Original Article

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Dentistry Section

Dentoalveolar and Smile Aesthetic Changes Following Fixed Orthodontic Treatment in Adults with Varying Anterior Overjet: A Retrospective Study

RADHA MANOJ PATURKAR[1], CHAITRA MASTUD[2], RAJAGANESH GAUTAM[3], SONALI DESHMUKH[4], ASMITA KHARCHE[5], PV SWATHI[6]

ABSTRACT

Introduction: Anterior overjet is a key determinant of dentofacial aesthetics and occlusal function, and its correction is a primary objective of fixed orthodontic therapy. It is still unclear how baseline overjet magnitude affects dentoalveolar adaptation during orthodontic treatment in adults. Although fixed appliance therapy routinely addresses excessive overjet, no single study has directly compared whether patients grouped by initial overjet category respond differently- or whether any such differences carry through to smile aesthetic parameters.

Aim: To compare skeletal, dental, and smile aesthetic changes after comprehensive fixed orthodontic treatment in 30 adult patients, divided into three groups by baseline anterior overjet (OJ): normal (0-4 mm), excessive (>4 mm), and negative/reverse (<0 mm).

Materials and Methods: This retrospective observational study was conducted at the Department of Orthodontics at Dr DY Patil Dental College and Hospital, Pimpri, Pune, Maharashtra, India using treatment records of patients treated between 2018 and 2024; the study itself was planned, executed, and analysed between January 2024 and February 2025 Thirty patients satisfied all inclusion criteria and were assigned to three groups of 10 on the basis of baseline anterior overjet: Group 1 (normal overjet, 0-4 mm), Group 2 (excessive overjet, >4 mm), and Group 3 (negative/reverse overjet, <0 mm). Pre- and post-treatment lateral cephalograms and standardised frontal smile photographs were assessed across 21 parameters - 7 skeletal, 7 dental, and 7 smile-related. Within-group changes were tested with paired-samples t-tests; between-group treatment change scores were compared using One-way Analysis of Variance (ANOVA) with Tukey HSD post-hoc testing (α=0.05).

Results: Group 2 (excessive overjet) showed the greatest and most consistent dentoalveolar response: U1-NA (mm) reduced by 4.00 mm (p=0.004), U1-NA° by 11.80° (p=0.004), L1-NB° by 4.00° (p=0.034), and U1-PP° increased by 16.90° (p = 0.003), with concurrent SNA reduction of 2.20° (p=0.002) and ANB reduction of 1.40° (p=0.039). Group 1 (normal overjet) showed significant retroclination of U1-NA° (6.70°; p=0.016), U1-NA (mm) reduction (p = 0.041), U1-PP° change (p=0.020), and a significant decrease in interlabial gap (p=0.035). Group 3 (negative overjet) showed no statistically significant change in any parameter. Between-group ANOVA confirmed significant differences for U1-NA° (F=3.665; p=0.042) and U1-PP° (F=4.938 p=0.016). Smile Index increased significantly within Group 2 (p=0.043); all other smile parameters were non significant across all groups.

Conclusion: Fixed orthodontic treatment produced dentoalveolar changes that scaled with baseline overjet severity. Adults with excessive overjet showed the most pronounced skeletal and dental changes, particularly in upper incisor inclination. Larger prospective trials are required to determine treatment sensitivity for these indices because smile aesthetic measures were mostly insensitive to tooth movement in study design.

Keywords: Aesthetics, Cephalometry, Dental, Incisor, Lip, Smiling

INTRODUCTION

One of the most clinically significant metrics in orthodontic evaluation is anterior overjet, which is the horizontal distance between the labial surfaces of the upper and lower central incisors at intercuspation [1]. Incisal guidance, anterior tooth inclination, resting lip posture, and facial profile convexity are all directly impacted by overjet. Adult patients have a wide range of overjet those with normal overjet (0-4 mm) typically only require alignment refinement; those with excessive overjet (>4 mm), which frequently present with Class II Division 1 malocclusion, require meaningful incisor retraction; and those with negative or reverse overjet (<0 mm), which is typical of Class III malocclusion, may require surgery or incisor proclination [2].

Despite this clinical range, direct comparative data on how each overjet category responds to fixed appliance treatment in adults across both cephalometric and smile photographic parameters remain scarce [2,3]. Most existing studies focus on a single type of malocclusion [3,4], or they include growing patients in whom ongoing skeletal changes obscures the true treatment effect [5]. Adults are a distinct group in this respect: because skeletal change is minimal after growth completion, treatment effects are largely confined to the dentoalveolar complex, making them well-suited for isolating the dental response to orthodontic mechanics across different overjet categories.

