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Macro, mini and micro-esthetics: An evaluation of orthodontically treated patients

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Abstract

Introduction: Patients mainly seek orthodontic treatment with the primary concern of an esthetic enhancement and one of the major goals of treatment in the field of orthodontics is attaining harmony and balance of the oral and facial soft tissues. The objective of this study was to compare the means of micro, mini and macro-esthetics in pre and post-treatment orthodontic patients with extraction protocol.

Material and methods: Fifty Pakistani patients, between 16 to 30 years age and treated with all first premolar extraction protocol were selected and their pre and post treatment records were retrieved. The lip prominence, nasolabial angle and interlabial gap were measured as macro esthetic parameters on the lateral cephalograph of the patients. The buccal corridors, Morley ratio, dental midlines and smile arc were measured as mini esthetic parameters on the smile frontal intraoral photographs of the patients. The connectors, crown height to width ratio of maxillary central incisor, golden ratio of anterior teeth and gingival zenith were measured as micro esthetics parameters on the smile intraoral frontal photograph and plaster casts. To compare the continuous and categorical variables a paired t-test and McNemar tests were applied respectively. Statistical significance level was set at $p \leq 0$ .05.

Results: The golden ratio of maxillary anterior teeth, connectors, buccal corridors, lip prominence, labiomental angle and nasolabial angle showed statistically significant differences for patients. ($p < 0.05$).

Conclusions: The micro, mini and macro esthetics improve with extraction orthodontic treatment protocol. The Buccal corridors space is maintained, the golden ratio and connectors of anterior teeth are improved and the smile arc does not flatten with extraction orthodontic treatment protocol.

Keywords: Connectors; golden proportion; nasolabial angle

Introduction

Dentofacial attractiveness is a major determinant of overall physical attractiveness.[1] Individuals mainly seek orthodontic treatment with the primary concern of an esthetic enhancement and one of the major goals of treatment in the field of orthodontics is attaining harmony and balance of the oral and facial soft tissues.

Angle, in the early 1900s, suggested that an intact dentition arranged in optimum occlusion, causes the soft tissues to assume a harmonious position.[2] The contemporary perspective places emphasis on the soft tissue profiles for enhancing esthetics and treatment

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outcomes rather than the older version of hard tissue as the basis of treatment.

For a successful orthodontic therapy, it is necessary to undertake an accurate orthodontic diagnosis based on a comprehensive clinical evaluation. Sarver et al[3] developed the 'Classification of Appearance and Esthetic Analysis'. This analysis provides a systematic examination of the facial and dental appearance and defines esthetic characteristics that are not new, however, are too often overlooked in orthodontic treatment planning. These should not be considered as rigid boundaries, but as artistic guidelines for the orthodontist.[4] They comprise of three components: macro, mini and micro-esthetics.

Macro-esthetic analysis incorporates the assessment of the face in all three planes of space. Esthetically attractive facial features are those in which the dental and overlapping soft tissues are harmonious and well-proportioned in the overall facial frame.[5] Distorted and asymmetric facial features are a major contributor to facial esthetic problems. Hence, an appropriate goal for the facial examination is to detect horizontal or vertical disproportions. Other components of macro-esthetics that require assessment include lip projection and fullness, chin and nasal projections as well as throat length and form.[6,7]

Mini-esthetics analysis focuses on the smile framework. Achieving an attractive, well balanced social smile is the focus of orthodontic treatment. Regardless of what teeth look like in isolation, if spatially they do not relate to the rest of the facial structure, the overall impression will not be appealing. Hence, features such as incisor and gingival display on smile, smile symmetry, smile arc, vermillion display and buccal corridors determine the esthetics of the smile framework.[2]

Micro-esthetic analysis emphasizes on the minute features of the smile which are important in providing it with harmony and balance. During treatment planning, the smile should be assessed with these various features independently and in composition. The features of micro esthetics that are needed to emphasize include golden proportions of teeth, contact points, embrasures, attached gingiva, black triangles, interdental papillae and gingival margins.[3] Once planned and executed to perfection with orthodontic biomechanics, these features determine the ultimate esthetically pleasing smile.[2]

