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Original Research Article

Comparative evaluation of the accuracy and reproducibility of indigenously developed profile, smile and dento-gingival (PSD) coding and grading system for facial esthetics amongst dental students and practitioners

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Abstract

Background: Facial esthetics play a crucial role in personal and professional interactions, influencing self-confidence and social perception. Standardized assessment methods are crucial for consistency in clinical evaluations and treatment planning. The purpose of this study was to compare the accuracy and reproducibility of Profile, Smile and Dento-gingival (PSD) coding and grading system for facial esthetics amongst dental students and practitioners, examining the impact of experience level on aesthetic evaluation.

Materials and Methods: Three standard photographs (extra-oral frontal smile, profile, and intra-oral frontal) were digitally manipulated to create 10 sets, each highlighting different facial features. These sets were coded and graded using the PSD system. A total of 100 examiners were divided into four groups: BDS interns (BS), BDS practitioners (BP), MDS (Orthodontics) students (MS), and MDS (Orthodontics) practitioners (MP) to evaluate photographs. One-way ANOVA with Tukey's post hoc test compared group scores, while intra-class correlation coefficient (ICC) and Cohen's kappa statistics assessed intra- and inter-examiner reliability. The level of significance was set at $P<0.05$.

Results: The MP group achieved the highest overall score (114.88 ± 11.74), while BS scored the lowest (85.2 ± 13.20). MP showed the highest intra-examiner reliability (0.974) and BS the lowest (0.832). Inter-examiner reliability was strongest in MP (0.69) and weakest in BS (0.56).

Conclusion: MDS Orthodontics practitioners demonstrated the highest accuracy and reproducibility, likely due to their specialized training and experience. In contrast, BDS interns had the lowest accuracy, emphasizing the importance of expertise in facial esthetics evaluation.

Keywords: Esthetics, Macro-esthetics, Micro-esthetics, Mini-esthetics, Coding, Grading, Profile, Smile, Dento-gingival.

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1. Introduction

Facial attractiveness and physical appearance play a crucial role in social interactions and self-esteem. Shared preferences for facial esthetics may be fundamental aspects of human nature. Orthodontists increasingly focus on maintaining and enhancing facial esthetics, despite challenges in defining treatment goals and establishing objective standards. The growing ability to alter facial features has intensified the need to understand beauty and develop reliable evaluation methods.

Arnett and Bregman[1] emphasize that study models, cephalometrics, and facial analysis together form the cornerstone of an accurate diagnosis, helping identify positive and negative facial traits. Peck and Peck's soft tissue analysis highlights frontal and lateral profile aspects.[2] Morley et al.[3] describe smile design theory encompassing facial, gingival, micro-, and macro-esthetics. Extensive literature on these parameters has been reviewed to develop a simplified approach for assessing facial esthetics.

Facial esthetics assessment is categorized into macro-, mini-, and micro-esthetics. Macro-esthetics evaluates facial profile, proportions, balance, and symmetry. Mini-esthetics considers excessive incisor display, buccal corridor dimensions, and smile arc. Micro-esthetics examines tooth proportions, golden proportion, gingival shape, connectors,

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embrasures, and tooth shade. Despite extensive research in these areas, no universally accepted system exists for objectively evaluating facial esthetics in a structured manner.

Clinicians often rely on subjective judgment, leading to inconsistencies in diagnosis and treatment planning. Additionally, with increasing patient awareness and demand for aesthetic dental treatments, a standardized approach becomes essential to ensure reliable evaluations. The complexity of analyzing smile features and predicting post-treatment aesthetic outcomes highlights the need for a systematic grading approach that simplifies aesthetic evaluation while maintaining accuracy and reproducibility.

The Profile, Smile, and Dento-gingival (PSD) coding and grading system aims to address these gaps by providing an organized, quantifiable method for assessing facial esthetics, assisting clinicians in making precise and informed treatment decisions. This study evaluated the accuracy and reproducibility of the indigenously developed PSD coding and grading system, providing clinicians with a structured classification tool for assessing facial attractiveness.

2. Materials and Methods

2.1. Profile, smile and dento-gingival (PSD) coding and grading system

According to William R. Profit, facial esthetics can be broadly classified into macro-, mini- esthetics and micro-esthetics. Based on this classification, an innovative PSD coding and grading system was devised to evaluate facial esthetics across multiple domains. Each esthetic domain and its respective parameters were assigned specific codes for standardized assessment.