Smile aesthetics has emerged as an important treatment outcome in orthodontics, extending beyond occlusal corrections to encompass the soft-tissue and photographic dimensions of treatment success. Photographic indices such as buccal corridor ratio, arc ratio, smile index, and interlabial gap have been proposed as objective measures of smile aesthetics [6]. Yet whether these parameters change meaningfully with fixed appliance treatment and whether any such response depends on the initial overjet category, is still not well established. Sarver DM highlighted that the smile arc (the relationship of maxillary incisor curvature to the lower lip contour) is the key aesthetic parameter

that can be altered by orthodontic mechanics, particularly incisor retraction and intrusion [7]. Moreover, recent evidences suggest that considerable variability exists in smile characteristics even within the same malocclusion class, leaving substantial room for improvement during orthodontic treatment [7].

The present study set out to compare skeletal, dental, and smile aesthetic treatment changes in 30 adult patients divided into three equal groups by baseline anterior overjet.

The null hypothesis states that there were no significant between-group differences in pre-to-post treatment changes would be detected for any measured parameter.

MATERIALS AND METHODS

This retrospective observational study was conducted at the Department of Orthodontics at Dr DY Patil Dental College and Hospital, Pimpri, Pune, using treatment records of patients treated between 2018 and 2024; the study itself was planned, executed, and analysed between January 2024 and February 2025. The study was carried out in accordance with the Declaration of Helsinki (2013 version), and Institutional Ethics Committee approval was obtained prior to data extraction (IEC approval number: DYPDCH/IEC/13/2024). All records were de-identified before analysis, and the requirement for informed consent was waived given the retrospective nature of the study.

Inclusion criteria: Patients aged ≥18 years of age who had completed their orthodontic treatment and complete orthodontic treatment records were included.

Exclusion criteria: Patients with craniofacial anomalies or syndromes; a history of orthognathic surgery; periodontal bone loss exceeding 3 mm; incomplete records; prior orthodontic treatment.

Sample size calculation: Sample size was calculated using the formula

$$n=\{(z_{1-}\alpha/2+z_{1-}\beta)/dz\}^2$$

$z_{\alpha/2}=1.96$,

$z_{\beta}=0.84$,

$d_z=1.0$,

$\alpha=0.05$,

power=80%.

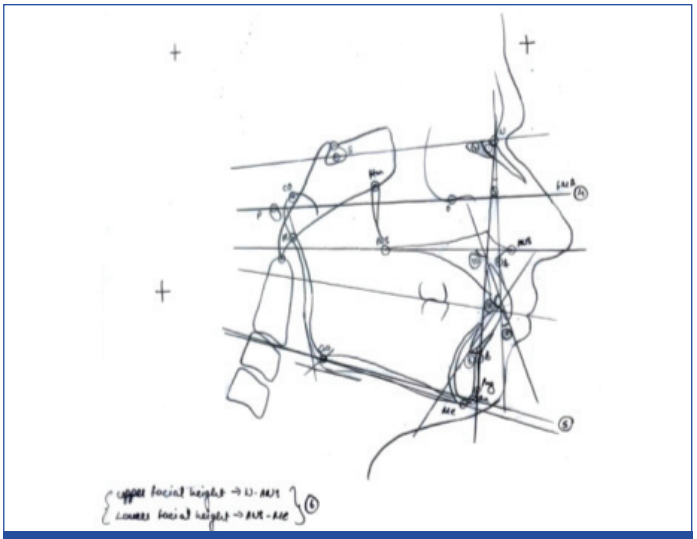
based on a paired sample t-test design for the primary within-group pre- to post-treatment comparisons. Assuming a large effect size (Cohen's dz=1.0), a sample of 10 patients per group provided approximately 80% power to detect significance within-group change at $\alpha=0.05$.

