations of single-frame photography by recording continuous motion, allowing the selection of reproducible frames to enhance diagnostic accuracy.[12]

While videography has been used to study smiles in various growth patterns – normodivergent, hyperdivergent, and hypodivergent – few studies have included molar relationships. This study bridges that gap using videography to analyze smile characteristics across facial growth patterns and molar relationships (Class I and II), aiming to support tailored orthodontic strategies that enhance both function and esthetics.

MATERIAL AND METHODS

The present cross-sectional study was conducted after obtaining approval from the Institutional Health Ethics Committee (IHEC #SR5OR18042023D) and Institutional Research and Development Committee (IRDC #SR5OR180420230). The study was conducted and reported in accordance with the STROBE guidelines. Written informed consent was obtained from all participants before enrolment. A total of 186 individuals reporting to the outpatient department of Department of Orthodontics and Dentofacial Orthopedics were initially screened. Based on the inclusion and exclusion criteria, 102 (57 females and 45 males) participants were selected. All participants were North Indian individuals residing in and around Lucknow, Uttar Pradesh. The study was conducted from June 2023 to August 2024.

The inclusion criteria included individuals aged 15–25 years, with no prior history of orthodontic treatment, willing to participate, absence of facial anomalies or pathologies, and presence of bilateral Class I and Class II molar relationships. Class II subjects included those with bilateral molar Class II relation without necessarily presenting with full Class II Division 1 or 2 malocclusion traits. The exclusion criteria included participants exhibiting gross facial asymmetry, history of dentofacial trauma, periodontal disease, carious lesions, excessive dental attrition, missing or supernumerary teeth visible during smiling, prosthetic or restorative work in the aesthetic zone, and individuals with lip irregularities or a history of lip surgery.

Sample size was calculated using formula $n = s\frac{S^2(Z1+Z2)^2}{(M1-M2)^2}$ where M1 = 23.36, M2 = 21.10, S1 = 2.35, S2 = 2.23, and the pooled standard deviation (S) was used. The values of Z used were $Z_1-\alpha/2 = 0.95$ for 5% significance level and $Z_1-\beta = 0.8$ for 80% power. Based on these values, the minimum sample size required for the study was 17 per group. Thus, the sample size was set at 102.

Participants were classified into Class I (n = 51) and Class II (n = 51) malocclusion groups based on Angle's molar relationship. Subsequently, standardized lateral cephalograms were obtained using CS 8100SC 3D cone-beam computed tomography (CBCT) scanner from Carestream Dental India Pvt. Ltd. with the exposure settings of 73 kV, 10 mA, and 11 s. For this study, only routine lateral cephalograms acquired as part of standard orthodontic diagnostic records were utilized. No participant was exposed to additional or unnecessary radiation beyond what was clinically indicated.

Each group was further subdivided into normodivergent (n = 17), hyperdivergent (n = 17), and hypodivergent (n = 17) skeletal patterns using cephalometric parameters: Sella-Nasion to Mandibular Plane angle, Frankfurt Mandibular Plane angle, and Jarabak's ratio (S-Go/N-Me × 100) [Figure 1]. Participants were classified into skeletal groups based on agreement in at least two of three cephalometric parameters, following Bishara and Augspurger and Zaher and Bishara, to ensure accurate and consistent skeletal pattern identification.[13,14] Cephalometric landmarks were traced using a film illuminator by the observer, who was specifically trained in cephalometric analysis before the study and measurements were validated by two independent orthodontists to ensure reliability. Although the inter-observer variability was not calculated, any discrepancies were resolved through mutual consensus among the reviewers.

The methodology for videographic recording of dynamic smiles was adapted from established protocols in prior research.[11,12] Participants were seated with the camera positioned three feet away at the level of the occlusal plane. Natural head position was ensured using a mirror placed at eye level. Participants were instructed to lick their lips, swallow, and say "Subject number __, my name is __" followed by a natural smile. Video capture began one second before speech and ended after the smile. Spontaneous smiles were encouraged by narrating jokes.