2.2. Profile analysis (P)

Macro-esthetics encompasses Profile analysis (P), which was evaluated under the following three heads:

2.2.1. Facial proportion (Pp)

1. **Vertical Division (V):** Graded as vertical equal (Veq) if 1/5 vertical proportions were equal; otherwise, vertical unequal (Vueq).
2. **Horizontal Division (H):** Graded as horizontal equal (Heq) if 1/3 horizontal proportions were equal; otherwise, horizontal unequal (Hueq).

2.2.2. Balance and Symmetry (Sy)

1. **Facial Midline (Mid):** Graded as deviated right (R), centered (C), or deviated left (L).
2. **Facial Symmetry (FS):** Graded as symmetrical (S) or asymmetrical (As).
3. **Facial Profile (Pf):** Graded as convex (Cx), concave (Ce), or straight (St).

2.2.3. Smile Analysis (S)

Mini-esthetics involves Smile analysis (S), evaluated under three heads:

1. **Gingival Incisor Display (GID):** Graded as ideal (I) for less than 2 mm, optimum (O) for 2–4 mm, or least esthetic (Le) for more than 4 mm of display.
2. **Buccal Corridor (BC):** Graded as narrow (N) if less than 10%, attractive (A) if between 10–20%, or wide (W) if more than 20%.
3. **Smile Arc (SA):** Graded as parallel (Pl), straight (St), or inverted (Id).

2.3. Dento-gingival analysis (D)

Micro-esthetics involves Dento-gingival analysis (D) was evaluated under five parameters:

1. **Width and Height of Crown (WH):** Evaluated using a width/height ratio of 0.8 for the upper central incisor. Graded as following (F) or not following (NF).

2. **Golden Proportion (GP):** Assessed using the 62% rule: the apparent width of the lateral incisor should be 62% of the central incisor; canine should be 62% of the lateral incisor; and first premolar should be 62% of the canine. Graded as following (F) or not following (NF).

3. **Connectors and Embrasures (CE):** Evaluated using the 50-40-30 rule: the connector area should be 50% between central incisors, 40% between central and lateral, and 30% between lateral and canine—based on central incisor crown length. Graded as following (F) or not following (NF).

4. **Gingival Zenith (Gz):** The most apical point of gingival contour, graded as distal (D), medial (M), or coinciding (Ci).

5. **Tooth Shade Color (TS):** Graded as lighter and brighter (LB) or darker and duller (DD).

According to this classification, the more esthetic parameters are P: Pp (Veq, Heq), Sy (Mid-C, FS-S), and Pf (St); S: GID (I), BC (A), and SA (Pl); and DG: WH (F), GP (F), CE (F), Gz (D), and TS (LB). The less esthetic parameters are: P: Pp (Vueq, Hueq), Sy (Mid-R/L, FS-As), and Pf (Cx/Ce); S: GID (Le), BC (N/W), and SA (Id); and DG: WH (NF), GP (NF), CE (NF), Gz (M), and TS (DD).

3. Study Design and Participant Selection

An observational cross-sectional study was designed to evaluate the accuracy and reproducibility of the Profile,

Smile, and Dento-gingival (PSD) coding and grading system among dental professionals at different stages of training. Following approval from the Institutional Ethical Committee (CDCRI/Dean/EthicsCommittee/Ortho-02/2022), 100 examiners were recruited via purposive sampling. Participants were allocated into four equal groups of 25 each: BDS students in internship (BS), BDS practitioners (BP), MDS (Orthodontics) students (MS), and MDS (Orthodontics) practitioners (MP).

4. Visual Dataset Preparation

A photograph depicting an ideal Indian female smile was selected (**Figure 1** a-c) and digitally modified using Adobe Photoshop CS3 (Adobe Systems, Inc., San Jose, California) to incorporate various aesthetic parameters defined in the PSD coding and grading system. Ten distinct sets of photographs were created, each digitally modified to represent specific variations across PSD parameters containing an extra-oral frontal smile, a profile view, and an intra-oral frontal image. All images were then numbered, coded, and graded by the researcher to establish reference standards according to the PSD criteria.

5. Training and Evaluation Workflow

Before data collection, participants attended a training session in which the principles and application of the PSD system were explained via a PowerPoint presentation. The training session ensured baseline familiarity and standardization of assessment procedures among participants. Subsequently, each examiner received a Google Form containing the ten sets of photographs. For each set, 13 questions addressed the different parameters of the PSD coding system, resulting in 130 evaluations per participant. Responses were scored dichotomously, with correct answers receiving a score of 1 and incorrect answers a score of 0. To determine intra-examiner reliability, 32 participants (eight per group) re-assessed 10 sets of photographs using the same Google Form after a 10-day interval.