Esthetics in orthodontic treatment has always been associated with profile enhancement,[4] and extraction mechanotherapy has gained increasing popularity to achieve this goal. However, some orthodontists still consider that extraction treatment can lead to constricted dental arches, which may have detrimental effects on the frontal esthetics of the smile[8,9] whereas other investigators [6,10,11] have found no difference in smile esthetic scores between extraction and non-extraction treated groups. Hence, the controversy regarding extractions for orthodontic treatment continues. In fact, possibly no area of orthodontics has generated more controversy than the concept of orthodontic extractions. Therefore, the following investigation aimed to evaluate the effect of premolar extractions on all aspects of dentofacial and smile esthetics.

Material and Methods

This quasi-experimental study was designed to assess the changes brought about by premolar extractions on macro, mini and micro-esthetics of the face and smile. Patients of Pakistani decent between 16 to 25 years of age, who had been treated with extraction of upper and lower first premolars and had good quality orthodontic records were incorporated into the sample. Patients with dental anomalies like missing, malformed and ectopia in the form of impacted and transposed teeth were excluded. A total of 49 patients achieves 80% power with 5% level of significance at a coefficient of variation of 9.44% and percentage change in mean of

5.23%. Data for this study was obtained from the pre and post cephalographs, study casts and photographs of 50 patients treated with extraction treatment at our Orthodontic department after approval from institutional review board (IRB Approval Number: Prime/IRB/2021-379). A total of 49 patients achieved 80% power with 5% level of significance at a coefficient of variation of 9.44% and percentage change in mean of 5.23% and the figure was rounded to 50 patients. Informed consent was taken from the patients at the time of obtaining pre-treatment records.

To assess macro-esthetic parameters, the patients' pre- and post-treatment cephalographs were traced on acetate paper under direct observation over an illuminator by the principal investigator. The macro-esthetic parameters (figs 1-3) namely lip prominence, interlabial gap, nasolabial angle and labiomental angle were measured and recorded on the data collection form.

Pre- and post-treatment frontal smile photographs of the patients were used to assess the mini-esthetic parameters. Relationship of the upper and lower dental midlines with the facial midline were recorded and categorized into centered or shifted (fig 4). Smile arcs were recorded and categorized into consonant, non-consonant and reverse, based on the relationship of the curvature of the maxillary incisal edges with the lower lip (fig 5a,b,c). The software Adobe Photoshop 7 was used to measure the buccal corridors of the smile as a difference between the visible maxillary dentition and inter commissure width. This was then converted to a percentage of the inter commissure width to give the buccal corridor percentage (fig 6). The amount of reveal of the maxillary incisors below the inter commissure line on full smile was measured using the same software and calculated as a percentage of the actual height of the incisors. This value was noted as the Morley ratio (fig 7).

The study casts and intraoral photographs were used to measure micro-esthetic parameters of the patients. The pre and post treatment maxillary plaster casts were used to measure central incisor crown width to height ratio, lateral incisor gingival zenith and connectors of the anterior teeth using digital vernier caliper (0-150mm ME00183, Dentaurm, Pforzheim, Germany, 0.02mm accuracy, 0.01mm repeatability). The height of the maxillary central incisor crown was taken from the most apical point on its gingival margin and the width between maximum convexity of crown mesiodistally. The ratio was then calculated and noted (fig 8). The connector heights were recorded as distance (mm) between convergence of incisal and gingival embrasures[12] and was converted to percentage (fig 9). Gingival Aesthetic Line (GAL) was used to measure maxillary lateral incisor gingival zenith as shown in (fig 10).[13] Golden Percentages of anterior six teeth were calculated using Adobe Photoshop as shown in (fig 11). All values of macro, mini and micro-esthetics were then recorded for the pre-treatment and post-treatment groups onto the data collection form (Annexure A).

