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Original Article

The Relationship between Posttreatment Smile Esthetics and the ABO Objective Grading System: Class I Extraction versus Non-Extraction Cases

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Main points:

- The goal of this study was to evaluate the relationship between the American Board of Orthodontics (ABO) objective grading system and post-treatment smile esthetics in Class I extraction versus non-extraction cases.
- Extremely poor Pearson correlation coefficients were found between the components of the ABO grading system and the average Q-scores of smiles.
- The total scores of both groups acquired from the ABO grading system and Q-scores of the captured smile showed no relevance at all.
- Combined results presented weak correlations among the parameters of the ABO grading system and smile esthetics. Logistic regression showed that a beautifully articulated dental cast with parallel roots did not necessarily result in an attractive smile.
- There was no relationship between smile esthetics and ideal post-treatment occlusion in Class I extraction vs non-extraction cases.

ABSTRACT

Objective: This study aimed to evaluate the relationship between the components of the objective grading system developed by the American Board of Orthodontics (ABO) and smile esthetics in Class I extraction vs non-extraction cases.

Methods: A total of 40 extraoral smile images of orthodontically treated (20 extraction and 20 non-extraction) cases in the age group of 13-30 years and Class I skeletal malocclusion with an average mandibular plane angle were selected. Smile images were rated only by the orthodontist, and this panel included 12 members. Scoring of post-treatment dental casts and panoramic radiographs of each patient was performed by 1 investigator per the guidelines of the ABO grading system. The Pearson correlation coefficient and logistic regression analysis were used to ascertain whether the scores of the ABO grading system could foretell whether a smile would be "attractive" or "unattractive."

Results: The correlation between all the criteria of the ABO grading system and attractiveness of the smile was extremely weak. The r values ranged from -0.53 to 0.37 for extraction cases and -0.63 to 0.003 for non-extraction cases ($p>0.05$). Neither individual parameters nor total scores of the ABO grading system could predict whether the smile was attractive or unattractive in either group.

Conclusion: No correlation was found between post-treatment ABO grading and smile esthetics in patients with extraction or non-extraction. Hence, this study recommends that ancillary soft tissue variables have to be incorporated into the grading system to evaluate a smile.

Keywords: ABO Objective Grading System, smile esthetics, Q-Sort

INTRODUCTION

A beautiful smile can act as a powerful communication tool. With the advent of digitization, patients are becoming more aware and specific with their treatment outcomes, especially their smile esthetics. Proper alignment of teeth with good occlusion is thought to be a fundamental component of an attractive smile (1). Smile esthetics

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encompasses various factors, including dentition and surrounding soft tissues (2). It is also one of the critical factors in evaluating orthodontic treatment outcome.

A common treatment modality in orthodontics is tooth extraction. There is almost always a dispute concerning the outcome of smile esthetics after extraction and non-extraction orthodontic therapy. Usually, we presume that extraction results in narrowing of the dental arches, thereby increasing the buccal corridors, and resulting in an unesthetic smile. Johnson and Smith (3) stated that the smile esthetic scores obtained and visible dentition while smiling were the same in patients with both extraction and non-extraction. Unlike non-extraction treatment, extraction treatment did not result in the narrowing of the intercanine arch width. Previous studies have evaluated frontal smile esthetics in post-treatment frontal smiling photos and found that the esthetic scores of both the extraction and non-extraction groups were insignificant (4-8).

Evaluation of the orthodontic treatment outcome helps to set certain treatment goals, establish orthodontic treatment standards, and achieve a measurable finish for patients after completion of their orthodontic treatment (9,10). The American Board of Orthodontics (ABO) grading system is a valid and reliable index to assess the post-treatment occlusal outcomes according to 8 different occlusal and radiographic components (11). Soft tissue components are not considered in the ABO grading system. No other studies have yet compared the outcome of smile esthetics with post-treatment results between extraction and non-extraction orthodontic treatment cases. Hence, this study aimed mainly to evaluate the relationship between the components of the ABO objective grading system and smile esthetics after orthodontic treatment in Class I extraction and non-extraction cases. Clinical significance of this study is that smile esthetics is not dependent on ideal occlusion or post-treatment outcome (ABO Grading System) in either extraction or non-extraction groups. The hypothesis is that when the outcomes of smile esthetics using post-treatment ABO grading system between extraction and non-extraction orthodontic treatment cases are correlated, they should show a significant difference between the 2 groups, whereas the null hypothesis is that there is no significant difference between the 2 groups.

