

The Facial Aesthetic index: An additional tool for assessing treatment need

Shobha Sundareswaran and Ranjith Ramakrishnan

ABSTRACT

Objectives: Facial Aesthetics, a major consideration in orthodontic diagnosis and treatment planning, may not be judged correctly and completely by simply analyzing dental occlusion or osseous structures. Despite this importance, there is no index to guarantee availability of treatment or prioritize patients based on their soft tissue treatment needs. Individuals having well-aligned teeth but unaesthetic convex profiles do not get included for treatment as per current malocclusion indices. The aim of this investigation is to develop an aesthetic index based on facial profiles which could be used as an additional tool with malocclusion indices.

Materials and Methods: A chart showing typical facial profile changes due to underlying malocclusions was generated by soft tissue manipulations of standardized profile photographs of a well-balanced male and female face. A panel of 62 orthodontists judged the profile photographs of 100 patients with different soft tissue patterns for assessing profile variations and treatment need. The index was later tested in a cross-section of school population. Statistical analysis was done using “irr” package of R environment version 2.15.1.

Results: The index exhibited very good reliability in determining profile variations (Fleiss kappa 0.866, $P < 0.001$), excellent reproducibility (kappa 0.9078), high sensitivity, and specificity (95.7%). Testing in population yielded excellent agreement among orthodontists (kappa 0.9286).

Conclusions: A new Facial Aesthetic index, based on patient's soft tissue profile requirements is proposed, which can complement existing indices to ensure treatment to those in need.

Key words: Bimaxillary protrusion, Facial Aesthetics, malocclusion index

INTRODUCTION

The World Health Organization's broader concept of health as a state of complete physical, mental, and social well-being is universally embraced. For medical and dental specialties in general and orthodontics, in particular, this has tipped the scales in favor of improved appearance rather than performance.^[1] Facial Aesthetics is an important concern in current society.^[2]

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Children, young adults, and parents rate pleasant aesthetics as an important factor for psychosocial well-being.^[3-5] Aesthetic improvement is the most frequently reported subjective reason for seeking orthodontic treatment.^[6-8] This means that an assessment of facial appearance should be included in the evaluation of orthodontic treatment need.^[2,9]

Recording or measuring of malocclusion is important for documentation of its prevalence and severity in population groups, planning and providing orthodontic services in a community and assessing treatment effects. Earliest methods of recording malocclusion were qualitative.^[10] Attempts to develop quantitative methods came later between 1950s and 1960s.^[11-17] More recent developments include the index of

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orthodontic treatment need (IOTN) in 1989,^[18] peer assessment rating (PAR) in 1992,^[19] the index of complexity, outcome and need (ICON) in 2000^[20] and the index of orthognathic functional treatment need (IOFTN) in 2014.^[21] The IOTN is quick and easy to use,^[22] unaffected by age,^[23] and hence widely used in orthodontic research.^[24] These indices aid in categorizing malocclusions into groups based on priority and need for treatment or treatment outcomes. Priority can be given to patients with the greatest treatment need whenever resources are limited, or availability of treatment is unevenly spread. Similarly, individuals with little need for treatment can be safeguarded from unnecessary interventions. However, the present indices and scales all deal with dental malocclusions, but not with overall Facial Aesthetics.^[2]

Brook and Shaw have rightly pointed out that the main benefit of orthodontic treatment may be improved aesthetics and social-psychological well-being. This may have an improved effect on attitudes to dental health as well.^[18] This led to the inclusion of standardized continuum of aesthetic need component in IOTN. However, the use of study models and standard history alone to determine treatment need without reference to facial photographs was recognized as a possible methodological limitation.^[25]

The soft tissue integument may not be judged correctly and completely by simply analyzing the dental occlusion or the skeletal structures. Likewise, an orthodontic treatment that is successful in the eyes of the professional does not always improve facial esthetics^[26,27] or facial balance,^[28] and, therefore, might be considered to be less satisfying in the eyes of the patient.^[2] Even in the absence of any form of measurable dental irregularity, facial profiles may be unacceptable. A typical example is “bimaxillary protrusion” (BMP), a feature prevalent among African-Americans, Blacks as well as many ethnic groups among the Asian population. This results in an unacceptable circumoral convexity of the facial profile in spite of an Angle’s Class I occlusion with normal overjet, overbite and well aligned upper and lower dental arches. It has a severe negative impact on the psychosocial well-being of the individual, and they seek orthodontic treatment for improvement of their facial profiles.^[29] However, they may not qualify for treatment as per the existing indices of malocclusion, which are insensitive to profile alterations. Majority of professionals and laypersons prefer a straight profile.^[30] Since affordability is a major concern in developing countries when seeking orthodontic treatment, dependence on government agencies is inevitable. Public health measures using screening procedures to assess orthodontic treatment needs should ideally be able to demonstrate profile alterations of the face due to underlying malocclusions. This would add to the existing information about the individual’s problem so as to enable prioritized discharge of treatment if and when needed.