To rule out measurement error, 15 sets of orthodontic records were randomly selected by using lottery method using serial numbers allocated to patient records, after one month. These parameters were re-evaluated by the principal investigator to check for intra-examiner reliability.

Data analysis was done using SPSS for windows (version 19.0, SPSS Inc. Chicago). Means and standard deviation for all continuous variables were generated namely age, lip prominence, interlabial gap, nasolabial angle, labiomental angle, buccal corridors percentage, Morely ratio, golden percentage, crown height-width ratios, gingival heights and connector heights. Frequencies were reported for the categorical variables – gender, midlines and smile arc. Paired sample t-test was used for analysis between the pre-treatment and post-treatment values for continuous variables and McNemar test was used for the categorical variables. Pearson correlation was used to test

intra-examiner reliability. Statistical significance level was established at p≤0 .05.

Results

The total sample of 50 patients comprised of 20% males and 80% females. Mean age for male patients were 17.8 ± 3.08 years while 19.42 ± 3.83 years for female patients.

Table I shows a comparison of pre- and post-treatment means and standard deviations of all the macro-esthetic variables. Statistically significant differences were observed for majority of the variables as shown in the table. Pre-treatment values for both upper and lower nasolabial angle, labiomental angle, lip prominence and interlabial gap were statistically different ($p \leq 0.01$) from post-treatment values. Means for all four variables were seen to reduce to normal limits post-treatment.

Table II displays a comparison of pre- and post-treatment means for mini-esthetic parameters namely buccal corridor percentage and Morley ratio. The pre- and post-treatment buccal corridor percentage ($p = 0.03$) and Morley ratio ($p < 0.001$) showed significant difference.

Table III describes the pre- and post-treatment frequencies for the mini-esthetic parameter namely upper and lower midlines. Out of a total of 12 patients who had shifted upper midlines pre-treatment, 11 were improved and centered after treatment, whereas 1 remained shifted. Out of 38 patients who had centered midlines before treatment, 6 became shifted whereas the remaining 32 were maintained, post-treatment. For lower midlines, all of the 12 patients who had deviated midlines, were improved and became centered, whereas out of 38 patients, who had centered midlines pre-treatment, 34 were maintained and 4 became shifted, post-treatment. The pre and post treatment upper and lower midlines showed statistically insignificant difference ($p > 0.05$).

Table IV describes the pre- and post-treatment frequencies for the mini-esthetic parameter namely smile arc. It reports no statistically significant difference ($p = 0.07$). Out of the total sample 2 patients had reverse smile arcs pre-treatment, of which one was improved and became consonant while the other became non-consonant. Since this figure was minimal, it was excluded from the statistical test. When the remaining 48 patients were compared, it was observed that from a total of 24 patients who had non-consonant smile arcs, 21 were improved to consonant, post-treatment, whereas only 3 remained non-consonant. Smile arcs of 24 patients who had pre-treatment consonant smile arcs were maintained after treatment.

Table V shows a comparison of pre- and post-treatment means for micro-esthetic parameters. It reports an insignificant difference between pre- and post-treatment gingival zenith levels as well as crown width-height ratio ($p > 0.05$). It also reports significant difference between pre- and post-treatment values of all the connectors ($p \leq 0.001$) and golden percentage of anterior teeth ($p \leq 0.05$). Significant improvement in the connectors between the central incisors, lateral incisors and canine were observed bilaterally.