From each video, two representative frames (posed smile and lips at rest) were extracted using Adobe Premiere Pro.

Only posed smiles were analyzed for standardization and reproducibility. Spontaneous smiles were excluded from final analysis. These frames were cropped to 6 × 4 inches in Adobe Photoshop to focus on the perioral region. Standardization was achieved using a visible 10-mm reference scale and calibrating the ruler tool accordingly.

The following linear parameters were assessed on both posed smile and rest frames using Adobe Photoshop's calibrated measuring tool [Figure 2]:

- Maxillary incisor display at rest: The vertical measurement from the most cervical to the most incisal portion of central incisors visible at rest[15]
- Maxillary incisal display (ID) on smiling: The vertical measurement of the central incisors visible on smiling, from the most cervical portion to the incisal edge[15]
- Gingival display on smiling: The vertical measurement from the most inferior point of the upper lip to the incisal edge, subtracted by the visible crown height[15]
- Upper lip length (ULL) at rest and smiling: The distance from subnasale to stomion superius.[16]

Statistical analysis

Data were compiled using Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) software, version 20.0 (SPSS Inc., Chicago, IL, USA). No missing data were encountered during data collection. Quantitative data were expressed as mean ± standard deviation. Comparative analysis between groups was performed using Student's *t*-test, Chi-square test, and one-way analysis of variance. Tukey's *post hoc* tests assessed differences across growth patterns within each malocclusion group. $P < 0.05$ was considered statistically significant.

RESULTS

The study included 102 participants, comprising 57 females and 45 males, with a mean age of 20.16 ± 4.02 years. All participants were North Indian individuals residing in and around Lucknow, Uttar Pradesh.

No statistically significant differences were observed between Class I and Class II participants in terms of incisor display at rest, ULL, or gingival display ($P > 0.05$). Although the mean incisor display at rest was slightly higher in Class I participants (3.04 ± 2.11 mm) compared to Class II participants (2.68 ± 1.87 mm), this difference was not statistically significant ($P = 0.346$) [Table 1].

In both Class I and II groups, hyperdivergent individuals showed significantly greater incisor display at rest and on smiling ($P = 0.001$), and shorter ULL on smiling ($P = 0.001$). Gingival display was higher in hyperdivergent participants, though differences were not statistically significant ($P = 0.387$) [Tables 2 and 3].

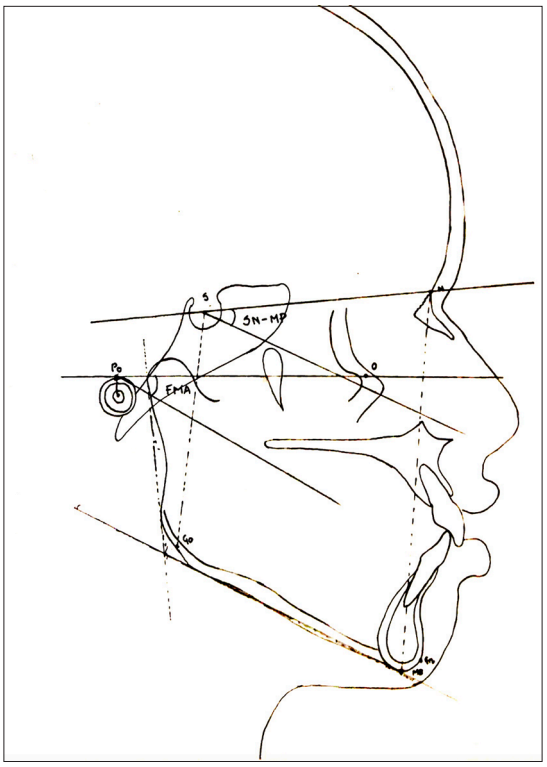

Figure 1: Parameters used for classification of facial patterns – Sella-Nasion to Mandibular Plane, Frankfurt Mandibular Plane angle, and the Jarabak ratio. The Jarabak ratio is calculated as (S-Go/N-Me) × 100, where Go represents the constructed gonion, and N-Me denotes the vertical skeletal height of the face.