5.1. Statistical analysis

Statistical analysis was conducted using IBM SPSS Statistics, Version 22. Continuous variables are reported as mean ± standard deviation, and categorical variables as percentages. Descriptive statistics summarized participant age and gender distributions. Normality of data was assessed using the Shapiro–Wilk test to determine the suitability of parametric statistical analysis. Group comparisons of total PSD scores were performed using one-way analysis of variance followed by Tukey's post hoc test. Intra-examiner reliability was assessed with the intraclass correlation coefficient, and inter-examiner reliability with Cohen's kappa statistic. A significance threshold of $P < 0.05$ was applied to all inferential tests.

6. Results

The descriptive statistics revealed no significant age differences between males and females across all study groups (**Table 1**). The MP group consistently demonstrated the highest mean scores (114.88 ± 11.74) across most parameters, indicating superior proficiency in facial esthetic assessment (**Table 2-Table 4**). In contrast, the BS group generally reported the lowest mean scores (85.2 ± 13.20), reflecting comparatively limited aesthetic evaluation expertise.

Significant intergroup differences were observed in parameters such as vertical and horizontal facial divisions, midline alignment, symmetry, and profile assessment, with the MP group outperforming all others ($P<0.05$). Post hoc comparisons further confirmed statistically significant differences between the MP group and each of the other groups, highlighting distinct levels of esthetic diagnostic proficiency ($P<0.05$).

Similar trends emerged for parameters including gingival incisor display, buccal corridor, smile arc, crown width-height ratio, golden proportion, and connectors and embrasures. The MP group consistently achieved higher scores, underscoring their advanced understanding of dental esthetics. However, for variables such as gingival zenith and tooth shade color, no significant differences were observed among the study groups, suggesting similar evaluative proficiency in these specific areas ($P<0.05$).

Intra-examiner reliability, evaluated using Intraclass Correlation Coefficients (ICC), showed excellent reliability (ICC > 0.9) for the MS (0.958) and MP (0.974) groups, and good reliability (ICC = 0.75–0.90) for the BP (0.885) and BS (0.832) groups (Table 5). Inter-examiner reliability, measured via Cohen's kappa, indicated moderate agreement for the BS group ($\kappa = 0.56$; 95% CI: 0.41–0.60) and substantial agreement for the BP ($\kappa = 0.66$), MS ($\kappa = 0.62$), and MP ($\kappa = 0.69$) groups (CI: 0.61–0.80).

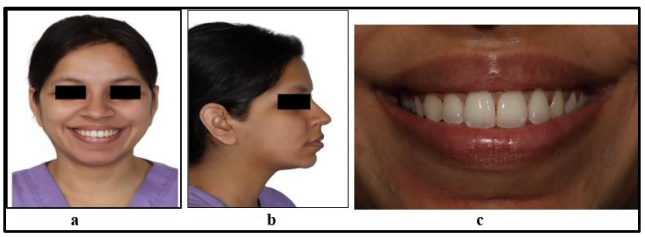

Figure 1: a. Extra-oral frontal smile view **b.** Extra-oral profile view **c.** Intra-oral frontal view

Table 1: Descriptive statistics of age and gender in different study groups

Groups	Gender	N	Mean	SD	P
BS	Male	10	24.30	0.94	0.313
	Female	15	24.67	0.81	
	Total	25	24.52	0.872	
BP	Male	11	27.00	1.09	0.251
	Female	14	27.50	1.01	
	Total	25	27.28	1.061	
MS	Male	13	27.00	1.958	0.735
	Female	12	27.25	1.658	
	Total	25	27.12	1.787	
MP	Male	9	34.33	4.331	0.066
	Female	16	31.19	4.636	
	Total	25	33.76	6.604	