METHODS

Patient Selection

The study protocol was reviewed and approved by the institutional ethical board. Ethical clearance was obtained from the institutional ethical committee before the commencement of the study (Ref: CODS/2427/201819). All the patients enrolled in this study were from the Department of Orthodontics and Dentofacial Orthopedics at College of Dental Sciences, Davangere who appeared during a regular post-treatment consultation. Written informed consent was procured from the patients who participated in this study; for patients below the age of 18 years, a legal guardian was asked to sign their consent form.

Inclusion criteria for the study included: age group of 13-30 years; skeletal Class I malocclusion; average mandibular plane i.e., the angle between the sella-nasion line and the mandibular plane (SN/MP=32°); completion of orthodontic treatment within the previous 6 months, either with non-extraction therapy or with 4 premolar extraction therapy; full set of post-treatment diagnostic records; South Indian Ethnicity .

To determine the sample size, power analysis was conducted on the basis of the previous study (12), a two-tailed test with $\alpha \leq 0.05$ which provided 90% power to detect the difference between the means at a significance level of 5% using a 2-sided t test; intra-class correlation coefficient of 0.94 and 95% confidence interval was also achieved to ensure an adequate sample size. A sample size of 40 patients with completed orthodontic treatment (20 extraction and 20 non-extraction) who met the inclusion criteria was selected. The extraction group included 14 men and 6 women with an average age of 18.25±4.4 years. The non-extraction group included 16 men and 4 women with an average age of 20.25±1.8 years, and the mean difference between the 2 groups was 2 years.

All the patients were treated with Gemini MBT prescription pre-adjusted edgewise brackets with 0.022x0.028 inch slots (3M Unitek Corporation, Monrovia, California, USA).The sequence of archwire was: nickel titanium, 0.014-inch, 0.016-inch, 0.018x0.025 inch, 0.019x0.025 inch; stainless steel (SS) 0.019x0.025 inch. During space closure, an elastic chain with SS 0.025-inch ligature wire was tied on the first molar hook to the anterior arch hook placed between the canine and lateral incisor and used for en-masse retraction of the anterior teeth using sliding mechanics in extraction cases, and elastomeric chains were used for space closure in non-extraction cases. The elastic chains were changed on a monthly appointment basis followed by finishing and detailing of the case.

Capturing of 40 Extraoral Smile Images of Orthodontically Treated Patients

All the images were captured by the same photographer. This study used only extra-oral smile images. A mounted Nikon FM10 SLR camera (Nikon Corporation, Cosina, Japan) 35 mm was used. A distance of 36 inches was fixed between the lens and the subject. A lighting source of 1 strobe was used to indirectly illuminate the patient using flash, a photographic umbrella was used to avoid any reflective diffusion, and all of this was connected to the camera. The patient was instructed by the photographer to "smile" before taking the photo. A posed smile is voluntary, and it is far more reproducible. Hence used for research purposes.

The photograph was imported using a software program for image editing (Adobe Systems Incorporated, San Jose, California, USA). Standardization of size and location on all the images were performed by designing a 3x5 inch template (Figure 1).Superimposition of the template on top of the photograph was performed by Adobe Photoshop software version 7.0 (Adobe Systems Incorporated, San Jose, California, USA).Superimposition was performed by enlarging the smile images until the outer commissures of the lips matched with the vertical tick marks inset, which were three-quarters of an inch from the border of the template. Then smile photograph were positioned such that

maxillary incisal edges coincided with the templates' horizontal line.

Healing brush tool in Adobe Photoshop was used to erase any skin aberration, blemishes, or spots in the resulting photograph so that this would not influence the rater when evaluating them. A 4-digit unique number was randomly chosen to label the finished images. Compressed photograph of 150 KB was achieved at the end of complete editing, and this was saved as joint photographic expert's group file type. The images were shown to the raters in a random order on a Microsoft Office PowerPoint 2007 presentation (Microsoft, Redmond, WA, USA).

Rater Selection

Smile images were rated only by the orthodontist. Clinical experience of the empaneled orthodontists ranged from 1 to 5 years, and there were 8 men and 4 women in this panel aged between 26 and 36 years (they were selected from the institution's orthodontic program and were graduates of the same university).