Within each growth pattern, no significant differences were found between Class I and Class II participants for any of the smile characteristics ($P > 0.05$) [Table 4].

DISCUSSION

Smile esthetics arises from the intricate interplay of skeletal, dental, and soft-tissue components, encompassing both static and dynamic interactions. While previous research, such as Senthilkumar *et al.*, relied on static photographs to assess smile characteristics, this method has limitations.[8] Static images cannot confirm whether the captured frame truly represents the intended expression, potentially skewing results. In contrast, videography captures continuous motion, providing a more accurate depiction of dynamic smile features, as highlighted by Walder *et al.*[10]

According to Benjasupattananan and Sirikururat, ID at rest is a crucial esthetic parameter, often associated with aging. Class II participants showed slightly reduced ID at rest compared to Class I, though ID during smiling was similar, suggesting smile expressiveness is not significantly influenced by sagittal malocclusion.[17] ULL at rest and on smiling was marginally shorter in Class I, with no significant differences

Table 1: Comparative evaluation of smile characteristics between Class I and Class II participants.

Smile Characteristic (mm)	Class I	Class II	Student '*t*'-test value	Significance '*P*-'value
	Mean±SD	Mean±SD		
Incisor display at rest	3.04±2.31	2.68±1.99	0.834	0.406 (NS)
Incisor display on smiling	8.08±2.13	7.99±1.77	0.229	0.820 (NS)
Upper lip length at rest	18.89±2.44	19.02±2.38	0.262	0.794 (NS)
Upper lip length on smiling	13.68±1.92	13.57±2.20	0.254	0.800 (NS)
Gingival display on smiling	1.44±1.55	1.28±1.48	0.514	0.608 (NS)

S: Significant ($P < 0.05$), NS: Not significant ($P > 0.05$)

Table 2: Tukey's *post hoc* for inter group comparison of smile characteristics in Class I participants.

Smile characteristic (mm)	Normo versus hyper		Normo versus hypo		Hyper versus hypo	
	Mean Diff	*P*-value	Mean Diff	*P*-value	Mean Diff	*P*-value
Incisor display at rest	−2.06235*	0.001 (HS)	2.26353*	0.001 (HS)	4.32588	0.001 (HS)
Incisor display on smiling	−1.88294*	0.009 (NS)	1.07235	0.194 (NS)	2.95529	0.001 (HS)
Upper lip length at rest	−1.46647	0.173 (NS)	0.48529	0.819 (NS)	1.95176	0.049 (S)
Upper lip length on smiling	1.24647	0.143 (NS)	0.28647	0.898 (NS)	-0.96000	0.309 (NS)
Gingival display on smiling	−0.18294	0.938 (NS)	0.53294	0.582 (NS)	0.71588	0.381 (NS)

*: Statistically Significance, HS: Highly Significant ($P < 0.001$), NS: Not Significant ($P > 0.05$), S: Significant ($P < 0.05$)

Table 3: Tukey's *post hoc* for inter group comparison of smile characteristics in Class II participants.