Study Procedure

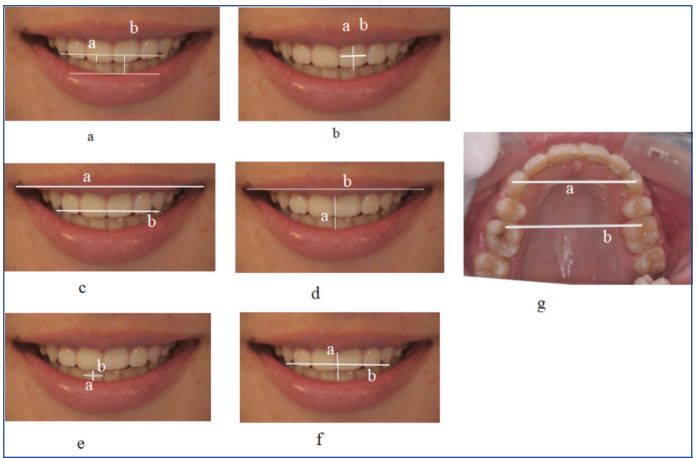
Thirty patients satisfied all inclusion criteria and were assigned to three groups of 10 on the basis of baseline anterior overjet: Group 1 (normal overjet, 0-4 mm), Group 2 (excessive overjet, >4 mm), and Group 3 (negative/reverse overjet, <0 mm).

Cephalometric analysis: Pre- and post-treatment lateral cephalograms were digitally traced in Dolphin Imaging v.11.9. Fourteen cephalometric parameters were recorded at each time point: seven skeletal (SNA, SNB, ANB, FMA, GoGn-SN, UFH/LFH, PFH/AFH) and seven dental (IMPA, U1-NA mm, U1-NA°, L1-NB mm, L1-NB°, U1-PP°, U1-L1°). All landmarks were identified by a single trained examiner, with intraclass correlation coefficients exceeding 0.92 for all measurements on 20 repeat tracings performed at a two-week interval [Table/Fig-1,2].

Smile analysis: Standardised frontal smile photographs were taken with a Canon EOS 80D camera fitted with a 100-mm macro lens, at a fixed distance of 80 cm, with the patient in natural head position and the Frankfort horizontal plane parallel to the floor. Seven smile parameters were then measured in ImageJ (NIH): upper lip height, smile index, buccal corridor, arch form index, lower teeth exposure, interlabial gap, and arc ratio. All photographic measurements were performed by the same examiner (ICC >0.90 on 15 repeat records).



[Table/Fig-1]: Cephalometric landmarks and skeletal, dental variables used in this study. Skeletal parameters: 1) SNA; 2) SNB; 3) ANB; 4) FMA; 5) GoSnSN; 6) Upper facial height, Lower facial height; Dental parameters; 7) U1NA; 8) L1NB; 9) U1L1; 10) U1PP.



[Table/Fig-2]: a) Arc Ratio; b) Upper lip height; c) Buccal corridor ratio; d) Smile index; e) Lower teeth exposure; f) Interlabial gap; g) Archform index.
(The Images were taken at Orthodontics department at Dr D.Y Patil Dental College and Hospital, Pimpri, Pune.)

Parameters definitions: All parameters are defined in [Table/Fig-3] as per mentioned in study by Cheng HC and Cheng PC [8].

No.	Parameters	Definition/Measurement method
Smile parameters		
1	Upper lip height	Shortest distance from the incisal edge of tooth 11 to the lower border of the upper lip ÷ mesiodistal width of tooth 11
2	Smile index	Intercommissure width ÷ interlabial gap
3	Buccal corridor	Intercommissure width ÷ intercanine width
4	Arch form index	Intercanine width ÷ intermolar width
5	Lower teeth exposure	Distance from incisal edge of tooth 11 to upper border of lower lip ÷ mesiodistal width of tooth 41
6	Interlabial gap	Interlabial gap ÷ intercanine width
7	Arc ratio	Perpendicular distance from incisal edge of tooth 11 to the line connecting maxillary canine cusp tips ÷ distance between a tangent line at the upper border of the lower lip and the maxillary intercanine line
Skeletal parameters (lateral cephalogram)		
8	SNA	Sella–Nasion–A point angle; anteroposterior maxillary position relative to cranial base.
9	SNB	Sella–Nasion–B point angle; anteroposterior mandibular position relative to cranial base.