Q-sort Method

In 1953,Stephenson (13) first proposed this method, which was an alternative approach for large samples and could create 9-category ordinal ranking according to a variety of subjective criteria. To generate a quasi-normal distribution of the sample, it used the progressive forced choice winnowing to make anesthetic scale "least pleasing" to "most pleasing" for rating the smile images in this study.

Figure 1. A standardized smile photograph using the 3x5 inch template

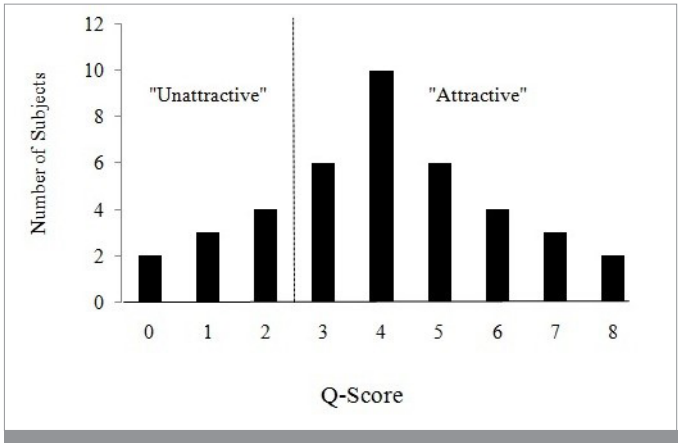

Figure 2. Q-sorting: assignment of scores to the cutoff point used to separate "attractive" from "unattractive" smiles in the Q-sort distribution. Note: A line between columns 2 and 3 is given a numeric score of 2.5

The panelists were asked to rate the clinical images of 40 patients for the attractiveness of smile images and then to apply the Q-sort technique to those images.

A specific order was employed by each of the panelist to select and organize the images (Figure 2). From these 40 images, the 2 most attractive and the 2 least attractive smiles were found and placed in their columns. The 3 most attractive and 3 least attractive smiles were selected similarly,4 smile images then followed by 6 smile images from each extreme, leaving only 10 smile images, presumably of neutral attractiveness. Between the 2 columns, there was a cutoff point separating the "unattractive" from the "attractive" smiles established by a survey performed by each rater.

Figure 2 depicts the score assigned for each Q-sort distribution. In a given group, each photograph was assigned a score, which is represented by the X-axis, and the number of patients is represented by the Y-axis. For each image, a score of 0–8 was given with 2 images each that were perceived least attractive as 0 and 2 images each that were perceived most attractive as 8. Overall, the Q-score for each patient was generated by calculating the average from the scores obtained for that patient by various raters.

A numeric value was given as a cutoff point, which separates the unattractive images from the attractive ones. Esthetic boundary for a panel member was represented by a score. For example (Figure 2), in a Q-sort distribution, if a line was drawn between columns 2 and 3, then it was given a scoring of 2.5, which indicated that particular panel member's esthetic boundary. Overall, a demarcation between attractive and unattractive images was generated by averaging the cutoff points received from the various raters.

Assessment of ABO Grading System

One of the best ways to assess a finished case is with the use of the ABO objective grading system. Per the guidelines of the ABO objective grading system, the principal author was initially trained in the ABO objective grading system using an ABO calibration kit as well as with a tutorial using the ABO gage. Only 1 investigator evaluated all the cases and scored panoramic radiographs and post-treatment dental casts of all the patients using the special gage (11).The occlusal outcome of each patient for either extraction or non-extraction case was measured using the scores obtained from each of the 8 components and total scores generated from the ABO objective grading system for that particular patient. The ABO objective grading system is an objective clinical examination tool that has been judged reproducible depending on its extensive inter- and intra-examiner reliability testing by various investigators (14).

Statistical Analysis

All the data were analyzed using the **Statistical Package for Social Sciences version 24.0 software (IBM Corp.; Armonk, NY, USA) for Windows.** The results were presented as means and standard deviations for age, criteria of the ABO objective grading system, esthetic boundary cutoff scores, and Q-sort scores. The Pearson correlation coefficients were calculated to evaluate the relationship between the occlusal outcome and perceived smile attractiveness of patients with extraction and non-extraction treatment. Specifically, the individual criteria and total combined scores of the ABO grading system were evaluated against the average combined Q-scores of smiles captured with clinical photography. To evaluate whether the individual criteria or total combined scores of the ABO grading system could predict whether a smile would be attractive or unattractive in patients with extraction vs. non-extraction treatment, logistic regression was used; $p<0.05$ was established as a level of significance for all the statistical tests.