Table I: Comparison of pre- and post-treatment means of Macro-esthetics variables

Variable	Pre-Treatment Value Mean ±SD (N= 50)	Post Treatment Value Mean ±SD (N= 50)	p Value
Upper Lip Prominence	5.72 ±1.179	3.86 ±1.278	**0.01***
Lower Lip Prominence	4.84 ±1.845	3.36 ±1.382	**0.01***
Interlabial Gap	3.08 ±2.554	0.82 ±1.466	**0.01***
Nasolabial Angle	98.94 ±9.133	105.34 ±8.368	**0.01***
Labiomental Angle	109.96 ±17.312	120.66 ±0.924	**0.01***

N= 50 Paired sample t-test $p \leq 0.05$; *$p \leq 0.001$

Table II: Comparison of pre- and post-treatment means of Mini-esthetics parameters

Variable	Pre-Treatment Value Mean ±SD (N = 50)	Post-Treatment Value Mean ±SD (N = 50)	p Value
Buccal Corridor Percentage	4.931 ±3.570	3.641 ±2.473	**0.03**
Morley Ratio	65 ±2.45	69±3.55	0.06

N= 50 Paired sample t-test $p \leq 0.05$; *$p \leq 0.001$

Table III: Comparison of pre- and post-treatment frequencies of Mini-esthetics parameters Midlines

Variable	Remained Centered	Remained Shifted	Became Centered	Became Shifted	p value
Upper midline	32	1	11	6	0.33
Lower midline	34	0	12	4	0.08

Table IV: Comparison of pre- and post-treatment frequencies of Mini-esthetics parameter Smile Arc

Variable	Remained Consonant	Remained Non-Consonant	Became Consonant	Became Non-consonant	p Value
Smile Arc	24	3	21	0	0.07

N= 48 *Reverse smiles excluded
McNemar Test P = 0.05

Table V: Comparison of pre- and post-treatment means of Micro-esthetics parameters

Variable	Pre-Treatment Value Mean ±SD (N = 50)	Post-Treatment Value Mean ±SD (N = 50)	p Value
Gingival Zenith level	0.733 ± 0.643	0.560 ±0.468	0.07
Crown Width-Height Ratio	0.9100 ±0.15434	0.942 ±0.132	0.14
Connector between Central Incisors	36.137 ±14.685	42.957 ±8.250	**0.001***
Connector between Central & Lateral Incisors	25.8446 ±12.37582	32.7846 ±7.09695	**0.001***
Connector between Lateral Incisors & Canines	16.567 ±8.850	23.632 ±8.387	**0.001***
Golden Percentage Central Incisor	22.441 ±3.060	23.631 ±2.199	**0.002**
Golden Percentage Lateral Incisor	12.954 ±3.964	14.083 ±1.056	**0.03**
Golden Percentage Canine	11.662 ±2.917	9.617 ±1.180	**0.001***

N= 50
Paired sample t-test
$p \leq 0.05$; $*p \leq 0.001$

FIGURES

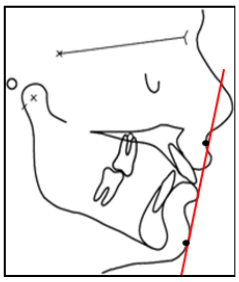

Figure 1: Lip prominence assessed by perpendicular distance of the upper and lower lip from the Burrstone line (B Line). The upper lip should be 3 ±1mm ahead and the lower lip should be 2 ± 1 mm ahead.

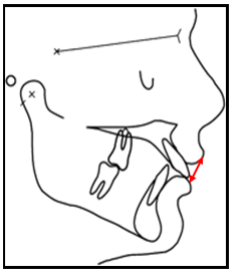

Figure 2: Interlabial gap is the distance in millimeters between the upper and lower lips at rest. Normal Value is 1-3mm

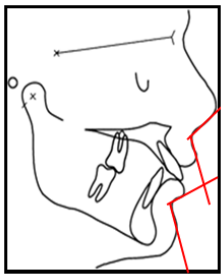

Figure 3: Nasolabial - Normal Value 90-110⁰; Labiomental Angle - Normal 120 ± 10⁰

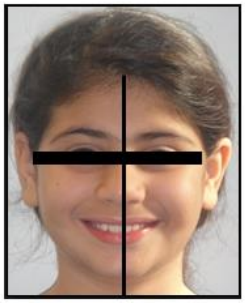

Figure 4: Facial Midline

Figure 5: Smile arc

Figure 6: Buccal Corridors that are 2% of the inter-commissure distance is considered to be most attractive