Smile Characteristic (mm)	Normo versus Hyper		Normo versus Hypo		Hyper versus Hypo	
	Mean Diff	*P*-value	Mean Diff	*P*-value	Mean Diff	*P*-value
Incisor display at rest	−2.17059*	0.001 (HS)	1.44765*	0.008 (NS)	3.61824	0.001 (HS)
Incisor display on smiling	−1.41235*	0.025 (S)	0.89471	0.210 (NS)	2.30706	0.001 (HS)
Upper lip length at rest	−0.01294	1.000 (NS)	−0.31118	0.926 (NS)	-0.29824	0.932 (NS)
Upper lip length on smiling	2.74706*	0.001 (HS)	0.18353	0.955 (NS)	-2.56353	0.001 (HS)
Gingival display on smiling	−0.41765	0.683 (NS)	0.56529	0.500 (NS)	0.98294	0.132 (NS)

*: Statistically Significance, HS: Highly Significant ($P < 0.001$), NS: Not Significant ($P > 0.05$), S: Significant ($P < 0.05$)

Table 4: Comparative evaluation of smile characteristics between Normodivergent, Hyperdivergent and Hypodivergent of Class I and Class II participants.

Smile characteristic (mm)	Normo divergent		Hyper divergent		Hypo divergent		*P*-value (Class I)	*P*-value (Class II)
	Class I	Class II	Class I	Class II	Class I	Class II		
Incisor display at rest	3.11±1.98	2.44±1.78	5.17±1.43	4.61±1.05	0.85±0.92	1.00±1.03	0.001 (HS)	0.001 (HS)
Incisor display on smiling	7.81±2.10	7.82±1.50	9.70±1.37	9.23±1.11	6.74±1.77	6.93±1.85	0.001 (HS)	0.001 (HS)
Upper lip length at rest	18.57±0.94	18.91±1.44	20.04±1.76	18.93±2.31	18.08±3.53	19.22±3.20	0.050 (S)	0.915 (NS)
Upper lip length on smiling	14.19±1.91	14.55±1.94	12.95±1.92	11.81±1.53	13.91±1.82	14.37±2.02	0.142 (NS)	0.001 (HS)
Gingival display on smiling	1.56±1.87	1.34±1.67	1.74±1.42	1.76±1.60	1.03±1.31	0.77±1.01	0.387 (NS)	0.154 (NS)

HS: Highly Significant ($P < 0.001$), NS: Not Significant ($P > 0.05$), S: Significant ($P < 0.05$)

overall, aligning with Tarnach *et al.* but contradicting Al-Sabbagh.[15,18]

Gingival display was marginally lower in Class II participants. Hyperdivergent individuals had the highest ID both at rest and on smiling, significantly more than normo- and hypodivergent groups, consistent with Miron *et al.* and Siddiqui *et al.*[19,20] Vertical maxillary excess contributes to this increased display.

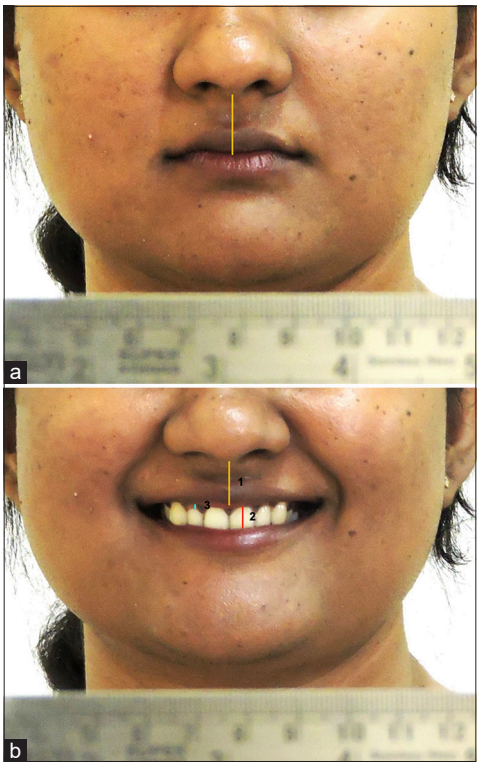

Figure 2: (a) Measurement taken at rest: upper lip length at rest. (b) Measurements taken on smiling: (1) upper lip length, (2) maxillary incisal display, and (3) gingival display.