Although the importance of soft tissue patterns in treatment planning is paramount, very little efforts have been made to

identify, categorize, and prioritize patients according to their soft tissue treatment needs. Since dental and Facial Aesthetics are two different parameters, a scoring system for orthodontic treatment need and treatment outcome should include dental as well as Facial Aesthetic scales.^[27,31] Thus, the face requires an independent appraisal, categorization, and prioritization in addition to the skeletal and dental analysis in order to deduce a comprehensive diagnosis and treatment planning. Such a “Facial Aesthetics” scoring system preferably has to be simple and applicable in clinical practice.^[2]

Hence, the aim of this study was to develop an orthodontic Facial Aesthetic index (FAI) for facial profile alterations using soft tissue parameters and to test its sensitivity, specificity, and reliability. Another aim was to test the reliability of orthodontists’ judgment of facial profiles in a cross-section of the population based on the developed FAI.

MATERIALS AND METHODS

Development of the Facial Aesthetic Index

A panel of 18 trained orthodontists with postgraduate degree in orthodontics and more than 15 years of teaching experience was formed. The panel examined a range of profile variations of 1200 patient photographs (715 females and 485 males) in the age range of 11–29 years, obtained from the Departmental Orthodontic pretreatment records. They identified eight typical facial profiles capable of depicting all profile variations in this sample. Males and females were assessed independently. Range of variations identified included (1) normal straight profiles, (2) bimaxillary retrusive, “dished-in” profiles, (3) circumorally convex, bimaxillary protrusive profiles, both mild and severe (4) convex facial profiles, both mild and severe varieties (typical of skeletal Class II) and (5) concave facial profiles, (typical of skeletal Class III) both mild and severe varieties. Thus, 16 representative photographs were selected (8 male and 8 female). Profile alterations depicting the underlying malocclusions were then coded from A to H the basis of which is given in Table 1. At this point, the index was considered to have face validity.

It is accepted that attractiveness is the end result of many other factors not related to the profile such as hairstyle, color, and shape of the eyes, color and texture of the complexion.^[32] In order to avoid bias from other factors, an ideal profile with well-balanced facial proportions was selected. The other profile variations were generated from this ideal. Accordingly, after obtaining approval from the Institutional Ethics Committee, color profile images of a male and a female with well-balanced facial profiles were obtained using DSLR camera (Nikon D60, Nikon Corporation, Tokyo, Japan). Informed consent to participate in the study was obtained from both to use and digitally manipulate their photographs. The profile photographs were standardized by positioning the patient five feet from the camera with the head in a natural posture.^[33] Digital lateral cephalograms were obtained with Planmeca 2002 Proline (Planmeca Oy, Helsinki, Finland) Machine.

Table 1: Codes used in the Facial Aesthetic index chart depicting the various profiles and their descriptions