Figure 7: Morley ratio - youthful smiles generally reveal 75 to 100% of the maxillary teeth below the inter-commissure line

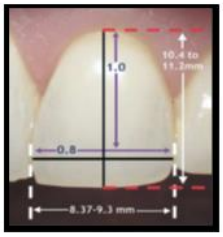

Figure 8: Crown width to height ratio - Normal ratio for the maxillary central incisor is 0.8

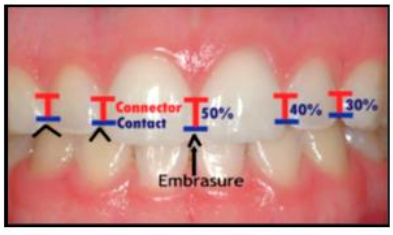

Figure 9: Connectors follow a 50-40-30 rule from the central incisors to the canines

Figure 10: Gingival heights

Figure 11: Golden percentage - the proportional width of each tooth, in percentage, should be: canine 10% each; lateral incisor 15% each and central incisor 25% each of the total distance in mms across the anterior segment during smile

Discussion

The enhancement of the observable esthetic outcomes is considered to be the objective of successful orthodontic treatment. For this reason, the evaluation of the esthetic features pre and post operatively is the integral part of orthodontic treatment. Several authors [8-10,14] believe that extraction treatment will cause the flattening of face and making the lips more retrusive giving more senile look to patients. The current study evaluates the changes by extraction orthodontic treatment in macro, mini and micro-esthetics.

Macro-esthetics was assessed by measuring linear and angular measurements on lateral cephalographs of the patients. Pre-treatment values were compared with the post-treatment values in order to assess the esthetic consequences of the changes produced on the soft tissue profile. All four parameters assessed were seen to improve at completion of treatment.

Most previous studies [15,16] have evaluated change in lip prominence after extraction treatment using Ricketts E line. The present study used the Burstone line to assess this change as the E line is negatively affected by the size of the nose as well as subsequent growth. The normal values for the upper and lower lip, as suggested by Burstone[17], are 3.5 ± 1.4 mm and 2.2 ± 1.6 mm. In our study, with reference to the Burstone line, prominence of the upper lip, decreased from a mean value of 5.72 mm to 3.86 mm with a mean change of 1.86 mm ($p < 0.01$). Similarly, the lower lip prominence reduced from 4.84 mm to 3.36 mm with a mean change of 1.48 mm ($p < 0.01$). Lip prominence for both lips was seen to improve after extraction treatment as the post-treatment means were within the normal range. Bravo[18] used the E line and H line along with the Burstone line to evaluate lip prominence before and after completion of treatment. His results for the Burstone line were similar to ours as they indicated a statistically significant improvement in both upper and lower lips ($p < 0.01$).

The normal value for the labiomental angle for Caucasians suggested in literature[19] is 115-145 degrees for males and 120-130 degrees for females. The current study reports mean pre-treatment values to be 109.96 degrees whereas the angle was found to increase to 116.20 degrees after treatment. The mean change for the angle was reported to be 6.24 degree ($p < 0.01$). This mean change is in contrast to Bravo et al's[18] result who found a mean change of only 0.1 degrees in their sample of 16 patients who had been treated with extraction treatment. This vast difference in treatment response could be due to a difference in soft tissue lip thickness and tonicity in different ethnic races. Ijaz et al[20] in their study while assessing the lip morphology of 50 Pakistani patients, reported lower lip thickness (12.38 ± 1.52 mm) of their sample to be significantly less ($p=0.002$) than Holdaway's proposed value (19 ± 2 mm).[20]

The mini-esthetics of the smile was evaluated using frontal smile photographs of the patients before and after treatment. Various authors[6,10] have reported concerns about the detrimental effects posed by extraction orthodontic treatment on smile esthetics.