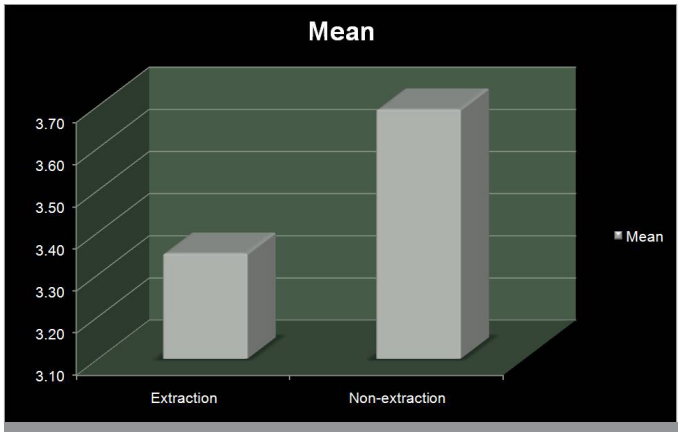

Figure 3. Comparison of mean Q-sort scores between the extraction and non-extraction groups

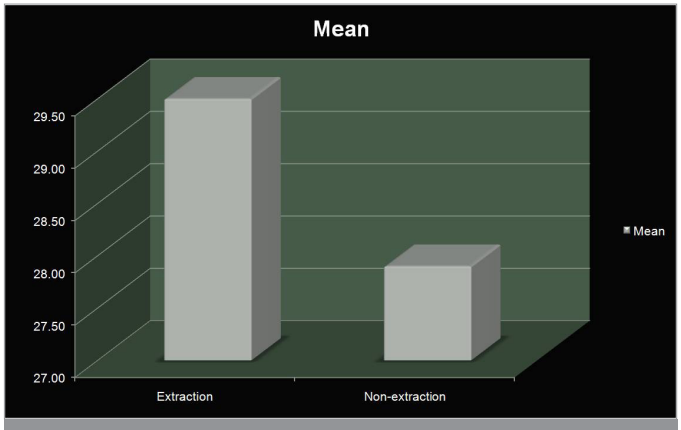

Figure 4. Comparison of mean total deductions of American Board of Orthodontics score between the extraction and non-extraction groups

RESULTS

Comparison of the mean Q-sort scores between Class I extraction and non-extraction cases showed differences in the mean scores as 3.35 and 3.69, respectively, which were statistically non-significant (Figure3). Similarly, comparison of mean total deductions of the ABO scores between extraction and non-extraction groups were 29.50 and 27.90, respectively, which were statistically non-significant (Figure 4). Table 1 represents the descriptive statistics of the ABO grading system in the extraction and non-extraction cases. Table 2 represents the descriptive statistics calculated for the average Q-scores. A combined result of all 12 raters for each photograph was calculated to determine the average Q-scores. Esthetic boundary scores were represented by an average cutoff point demarcation between the unattractive and attractive smile images during the Q-sort assessment. Because of the ordinal nature and normal distribution of the Q-sort, 4 would be the mean Q-sort score when all the patient scores were combined. The scores ranged from 0 to 8 between Q-sort scores and esthetic boundary.

To distinguish the relationship between the average Q-scores of smiles and the 8 criteria of the ABO grading system for extraction and non-extraction cases, the Pearson correlation coefficients were calculated (Table 3). A score of 0 in the ABO grading system means a perfect occlusal outcome; a score of 1 would mean a perfect correlation between optimal occlusion and an attrac-

Table 1. Descriptive statistics of the citeria of American Board of Orthodontics objective grading system in extraction and non-extraction cases with point deductions of criteria and total scores

ABO Criteria	Extraction				Non-extraction			
	Range				Range			
	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD
Alignment	2	7	4.30	1.38	1	7	4.15	1.66
Marginal ridge	2	7	4.15	1.42	2	8	4.45	1.76
Buccolingual inclination	1	7	3.85	1.93	1	7	3.50	1.47
Occlusal relationship	1	6	2.90	1.45	0	5	2.45	1.23
Occlusal contacts	2	10	4.85	2.56	0	7	4.55	1.85
Overjet	1	3	1.70	0.73	1	5	1.90	1.02
Interproximal contacts	0	7	3.75	2.02	0	5	2.60	1.67
Root angulation	2	6	4.20	1.54	0	9	4.20	2.61
Total deductions	16	43	29.50	9.26	17	43	27.90	7.90