ULL at rest was longest in hyperdivergent participants, and ULL on smiling was shortest. The width of visible maxillary teeth was greatest in hypodivergent individuals. According to Tiwari and Jain and Senthilkumar *et al*., increased ID is typical in vertical growth patterns, while horizontal patterns show reduced ID.[8,21] Siddiqui *et al*. also found greater ULL change in vertical growers, reflecting higher upper lip elevation capacity.[20]

Gingival display was higher in hyperdivergent individuals but not statistically significant, aligning with Hayani *et al*., who associated increased display with reduced posterior facial height to anterior facial height ratio (PFH/AFH)ratios.[22] This may be attributed to individual soft-tissue variation or upper lip muscle tone, which modulate gingival visibility independently of skeletal pattern.

No significant differences in smile characteristics were observed between Class I and Class II malocclusions within each growth pattern, indicating that vertical skeletal patterns dominate over sagittal malocclusion in influencing smile esthetics.[21,23,24]

The skeletal growth patterns observed align with the vertical proportions described in Sassouni's analysis, which links craniofacial divergence to vertical maxillary excess and incisor display. Future studies incorporating full Sassouni cephalometric analysis could provide a more comprehensive skeletal correlation.

This study has limitations, including the exclusion of Class III malocclusions which restrict the comprehensiveness of comparisons across all skeletal patterns. There was a slight gender imbalance and the study sample was limited to North Indian population, which may affect generalizability. Although measurements were validated by experienced orthodontists, inter-observer reliability was not quantified using the intraclass correlation coefficient, which may introduce potential observer bias. Future research should include Class III malocclusions and aim for gender and age diversity. Future studies should include diverse populations to enhance external validity. Assessing inter-observer reliability would strengthen methodological rigor. In addition, exploring soft tissue and muscle activity could enhance understanding of smile dynamics. Incorporating 3D imaging and longitudinal designs would allow for more precise evaluations. Finally, assessing patient satisfaction and psychosocial outcomes could bridge clinical findings with quality-of-life improvements.

CONCLUSION

Incisor display at rest and on smiling was higher in Class I and hyperdivergent participants across both malocclusion groups. Hyperdivergent individuals with Class II malocclusion showed significantly shorter ULL on smiling, along with increased gingival display which was more evident in Class I participants. Overall, vertical skeletal patterns had a more significant impact on smile esthetics than sagittal classification, highlighting the need to prioritize vertical discrepancies during orthodontic planning.

Acknowledgments: The authors would like to thank the faculty and staff of the department of orthodontics and dentofacial orthopedics, for their guidance and support during the course of this study.

Ethical approval: The research/study was approved by the Institutional Review Board at Saraswati Dental College and Hospital Lucknow, (IHEC #SR5OR18042023D) and Institutional Research and Development Committee IRDC No. #SR5OR18042023D dated 13/04/2023.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent.

Financial support and sponsorship: Nil.

Conflicts of interest: There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation: The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

REFERENCES

1. Kaur S, Soni S, Prashar A, Kaur R. Perception and characterization of posed smile: A photographic study. J Indian Orthod Soc 2021;55:270-7.
2. Singh H, Maurya RK, Kapoor P, Sharma P, Srivastava D. Subjective and