Mackley[9] compared treated and untreated smiles and found a flatter maxillary incisal curvature in the treated group as compared to untreated patients. In other studies,[21,22] smiles with flatter arcs were judged by panels and found to be unattractive in terms of esthetic values. Similarly, Ackerman et al[23] stated that orthodontic treatment could cause flattening of the smile arc with subsequent reduced smile esthetics. They evaluated the smile arcs and found 32% of the treated group had flattening of the smile arcs compared to only 5% of untreated patients. The current study found a statistically insignificant difference for smile arcs before and after treatment ($p = 0.07$). Only 3 smiles were found to be non-consonant after treatment, whereas majority of the non-consonant smiles in the sample, i.e., 21 smiles, improved and became consonant after treatment. Also, the 24 smiles that were consonant pre-treatment were maintained.

Micro-esthetics of the smile was assessed using pre- and post-treatment casts of the patients. Raj et al[24] compared connector heights in treated and untreated casts. The findings, they reported for average connector heights in orthodontic treated sample were 49% for central incisors, 38% for central and lateral incisors and 27% for lateral incisors and canines. In our study a significant overall improvement in the connector heights of the anterior sextant was observed after correction of malalignment and axial inclinations. Mean pre-treatment percentage of the central incisor's connector heights was 36.14%, whereas after treatment this value increased to 42.96% with a mean change of 6.82% ($p < 0.01$). Similarly, connectors between the central and lateral incisors improved from 25.84% to 32.78% ($p<0.01$) and that between the lateral incisor and canine increased from 16.57% to 23.63% ($p<0.01$). All connectors were improved up to values that are

suggested by Morley et al[12] as optimal. However, ideal values are difficult to achieve due to restrictions posed by tooth morphology and size.

Snow[25] proposed the golden percentage of the maxillary incisors and canine in esthetic smiles to be 25%, 15% and 10% of the width of the anterior six teeth¸ respectively. Murthy et al[26] assessed the existence of this percentage in natural smiles of 56 patients and reported 22%, 15.5% and 12.5% golden proportions for anterior maxillary teeth. In this study, we have found the mean pre-treatment golden percentage of the maxillary central incisor was 22.44%, which changed post-orthodontically to 23.63%, with a mean change of 1.19% ($p = 0.002$). Changes in the golden percentage of the lateral incisor were similar, with a mean change of 2.31% from 12.95% to 14.08% ($p = 0.03$). The golden percentage of the canine also improved after treatment from 11.66% to 9.62% ($p < 0.01$). These changes can be attributed to better alignment and maintenance of arch form despite the extraction of premolars during treatment.

It should be noted that a detailed analysis of facial and smile esthetics is a prerequisite to initiation of treatment in order to achieve the final artistic outcomes of appearance. The decision for extraction treatment should be made only on the basis of solid indications. However, the final appearance of the patient is highly dependent on the technique and skill of the orthodontist

Conclusions

The following conclusions have been drawn from the present study:

- The micro, mini and macro esthetics are not affected negatively by extraction orthodontic treatment.
- All the parameters of macro-esthetics like lip prominence, interlabial gap, nasolabial and labiomental angles improve with in normal limits with extraction orthodontic treatment.
- Buccal corridors space does not increase with extraction orthodontic treatment.
- Incisor display during smile improves after correction of malalignment.
- Orthodontic treatment does not flatten smile arcs and deviated dental midlines are corrected with orthodontic treatment.
- Crown heights-width ratios of maxillary central incisor and gingival zenith levels of maxillary lateral incisor are not significantly affected by orthodontic treatment.
- Golden percentage and connectors between the anterior teeth improve with correction of malalignment.