SD: Standard deviation; ABO: American Board of Orthodontics

tive smile. Between all the factors of the ABO grading system and perceived smile attractiveness, extremely weak positive and negative relationships (r values ranging from -0.53 to 0.37 for extraction cases and -0.63 to 0.003 for non-extraction cases) were found. Although individual components, such as occlusal relationship (-0.53) and interproximal contact (-0.46), showed significance for extraction group and buccolingual inclination (-0.48), occlusal contacts (-0.62) and root angulations (-0.63) showed significance for non-extraction cases. Moreover, total deductions between the 2 groups showed significance.

Logistic regression equation predictors: regression coefficients (B) and probabilities (P) for individual parameters and combined total scores of the ABO grading system with "attractive" and "unattractive" smiles in an extra-oral smile photograph as the dependent variable are presented in Table 4. Whether the smile was attractive or unattractive could not be predicted, by either the individual score or the total scores obtained from components of the ABO grading system.

DISCUSSION

A large number of adult patients seek orthodontic treatment for esthetic reasons. However, these patients also demand a high level of comfort, greater treatment efficiency, and better esthetic results, especially smile esthetics and faster treatment. No other studies have yet compared the outcome of smile esthetics with post-treatment results between the extraction and non-extraction orthodontic treatment cases. Hence, this study was undertaken to analyze the relationship between the occlusal outcomes of the ABO grading system and post-treatment smile esthetics in Class I extraction vs non-extraction cases.

A previous study evaluating the smile esthetics found that the Q-sort technique indicated a higher reliability than that of the visual analog scale(15).The same study reported that both patients' parents and orthodontists agree on whether the smiles are attractive or unattractive. Therefore, our study participants were only orthodontists. The results from previous studies comparing the smile esthetics between the extraction and non-extraction cases reported that the differences were of no significance (4-8).

Johnson and Smith (3) evaluated the smile esthetics in patients with completed orthodontic treatment with or without extraction of the first 4 premolars. The mean esthetic score of patients with extraction and non-extraction treatment was insignificant. The results showed that there was no predictable relationship between the esthetics of a smile and the extraction of the premolars. This correlates with the results of our study.

Table 2. Descriptive statistics for average Q-sort and esthetic boundary scores of the various raters for each image type

Smile photo			Range	
Variable and Rater	Mean	SD	Minimum	Maximum
Average Q-sort score (range 0-8)[a] Orthodontist	4	1.4	0.5	6.7
Average esthetic boundary (range,0-8) Orthodontist	3.2	1.3	0.5	6.5

[a]The normal distribution of the Q-sort score results in a mean of 4 when patients are combined
SD: Standard deviation

Table 4. Logistic regression: regression coefficients (B) and probabilities (p) for individual ABO criteria and total scores with "attractive" and "unattractive" smiles captured with clinical photograph as the dependent variable

ABO Criteria	Regression coefficient (B)	SE (B)	p
Alignment	0.20	0.79	0.80
Marginal ridge	0.71	0.72	0.33
Buccolingual inclination	0.40	0.87	0.65
Occlusal relationship	-0.70	0.81	0.38
Occlusal contacts	0.39	0.62	0.53
Overjet	0.36	0.78	0.64
Interproximal contacts	-0.05	0.72	0.95
Root angulation	-0.25	0.70	0.73
Total deductions	-0.31	0.63	0.62

ABO: American Board of Orthodontics; SE: Standard error of the coefficient

Table 3. Pearson correlation coefficients between the criteria of the American Board of Orthodontics objective grading system and average Q-sort scores of smiles captured with clinical photography between the extraction and non-extraction groups

	Extraction group		Non-extraction group	
ABO Criteria	Correlation coefficient* with Q-sort scores	p	Correlation coefficient* with Q-sort scores	p
Alignment	-0.19	>0.05	–0.32	>0.05
Marginal ridge	-0.26	>0.05	-0.09	>0.05
Buccolingual Inclination	-0.43	>0.05	-0.48	<0.05*
Occlusal relationship	-0.53	<0.05*	-0.09	>0.05
Occlusal contacts	-0.26	>0.05	-0.62	<0.01*
Overjet	0.37	>0.05	0.003	>0.05
Interproximal contacts	-0.46	<0.05*	-0.36	>0.05
Root angulation	-0.26	>0.05	-0.63	<0.01*
Total deductions	-0.49	<0.05*	-0.62	<0.01*