Code	Profile	Description
A	Normal straight profile	Pleasing countenance not needing orthodontic correction
B	Bimaxillary retrusion	Normal maxilla and mandible with retrusive dentoalveolar structures, prominent nose and chin, leading to a retrusive, concave profile Needs treatment to obtain a fuller pleasing profile. Considered to be the second best preferred profile in many populations ^[15]
C	Bimaxillary protrusion	Normal maxilla and mandible, but protrusive dentoalveolar structures Circumoral convexity, with competent lips Acute nasolabial angle, upper and lower lips positioned well ahead of the subnasale-pogonion line Shows great need for treatment to reduce the circumoral convexity
D	Class II profile	Normal maxilla and retrognathic mandible/prognathic maxilla and normal mandible or combinations Posteriorly divergent profile and a reduced profile angle (glabella – subnasale – soft tissue pogonion <165°) ^[19] Shows great need for treatment to obtain a straight profile
E	Class III profile	Normal maxilla and prognathic mandible/retrognathic maxilla and normal mandible or combinations Anteriorly divergent profile and an increased profile angle >175° Shows great need for treatment to obtain a straight profile
F	Severe bimaxillary protrusion	Severely protrusive maxillary and mandibular dentoalveolar structures Marked circumoral convexity with incompetent lips Very acute nasolabial angle, upper and lower lips positioned well ahead of the subnasale-pogonion line, deficient chin and an increased lower facial height Shows very great need for treatment to reduce circumoral convexity and achieve lip competence
G	Severe Class II profile	Normal maxilla with severely retrognathic mandible/severely prognathic maxilla with normal mandible or combinations Posteriorly divergent profile and a Markedly reduced profile angle- <165° with inability to approximate the lips Shows very great need for treatment to achieve a straight profile and lip competence
H	Severe Class III profile	Normal maxilla and severely prognathic mandible/severely retrognathic maxilla and normal mandible or combinations Anteriorly divergent profile and a Markedly increased profile angle >175° with inability to approximate the lips Shows very great need for treatment to achieve a straight profile and lip competence

The images and cephalograms were transferred to a desktop computer. Vistadent cephalometric software (Vistadent OC, Version 4.2.61 – Dentsply GAC International Inc., USA) was used for manipulating and generating different profiles after superimposing the color images over the lateral cephalograms. Eight profile variations were generated using skeletal and dental movements based on the prepared profile codes A to H, the basis of which is given in Table 1. Minor artefacts that emerged after morphing were edited with Adobe Photoshop CS Middle Eastern version (Adobe Systems Incorporated, San Jose, CA, USA) software. A scale with a total of 16 profile photographs (eight male and eight female) was thus prepared.

Profile variations were created by altering profile angle,^[34] nasolabial angle,^[34,35] distance of upper and lower lips to the Burstone's integumental profile line (subnasale – pogonion)^[36] and lip competence. The sign "+" was used with increasing grades to depict treatment need. Both male and female FAI charts were prepared [Figures 1 and 2]. Subjective judgment was used to differentiate normal to moderate and severe changes in profiles, as that would be representative of a clinical situation where the orthodontist does a chairside examination. Figure 3 shows a flow chart depicting how the patient's profile has to be assessed based on the FAI chart.

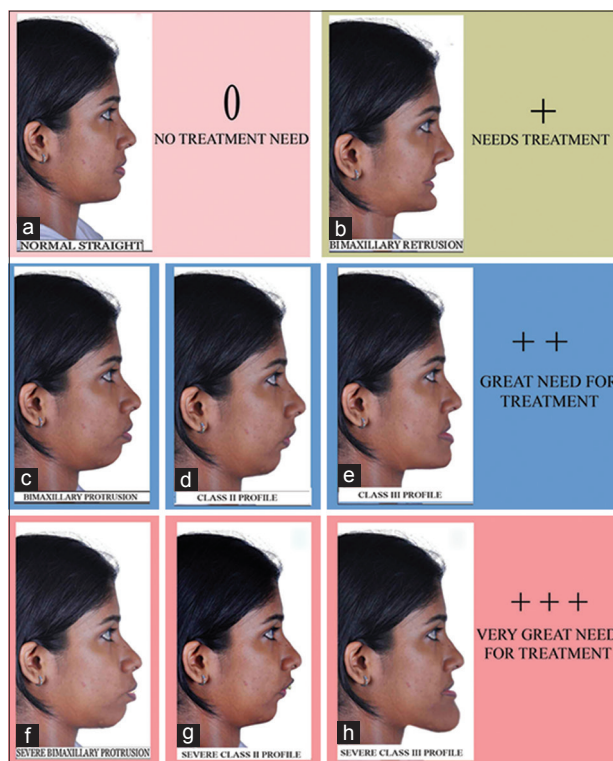


Figure 1: Facial Aesthetic index chart – female (0 - no treatment need, "+" - needs treatment, "++" - great need for treatment, "+++'' - very great need for treatment)