10	ANB	Difference SNA – SNB; classifies jaw relationship (Class I: 2-4°; Class II: >4°; Class III: <2°).
11	FMA	Frankfort–Mandibular plane angle; reflects vertical facial pattern.
12	GoGn-SN	Gonion–Gnathion to Sella–Nasion angle; alternative measure of vertical facial divergence.
13	UFH/LFH	Upper (Nasion–ANS) to lower (ANS–Menton) facial height ratio.
14	PFH/AFH	Posterior (Sella–Gonion) to anterior (Nasion–Menton) facial height ratio.
Dental parameters (lateral cephalogram)		
15	IMPA	Incisor–Mandibular plane angle; inclination of lower central incisor to mandibular plane.
16	U1-NA	Linear distance from most labial point of upper central incisor to NA line.
17	U1-NA	Angle between long axis of upper central incisor and NA line; upper incisor inclination.
18	L1-NB	Linear distance from most labial point of lower central incisor to NB line.
19	L1-NB	Angle between long axis of lower central incisor and NB line; lower incisor inclination.
20	U1-PP	Angle between the long axis of the upper central incisor and the palatal plane (ANS–PNS).
21	U1-L1 / Interincisal Angle	Angle between the long axes of the upper and lower central incisors.

[Table/Fig-3]: Definitions and measurement methods for all skeletal, dental, and smile parameters.
All the smile parameters are in a % (ratio) form.
ICC= Intraclass correlation coefficient

STATISTICAL ANALYSIS

The Shapiro-Wilk test confirmed normality for all variables (p>0.05). Within-group pre-to-post differences were assessed with paired-samples t-tests. Between-group differences in treatment change scores were evaluated by One-way ANOVA, followed by Tukey HSD post-hoc testing where the ANOVA reached significance. All statistical analyses were performed in Statistical Package for Social Sciences (SPSS) version 26.0 v.26 (IBM Corp., Armonk, NY, USA) with significance set at p<0.05.

RESULTS

Sample characteristics: The final sample comprised 30 adult patients, 10 per group. Mean age at the start of treatment was 22.4±3.1 years (group 1), 21.8±4.3 years (group 2), and 23.1±3.8 years (group 3). Mean treatment duration across the whole cohort was 22.3±5.6 months. As clinically necessary, extractions were carried out on a subset of patients in each group; the ensuing variance in extraction rates between groups is a potential confounding factor that is covered in the limitations section.

Within-group Treatment Changes

Group 1 (Normal OJ): All skeletal parameters and the remaining smile indices were non significant (all p>0.17), consistent with a purely dentoalveolar treatment effect; on the dental side, U1-NA° retroclined by 6.70° (p=0.016) and U1-NA (mm) decreased by 2.30 mm (p=0.041), together confirming upper incisor retraction in both angular and linear dimensions. All the smile parameters are in a % (ratio) form. Upper incisor retraction was confirmed in both angular and linear dimensions on the dental side by U1-NA° retroclining by 6.70° (p=0.016) and U1-NA (mm) decreasing by 2.30 mm (p=0.041). Palatal retroclination independent of jaw location was indicated by a 6.70° (p=0.020) increase in U1-PP°. The interlabial distance decreased by 4.31 mm (p=0.035), suggesting that lip competence has improved. A primarily dentoalveolar treatment effect was consistent with the non significance of all skeletal measures and the remaining smile indices (all p>0.17) [Table/Fig-4].

Parameters	Pre-treatment Mean±SD	Post-treatment Mean±SD	Mean difference	p-value
Smile parameters				
Upper lip height	107.04±16.71	112.50±49.85	-5.46	0.673
Smile index	510.54±75.25	577.33±124.98	-66.79	0.128
Buccal corridor	164.84±13.83	166.30±11.31	-1.46	0.573
Arch form index	78.39±7.62	81.01±8.58	-2.62	0.174
Lower teeth exposure	45.44±30.01	54.44±54.20	-8.99	0.660
Interlabial gap	32.79±4.35	28.48±4.62	4.31	0.035*
Arc ratio	34.54±27.70	43.37±32.27	-8.83	0.468
Skeletal parameters				
SNA	85.40±3.24	84.50±3.37	0.90	0.171
SNB	81.90±2.69	81.20±3.58	0.70	0.242
ANB	3.30±1.16	3.40±1.26	-0.10	0.859
FMA	20.70±4.32	21.40±6.35	-0.70	0.603
GoGn-SN	26.00±5.25	25.50±6.45	0.50	0.637
UFH/LFH ratio	0.74±0.08	0.77±0.07	-0.02	0.297
PFH/AFH ratio	70.12±5.36	70.54±7.37	-0.42	0.713
Dental parameters				
IMPA	101.00±6.78	97.81±6.01	3.19	0.330
U1-NA	5.20±1.99	2.90±1.79	2.30	0.041*
U1-NA	27.70±4.03	21.00±4.35	6.70	0.016*
L1-NB	6.30±2.63	4.80±1.03	1.50	0.101
L1-NB	30.60±7.62	25.60±4.12	5.00	0.137
U1-PP	66.50±4.97	73.20±5.05	-6.70	0.020*
U1-L1 / Interincisal angle	116.36±11.25	127.50±7.11	-11.14	0.061