*Statistically significant at p<0.05; ABO: American Board of Orthodontics

Kim and Gianelly (6) studied the dental casts and frontal smile images of the patients treated with and without extraction of the first 4 premolars to as certain changes in the arch width. The esthetics of the smile was judged by 50 laypeople. The results of their study showed that both extraction and non-extraction treatment did not have any preferential effect on smile esthetics, and no constriction of the arch was seen in patients with extraction treatment. Isiksal et al. (7) compared the esthetics of a smile between patients with extraction and those with non-extraction treatment and a control group, who were judged by orthodontists, plastic surgeons, artists, general dentists, dental professionals, and parents. The mean esthetic scores for all the 3 groups were non-significant. The results of these 2 studies are similar to those of our study.

Extremely poor Pearson correlations were found between the components of the ABO grading system and average Q-scores of smiles (the r values ranged from -0.53 to 0.37 for extraction and -0.63 to 0.003 for non-extraction cases).Individual components of the ABO grading, such as occlusal relationship (-0.53) and interproximal contact(-0.46), showed significance for the extraction group. This may be explained by the larger space available for precise positioning of the teeth after extraction. Buccolingual inclination (-0.48), occlusal contacts (-0.62), and root angulations (-0.63) showed significance for non-extraction cases. This may be because of the tipping movement of the teeth and owing to the lack of available space for a perfect tooth placement. The total ABO scores procured from both the groups and the captured smile Q-scores bear no relevance at all, although total deductions between the 2 groups showed significance. A study by Anthopoulou et al. (16) found similar results. They found that for a patient with Class I malocclusion, the same quality of results was achieved as assessed by the ABO objective grading system, irrespective of extraction and non-extraction treatment.

Neither the individual parameters nor the combined total scores obtained from the ABO grading system in logistic regression could predict whether a smile would be considered unattractive or attractive in patients with or without extraction. Combined results presented weak correlations among the parameters of the ABO grading system and smile esthetics. Logistic regression analysis shows that a beautifully articulated dental cast with parallel roots does not necessarily result in an attractive smile. None of the soft tissue parameters were evaluated in the current objective grading system; hence, these results are not surprising. Schabelet al. (17) and Cheng and Wang (18) have found similar results, which are in accordance with our study.

Irrespective of the other parameters that could affect a clinician's decision regarding the treatment protocol, extraction or non-extraction did not have any significance when evaluated. This result was not in accordance with the study conducted by Vaidya et al. (19).

The results of this study suggest that there is no relationship between ideal post-treatment occlusion and smile esthetics. Overall, majority of people use smile as a factor to judge whether their treatment was successful (20).Orthodontists should endeavor to create an ideal smile with facial and occlusal outcomes, which would satisfy and benefit the patient the most (21).

CONCLUSION

This study comprehensively evaluated the relationship between the ABO objective grading system and post-treatment smile esthetics in Class I extraction versus non-extraction cases and found no significant relationship between them. The ABO objective grading system could not predict whether the smile was attractive or unattractive after orthodontic treatment in both groups. Soft tissue parameters, neither intraoral nor extraoral, were assessed in the objective grading system. Therefore, our study suggests that when assessing the overall post-treatment orthodontic outcomes, inclusion of ancillary soft tissue variables into the grading system is necessary to evaluate the smile esthetics.

Ethics Committee Approval: This study was approved by Ethics committee of College of Dental Sciences affiliated with Rajiv Gandhi University of Health Sciences (Approval No: CODS/2427/201819).

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

Peer-review: Externally peer-reviewed.

Author Contributions: Supervision – G.S., N.S.; Design – V.K., N.S.; Resources – V.K., G.S.; Materials – V.K., N.S.; Data Collection and/or Processing – V.K., G.S.; Analysis and/or Interpretation – V.K., G.S.; Literature Search – V.K., N.S.; Writing Manuscript – V.K., N.S.; Critical Review – V.K., G.S.

Conflict of Interest: The authors have no conflict of interest to declare.

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