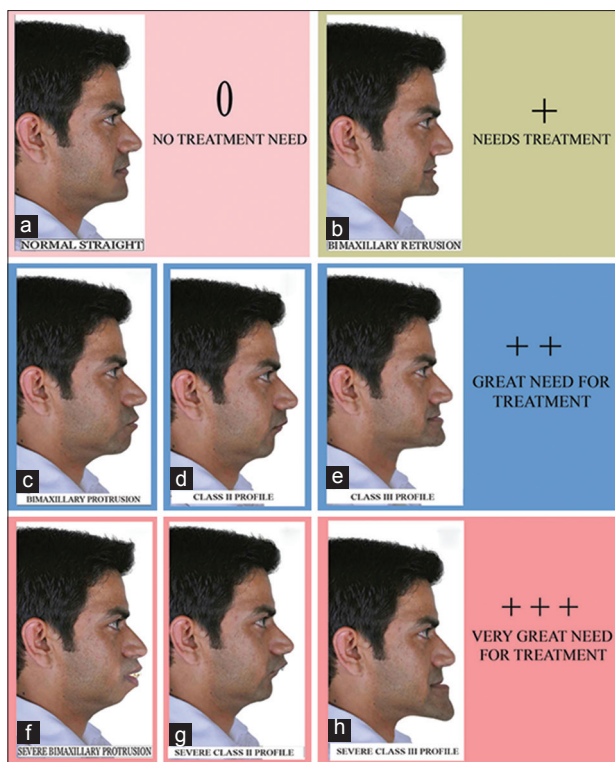


Figure 2: Facial Aesthetic index chart – male (0 - no treatment need, “+” - needs treatment, “++” - great need for treatment, “+++” - very great need for treatment)

A total of 100 patients attending the Department of Orthodontics, willing to participate in the study with informed consent were selected. The sample included all profile variations representing the full range of malocclusions. Standardized profile photographs in natural head position and relaxed perioral muscles were obtained. The photographs were consecutively numbered.

The panel of 18 orthodontists scrutinized the 100 profile photographs used in the study and rated them with grades from A to H depending on the profile variations in the FAI chart. The aggregate opinion of the panel members was taken as the gold standard. Any disagreement between panel members in assigning the scores was solved by direct clinical examination of the patient. The content validity of the index was ensured, as all possible variations were included.

Testing the Facial Aesthetic Index

Reliability

A total of 62 dental specialists with postgraduate degree in orthodontics from different states of South India consented to take part in the study. None of the orthodontists were paid for their participation in the exercise. A proforma containing detailed information of the orthodontist regarding age, sex, location, and professional affiliation was obtained. They were then familiarized with the FAI chart and the profile code description table. Each orthodontist was provided with all instructions and a response sheet containing

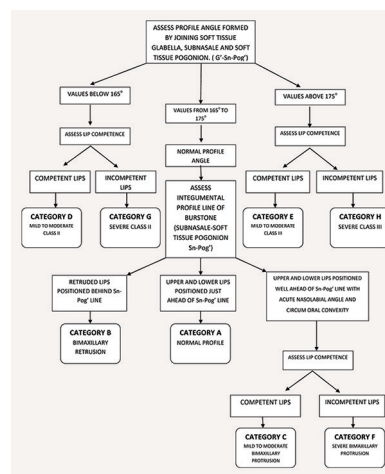


Figure 3: How to assess facial profiles based on Facial Aesthetic index

the numbers of all the photographs [Figures 4 and 5]. Corresponding to each number, the range of alphabetical options A to H pertaining to the profile variations in the FAI chart was provided.

The profile photographs of the 100 patients, numbered on the top right-hand corner were displayed on the screen one by one, each for a period of 20 s. Against the number of the patient in the response sheet, the orthodontists were asked to simply tick the most appropriate alphabet resembling the profile photograph in the FAI chart based on their subjective judgment. The responses obtained from all the 62 orthodontists were then fed into a Microsoft Excel data sheet and tabulated for further statistical analyses.

Multirater Fleiss' kappa agreement was calculated using “irr” package of R environment version 2.15.1.(R foundation, 1020 Vienna, Austria)

Reproducibility

To test the intraexaminer reproducibility, this procedure was repeated among 10 randomly selected orthodontists. Kappa statistic was then calculated using “irr” package of R environment version 2.15.1.

Sensitivity and specificity

The sensitivity and specificity of the FAI were then ascertained by comparing the opinion of all the 62 orthodontists who participated in the study with the gold standard.

The second part of this study was aimed at assessing the reliability of using FAI as an additional screening tool in population for identifying those patients needing orthodontic treatment for profile improvement.