Independent t test, P<0.05=Not significant

Table 2: Intergroup comparison of profile analysis

Parameter	BP Mean ± SD	BS Mean ± SD	MP Mean± SD	MS Mean ± SD	P	Multiple Comparisons					
						BP/ BS	BP/ MP	BP/ MS	BS/ MP	BS/ MS	MP/ MS
Vertical Division	7.00 ± 1.84	6.80 ± 1.08	9.12 ± 1.33	8.12 ± 1.23	<0.001[c]	0.616	<0.001[c]	0.006[b]	<0.001[c]	0.001[b]	0.013[a]
Horizontal Division	7.00 ± 1.30	6.04 ± 1.30	9.08 ± 1.35	8.32 ± 1.10	<0.001[c]	0.001[b]	<0.001[c]	0.005[b]	<0.001[c]	<0.001[c]	0.037[a]
Facial Midline	7.72 ± 2.09	6.52 ± 1.73	9.04 ± 1.33	8.90 ± 1.07	<0.001[c]	0.1	0.005[b]	0.01[b]	<0.001[c]	<0.001[c]	0.792
Facial Symmetry	8.12 ± 1.71	7.00 ± 1.41	9.24 ± 1.20	8.44 ± 1.38	<0.001[c]	0.007[b]	0.007[b]	0.434	<0.001[c]	0.001[c]	0.053
Facial Profile	7.36 ± 1.93	6.10 ± 2.31	8.60 ± 1.44	7.88 ± 1.45	<0.001[c]	0.018[a]	0.018[a]	0.316	<0.001[c]	0.001[c]	0.166

One way ANOVA followed by Tukey's post hoc test; aP<0.05: significant; bP<0.01: highly significant; cP<0.001: very highly significant.

Table 3: Intergroup comparison of smile analysis

Parameter	BP Mean ± SD	BS Mean ± SD	MP Mean ± SD	MS Mean ± SD	P	Multiple Comparisons					
						BP/ BS	BP/ MP	BP/ MS	BS/ MP	BS/ MS	MP/ MS
Gingival Incisor Display	7.50 ± 1.87	5.90 ± 1.97	8.96 ± 1.24	7.80 ± 2.00	<0.001[c]	0.002[b]	0.007[b]	0.638	<0.001[c]	<0.001[b]	0.025[a]
Buccal Corridor	6.84 ± 1.49	6.52 ± 1.55	8.64 ± 1.46	8.00 ± 1.63	<0.001[c]	0.464	<0.001[c]	0.009[b]	<0.001[c]	0.001[b]	0.145
Smile arc	6.92 ± 1.93	6.60 ± 1.54	8.40 ± 1.93	7.04 ± 1.90	<0.006[b]	0.645	0.005[b]	0.818	0.001[b]	0.49	0.01[a]

One way ANOVA followed by Tukey's post hoc test; a P<0.05: significant; b P<0.01: highly significant; cP<0.001: very highly significant.

Table 4: Intergroup comparison of dento-gingival analysis

Parameter	BP Mean ± SD	BS Mean± SD	MP Mean± SD	MS Mean± SD	P	Multiple Comparisons					
						BP/ BS	BP/ MP	BP/ MS	BS/ MP	BS/ MS	MP/ MS
Width- Height ratio of crown	7.00 ± 1.68	6.80 ± 1.80	8.76 ± 1.61	7.80 ± 1.80	<0.001[c]	0.683	0.001[b]	0.105	<0.001[c]	0.043[a]	0.052

Golden proportion	7.24 ± 2.02	6.60 ± 1.77	9.04 ± 1.30	7.80 ± 1.52	<0.001[c]	0.182	<0.001[c]	0.182	<0.001[c]	0.008[b]	0.017[a]
Connector and embrasure	7.00 ± 1.80	5.96 ± 1.36	8.92 ± 1.38	8.08 ± 1.35	<0.001[c]	0.015[a]	<0.001[c]	0.012[a]	<0.001[c]	<0.001[c]	0.049[a]
Gingival zenith	7.04 ± 2.30	6.56 ± 2.51	8.08 ± 2.15	7.32 ± 1.84	0.111						
Tooth shade colour	8.12 ± 2.10	7.68 ± 1.95	9.00 ± 1.52	8.20 ± 1.58	0.081						
Overall score	95.20 ± 16.46	85.20 ± 13.20	114.88 ± 11.74	103.80 ± 10.18	<0.001[c]	0.008[b]	<0.001[c]	0.022[a]	<0.001[c]	<0.001[c]	0.004[b]

One way ANOVA followed by Tukey's post hoc analysis; aP<0.05: significant; bP<0.01: highly significant; cP<0.001: very highly significant.

Table 5: Intra-examiner and Inter-examiner reliability

Groups	Intraclass correlation coefficient (ICC)	Cohen's kappa coefficient (κ)
BS	0.832	0.56
BP	0.885	0.66
MS	0.958	0.62
MP	0.974	0.69

7. Discussion

William R. Proffit's classification of facial esthetics remains a cornerstone in orthodontic diagnosis.[4] Building upon this framework, the PSD (Profile, Smile, Dento-gingival) coding and grading system was developed to offer a comprehensive, standardized approach for identifying esthetic and unesthetic facial profiles. Incorporating thirteen key parameters across the three esthetic domains, the system aims to streamline evaluation and enhance objectivity in clinical settings.