References

1. Linn EL. Social meanings of dental appearance. J Health Hum Behav. 1966;7(4):289-295.
2. Proffit WR, Fields HW, Sarver DM. Contemporary orthodontics. 6th ed. St. Louis: Mosby Elsevier; 2018.
3. Aravind KR, Nivedita S. Role of macro, mini and micro esthetics in orthodoctics. Lambart academic publishing; 2020.
4. Sabri R. The eight components of a balanced smile. J Clin Orthod. 2005;39(3):155-154.
5. Jacobson A. Radiographic cephalometry: from basics to video imaging. 2nd ed. Alabama: Quintessence Publishing;1995.
6. Kim E, Gianelly A A. Extraction vs non-extraction: arch widths and smile esthetics. Angle Orthod 2003;73(4):354–8.
7. Gupta L, Gupta K, Hegde V, Pradeep S, Singh P. Embodiment of Macro and Mini aesthetic elements in rehabilitation of maxillary anterior teeth with porcelain laminates veneer- A clinical report. Int J Clin Dent. 2019;12(4):281-7.
8. Witzig JW, Spahl TJ. The clinical management of basic maxillofacial orthopedic appliances. Littleton-Mass: PSG Publishing Co; 1987.
9. Joy J, Anilkumar. Smile Esthetics in Orthodontics - Review of Literature. IJSR 2020;9(10):367-71.
10. Mackley RJ. An evaluation of smiles before and after orthodontic treatment. Angle Orthod 1993;63(3):183-190.
11. Godinho, Gonc¸alves, and Jardim; Contribution of facial components to the attractiveness of the smiling face in male and female patients: A cross-sectional correlation study. Am J Orthod Dentofacial Orthop 2020; 157(1):98-104.
12. Morley J, Eubanks J. Macroesthetic elements of smile design. J Am Dent Assoc 2001;132(1):39-45.

13. Waldrop TC. Gummy smile: the challenge of ginigival excess: prevalence and guidelines for clinical management. Semin Orthod 2008;14:260-71.
14. Mohammed DR, Al-Sheakli I. Photographic Analysis of Macro- Aand Micro-Aesthetic Appearance in a Sample of Iraqi Adults With Class I Normal Occlusion. J Bagh Coll Dentistry. 2017;29(1):153-9..
15. Finnoy JP, Wisth PJ. Changes in soft tissue profile during and after orthodontic treatment. Eur J Orthod 1987;9(1):68-78.
16. Hazar S, Akyal S,Boyacioúlu H. Soft Tissue Profile Changes in Anatolian Turkish Girls and Boys Following Orthodontic Treatment With and Without Extractions. Turk J Med Sci 2004;34(3):171-8.
17. Burstone CJ. Lip posture and its significance in treatment planning. Am J Orthod 1967;53(4):262-84.
18. Bravo LA. Soft tissue facial profile changes after orthodontic treatment with four premolars extracted. Angle Orthod 1994;64(1):31-42.
19. Jacobson RL. Facial analysis in two and three dimensions. In: Jacobson A. Radiographic cephalometry: from basics to videography. Illinois: Quintessence Publishing Co, Inc; 1995 p273-94.
20. Ijaz A, Sheikh A, Israr J. Lip morphology: a factor leading to bimaxillary dentoalveolar protrusion. Pakistan Oral Dental Journal 2011;31(2):321-7.
21. Frush JP, Fisher RD.The dynesthetic interpretation of the dentogenic concept. J Prosth Dent1958; 8(4):558–581.
22. Zachrisson BU. Making the premolar extraction smile full and radiant. World J Orthod 2002;3:260-5.
23. Ackerman J, Ackerman MB, Brensinger CM, Landis JR. A morphometric analysis of a posed smile. Clin Orthod Res 1998;1(1):2–11.
24. Raj V, Heymann HO, Hershey HG, Ritter AV, Casko JS. The apparent contact dimension and covariates among orthodontically treated and nontreated patients. J Esthet Restor Dent 2009;21(2):96-111.
25. Snow SR. Esthetic smile analysis of maxillary anterior tooth width: The golden percentage. J Esthet Dent 1999;11(4):177-84.
26. Murthy S. B. V, Ramani N. Evaluation of natural smile: Golden proportion, RED or Golden percentage. J Conserv Dent 2008;11(1):16-21.