Testing the Index in Population

Four orthodontists visited a cross-section of schools attended by students from different social backgrounds. The orthodontists were instructed on the use of the FAI chart. All available

students in the age range of 15–17 years were examined in their respective school medical rooms under natural light conditions. Each student was asked to stand erect against the wall with their eyes focused on a distant object. No instruments were used. A total of 478 students were examined.

Using the FAI chart, the four orthodontists visually inspected the facial profile of each of these students for a period of 20 s and made independent assessments. This was recorded in the pro forma provided to each one of them. Multirater kappa analysis was done using WINPEPI software version 11.0.

RESULTS

Testing the Facial Aesthetic Index

The reliability of the index in determining profile variations was excellent (Fleiss kappa value of 0.866, $P < 0.001$). Excellent test – retest reproducibility was noted for profile variations. The intraexaminer reproducibility of the FAI ranged between kappa values of 0.892 and 0.928 with an average of 0.908 indicating very good reproducibility ($P < 0.001$). The sensitivity of FAI in identifying profile variations from B to H were 93.7%, 90.5%, 93.3%, 95.5%, 93.5%, 95.9%, and 94.9%, respectively. The specificity of the index as indicated by the accuracy in identifying profile variation A was 95.7% [Table 2].

Test in Population

The overall weighted kappa score was 0.9286 indicating excellent agreement among the orthodontists. The nominal kappa for individual categories ranged from 0.88 to 1.00 showing very good agreement. The raters' kappa for the four orthodontists also ranged between 0.909 and 0.947.

DISCUSSION

Patients seek orthodontic treatment mainly for aesthetic improvement.^[6,8] Psychological aspects have also been cited as justification for treatment.^[5] Therefore, it is very important to include both dental and Facial Aesthetic scales during orthodontic evaluation.^[2]

During the original development of the index, wider options of profile variations, in terms of mild, moderate, and severe versions of each malocclusion, had been formulated. However, this led to confusion, chiefly due to differences in opinion, thus defeating the very purpose of developing the index. Later, eight profile variations were considered appropriate for each chart (male and female). This is in agreement with a previous study which concluded that it was easier to assess a range of eight profile variations.^[30]

The main aim of the FAI was to convey information regarding the nature of the facial profile of the patient to ensure

Figure 4: Annexure 1

Figure 5: Annexure 2

Table 2: 62 orthodontists versus gold standard cross tabulation showing sensitivity and specificity of Facial Aesthetic index

62 orthodontists	Gold standard (%)								Total
	A	B	C	D	E	F	G	H	
A	1127 (95.7)	3 (2.4)	8 (0.7)	12 (0.8)	4 (0.5)	0 (0)	0 (0)	0 (0)	1154 (18.6)
B	4 (0.4)	121 (97.6)	1 (0.1)	6 (0.4)	1 (0.1)	0 (0)	0 (0)	0 (0)	133 (2.1)
C	35 (3)	0 (0)	1010 (90.5)	55 (3.7)	10 (1.2)	5 (2.7)	0 (0)	0 (0)	1115 (18)
D	9 (0.8)	0 (0)	41 (3.7)	1388 (93.3)	2 (0.2)	2 (1.1)	11 (2)	0 (0)	1453 (23.4)
E	3 (0.3)	0 (0)	0 (0)	0 (0)	829 (95.5)	0 (0)	0 (0)	35 (5.1)	867 (14)
F	0 (0)	0 (0)	56 (5)	1 (0.1)	2 (0.2)	174 (93.5)	12 (2.2)	0 (0)	245 (4)
G	0 (0)	0 (0)	0 (0)	26 (1.7)	1 (0.1)	5 (2.7)	535 (95.9)	0 (0)	567 (9.1)
H	0 (0)	0 (0)	0 (0)	0 (0)	19 (2.2)	0 (0)	0 (0)	647 (94.9)	666 (10.7)
Total	1178 (100)	124 (100)	1116 (100)	1488 (100)	868 (100)	186 (100)	558 (100)	682 (100)	6200 (100)