The present study evaluated proficiency across four distinct groups—BDS interns, general dental practitioners, orthodontic postgraduate students, and orthodontic practitioners—in applying the PSD system. Absence of age-related gender disparities enabled pooled analysis, thereby reinforcing the statistical strength of group-wise comparisons (P<0.05).

Profile analysis, central to macro-esthetic evaluation, includes assessment of facial balance, symmetry, and proportional divisions. The MP group demonstrated superior performance in this domain, in line with findings by Jackson et al.[5,6] who reported that orthodontists possess heightened accuracy in evaluating symmetry, particularly under complex conditions. Romani et al.[7] and Burcal et al.[8] further supported this trend, showing increased sensitivity among orthodontists when analyzing female profiles. These differences are likely influenced by both professional training and pre-existing aptitude, contributing to enhanced perceptual acuity.

Smile analysis encompassed gingival display, buccal corridor, and smile arc. Studies by Alhammadi et al.[9] and Johnston et al.[10] revealed that perception thresholds for midline deviation and gingival exposure vary based on clinical training. While a gingival display of 1 mm is generally considered acceptable, other authors—Omar et al.[11] Moore et al.[12] and Ker et al.[13]—suggested ideal values range between 2.1 mm and 4 mm. The MP group demonstrated heightened sensitivity in this dimension as well, likely attributable to their focused training in orthodontic smile design. Furthermore, works by Al Taki et al.[14] and Pisulkar et al.[15] confirmed orthodontists' greater discernment of buccal corridors and smile arc consonance. Parekh et al.[16] and Badran et al.[17] emphasized that smiles paralleling the lower lip are considered most esthetic, again corroborating the superior performance of the MP group in smile assessment.

Dental esthetics—addressed in the PSD system's dento-gingival module—included evaluation of crown proportions, golden ratios, gingival zenith, connectors, embrasures, and shade selection. Studies by Kokich et al.[18] showed orthodontists' enhanced ability to detect subtle dental discrepancies, often more critically than general dentists or laypersons. This heightened perception was mirrored in the MP group's consistently higher scores, suggesting deeper conceptual grounding in esthetic principles. Rocha et al.[19] reported that laypersons and orthodontists share similar judgments when symmetry is preserved in gingival zenith placement, adding further nuance to the subjective-objective interface in esthetic analysis.

The observed variations in accuracy between groups can be attributed to differences in training exposure and esthetic literacy. Orthodontists, by virtue of their specialization, apply a more calibrated and critical lens when assessing facial and dental esthetics. These findings align with Brisman's[20] observations that education, rather than gender, significantly influences esthetic judgment. Similarly, Kokich et al.[18] reported orthodontists' greater sensitivity to esthetic deviations, reinforcing the trend identified in the present study.

Despite its utility, the PSD system may be vulnerable to subjectivity, especially among less experienced evaluators. To mitigate inter-individual variability, calibration protocols and visual scales or grids should be integrated into training. Doing so could enhance inter-rater reliability and improve the

consistency of esthetic assessments in both academic and clinical contexts.

8. Conclusions

MDS (Orthodontics) practitioners (group MP) achieved the highest overall accuracy scores (114.88 ± 11.74), while BDS internship students (group BS) recorded the lowest (85.2 ± 13.20) in evaluating esthetic parameters using the PSD coding and grading system. The MP group also demonstrated the highest intra-examiner (ICC = 0.974) and inter-examiner (κ = 0.69) reliability, whereas the BS group showed the lowest intra-examiner (ICC = 0.832) and inter-examiner (κ = 0.56) values. These findings underscore the influence of specialized training on esthetic assessment proficiency. The PSD system thus emerges as a valuable tool for clinicians and researchers, enabling structured evaluation and monitoring of esthetic outcomes across macro-, mini-, and micro-esthetic domains in dental practice.

9. Conflict of Interest

None.

10. Author Contributions Statement

Conception/Design of the work: SS, JS, PK, TM, JP
Acquisition/Analysis: SS, JS, PK, TM, JP
Interpretation of data: SS, JS, PK, TM, JP
Draft/Revision of the work: SS, JS, PK, TM, JP

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