objective evaluation of frontal smile esthetics in patients with facial asymmetry-a comparative cross-sectional study. Orthod Craniofac Res 2016;20:8-20.
3. Parekh H, Patel D, Mehta F, Joshi N, Bhattacharya A. Smile-a diagnostic tool: Photographic analysis in adult Gujarati population. IOSR J Dent Med Sci 2013;12:39-46.
4. Ramaswamy S, Rohilla N, Sathe TT. Analysis of various smile parameters using digital photography: An observational study. World J Dent 2021;12:392-8.
5. Sarver DM. The importance of incisor positioning in the esthetic smile: The smile arc. Am J Orthod Dentofacial Orthop 2001;120:98-111.
6. Schabel BJ, Baccetti T, Franchi L, McNamara JA. Clinical photography vs digital video clips for the assessment of smile esthetics. Angle Orthod 2010;80:678-84.
7. Sachdeva K, Singla A, Mahajan V, Jaj HS, Negi A. Esthetic and smile characteristics at rest and during smiling. J Indian Orthod Soc 2012;46:17-25.
8. Senthilkumar A, Krishnan P, Arasappan R, Muthukumar K, Subramani R, Parvin R. Evaluation of smile characteristics of attractive smile in various growth patterns. J Indian Orthod Soc 2024;59:17-25.
9. Van Der Geld P, Oosterveld P, Bergé SJ, Kuijpers-Jagtman AM. Tooth display and lip position during spontaneous and posed smiling in adults. Acta Odontol Scand 2008;66:207-13.
10. Walder JF, Freeman K, Lipp MJ, Nicolay OF, Cisneros GJ. Photographic and videographic assessment of the smile: Objective and subjective evaluations of posed and spontaneous smiles. Am J Orthod Dentofacial Orthop 2013;144:793-801.
11. Maulik C, Nanda R. Dynamic smile analysis in young adults. Am J Orthod Dentofacial Orthop 2007;132:307-15.
12. Chetan P, Tandon P, Singh GK, Nagar A, Prasad V, Chugh VK. Dynamics of a smile in different age groups. Angle Orthod 2013; 83:90-6.
13. Bishara SE, Augspurger EF Jr. The role of mandibular plane inclination in orthodontic diagnosis. Angle Orthod 1975;45:273-81.
14. Zaher AR, Bishara SE, Jakobsen JR. Posttreatment changes in different facial types. Angle Orthod 1994;64:425-36.
15. Tarnach K, Mittal S, Teja P. A correlative study to evaluate the effect of various skeletal and dentoalveolar parameters on smile esthetics in different malocclusion groups. Int J Orthod Rehabil 2020;11:157-67.
16. Desai S, Upadhyay M, Nanda R. Dynamic smile analysis: Changes with age. Am J Orthod Dentofacial Orthop 2009;136:310.e1-10; discussion 310-1.
17. Benjasupattananan S, Sirikururat P. Assessment of smile line and attractiveness in a group of thai university students. SWU Dent J 2023;16:11-22.
18. Al-Sabbagh R. An Evaluation of upper lip length and thickness changes on smiling in patients with class I, class II div1, 2 of malocclusion according to angle's classification. J Health Med Inform 2020;11:20-1.
19. Miron H, Calderon S, Allon D. Upper lip changes and gingival exposure on smiling: Vertical dimension analysis. Am J Orthod Dentofacial Orthop 2012;141:87-93.
20. Siddiqui N, Tandon P, Singh A, Haryani J. Dynamic smile evaluation in different skeletal patterns. Angle Orthod 2016;86:1019-25.
21. Tiwari A, Jain RK. Evaluation of the lip-tooth relation in various growth patterns-a cephalometric study. Indian J Forensic Med Toxicol 2020;14:5713-8.
22. Hayani A, Dabbas J, Zeitoun M. Evaluation of skeletal and dentoalveolar components in Syrian females with a gummy smile. APOS Trends Orthod 2016;4:30-5.
23. Grover N, Kapoor DN, Verma S, Bharadwaj P. Smile analysis in different facial patterns and its correlation with underlying hard tissues. Prog Orthod 2015;16:28.
24. Alhakeem MM, Elkalza AR, El Harouni NM. Smile esthetics in different vertical skeletal patterns in an Egyptian sample (a cross sectional observational study). Egypt Orthod J 2024;65:116-28.

How to cite this article: Ahlawat R, Tandon R, Singh K, Chauhan A. A photographic evaluation of smile characteristics in different dental and skeletal patterns: A cross-sectional study. Asian J Oral Health Allied Sci. 2025;15:16. doi: 10.25259/AJOHAS_18_2025