availability of treatment. According to Arnett and Bergman, the profile angle is the most important key to anteroposterior discrepancies.^[34] Hence, it was used to differentiate Class II and Class III profile variations. The profile line is helpful in assessing lip protrusion. In the appraisal of Facial Aesthetics, especially with regard to the lower third of the face, assessment of competence of the lips is another key step. Incompetent lips with increased incisor visibility would impact Facial Aesthetics. FAI effectively measures the negative aesthetic impact caused by such soft tissue factors. The profile line and competence of the lips have been carefully used to evaluate, assess and grade the facial profiles here. As per FAI, acceptable profiles, are graded "A." Bimaxillary retrusive profiles needing more fullness are graded "B." Bimaxillary retrusive profiles are considered to be the second best-preferred profile in many populations.^[37,38] Mild to moderate profile variations in Classes I, II, and III come under C, D, and E, respectively. These can usually be improved with orthodontic or functional/orthopedic therapy. The most severe varieties are graded under F, G, and H. Surgical interventions may be needed here.

The FAI exhibited very high sensitivity in identifying all profile variations. Percentage agreement with the gold standard from profiles B to H were 97.6%, 90.5%, 93.3%, 95.5%, 93.5%, 95.9%, and 94.9%, respectively. The specificity of the index, as indicated by the accuracy in identifying the profile variation A, was 95.7%. Thus, it can be seen that, on an average, more than 94% of the time, the orthodontists were able to accurately categorize the patient photographs as per the gold standard, showing their agreement with the panel decision.

The requirements of an index of occlusion were published by WHO in World Health Organization report.^[39] It contains 9 points to which Summers added the tenth.^[10,40] The FAI was found to meet these requirements. The index can be used to assess a range of profile variations from an acceptable normal to mild-moderate and severe versions. It was found to be sensitive to variations throughout the scale and corresponds closely to the clinical profile and underlying skeletal morphology of the patient. It has good reproducibility, can be applied to population studies and is amenable to statistical analysis. Orthodontists and maxillofacial surgeons, who are trained to assess facial profiles, can utilize this index since it is simple to use and requires minimum time to complete.

Test in Population

The use of this index was further validated in a population setting. Direct visualization of the patient's face, profile variations, and aesthetic impairments generated more accurate decisions as evidenced by the increased sensitivity of the FAI. Weighted kappa of 0.9286 indicated excellent agreement. Clinical examination, obviously, was less prone for any indecisions or errors in judgment. So also, the raters' kappa for the four orthodontists ranged between 0.909 and 0.947. This

indicates the similarity in the outlook of the four experienced orthodontists.

Practical Use of the Index

The FAI is intended as an additional screening tool to the existing indices in a hospital setting or in population groups. It can be used along with indices like IOTN and ICON to generate more information about the patient. This will simultaneously give us an idea regarding the patient's facial profile as well. It will help to bring more needy patients under the umbrella of treatment. For example, ICON signifies scores <31 as acceptable, not needing treatment.^[20] However, if a person has an Angle's Class I malocclusion with BMP, his occlusion would probably be excellent. But with an ICON score of <31, he would not qualify for receiving treatment. Adding the FAI scores would make it 31C, indicating the presence of "a circumorally convex profile" needing treatment. The FAI designations will not interfere with the scores obtained by existing indices.

Limitations

A disadvantage of the FAI is that transverse facial problems and facial asymmetries are not represented. This may need three-dimensional images.^[41] Dynamic characteristics of the face are not taken into account here. However, Howells and Shaw have shown that a close relationship exists between judgments of Facial Aesthetics on live stimuli and single color photographs.^[42] Furthermore, photographs in the chart belong to a specific race. Other races may need to formulate charts suitable for them.

CONCLUSIONS

The FAI represents a simple, quick, reliable, and reproducible method of recording treatment need based on soft tissue requirements. We do not suggest that clinicians should disregard any previously established malocclusion indices. Rather, the FAI complements current methods for evaluating malocclusion by lending itself as an additional information tool for assessing facial profiles and screening those needy patients, who would, otherwise, have not come under the purview of orthodontic treatment.

The following conclusions are drawn:

- The FAI showed good interexaminer reliability and good intraexaminer reproducibility
- The index had good sensitivity in determining different profile variations
- The index showed excellent specificity in highlighting patients not needing treatment based on facial profile
- Use of the index in a population setting generated better sensitivity and accuracy. It was possible to assess treatment requirements based on soft tissue needs. To the best of our knowledge, this is the first time that such an attempt is being made. This will definitely bring more needy patients under the umbrella of orthodontic treatment.

Declaration of Patient Consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of Interest

There are no conflicts of interest.

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