[Table/Fig-4]: Group 1 (Normal Overjet, 0-4 mm; n=10) Pre- and post-treatment comparison.
SNA: Sella–Nasion–A point; SNB: Sella–Nasion–B point; ANB: A point–Nasion–B point; FMA: Frankfort–mandibular plane angle; GoGn-SN: Gonion–Gnathion to Sella–Nasion; UFH/LFH: Upper-to-Lower facial height ratio; PFH/AFH: Posterior-to-Anterior facial height ratio; IMPA: Incisor–Mandibular plane angle; U1-NA: Upper incisor to NA line; L1-NB: Lower incisor to NB line; U1-PP: Upper incisor to palatal plane; U1-L1: Interincisal angle. * p<0.05; highlighted rows: statistically significant parameters.

Group 2 (Excessive OJ): According to [Table/Fig-5], this group had the most significant characteristics, with six of them approaching significance. Particularly noticeable was the retraction of the upper incisor: U1-NA° decreased by 11.80° (p=0.004) and U1-NA (mm) by 4.00 mm (p=0.004), which is about double the magnitude observed in group 1. The greatest palatal retroclination among the three groups was seen in U1-PP°, which increased by 16.90° (p=0.003). During space closure, L1-NB° decreased by 4.00° (p=0.034), indicating concurrent lower incisor retroclination. SNA decreased by 2.20° (p=0.002) and ANB by 1.40° (p=0.039) at the skeletal level; these results are consistent with anterior alveolar remodeling caused by incisor retraction. All other smiling metrics were non significant (p>0.20), but the smiling Index increased significantly (p=0.043) [Table/Fig-5].

Parameters	Pre-treatment Mean±SD	Post-treatment Mean±SD	Mean difference	p-value
Smile parameters				
Upper lip height	120.90±36.23	121.02±17.49	-0.12	0.990
Smile index	437.53±74.63	486.16±86.05	-48.63	0.043*
Buccal corridor	163.47±12.54	171.01±8.56	-7.53	0.210
Arch form index	80.04±13.45	79.40±3.79	0.64	0.899
Lower teeth exposure	59.55±36.01	79.38±51.26	-19.82	0.349
Interlabial gap	60.73±68.31	37.06±7.22	23.66	0.290
Arc ratio	36.45±34.75	46.32±24.00	-9.87	0.504
Skeletal parameters				
SNA	84.20±2.86	82.00±2.16	2.20	0.002*
SNB	80.00±2.26	79.10±1.20	0.90	0.171

ANB	4.20±2.04	2.80±1.75	1.40	0.039*
FMA	23.20±4.71	25.00±5.25	-1.80	0.051
GoGn-SN	27.30±4.52	28.10±3.78	-0.80	0.343
UFH/LFH ratio	0.71±0.10	0.70±0.09	0.01	0.700
PFH/AFH ratio	69.52±4.08	68.45±3.18	1.07	0.246
Dental parameters				
IMPA	101.40±7.88	97.90±6.44	3.50	0.157
U1-NA	7.30±3.02	3.30±1.89	4.00	0.004*
U1-NA	35.10±8.37	23.30±4.83	11.80	0.004*
L1-NB	6.30±2.87	5.00±2.00	1.30	0.083
L1-NB	32.10±6.44	28.10±5.04	4.00	0.034*
U1-PP	58.00±6.70	74.90±11.31	-16.90	0.003*
U1-L1/Interincisal angle	106.30±10.72	117.70±20.23	-11.40	0.107

[Table/Fig-5]: Group 2 (Excessive Overjet, >4 mm; n = 10)- pre- and post-treatment comparison.
SNA: Sella–Nasion–A point; SNB: Sella–Nasion–B point; ANB: A point–Nasion–B point; FMA: Frankfort–Mandibular plane angle; GoGn-SN: Gonion–Gnathion to Sella–Nasion; UFH/LFH: Upper-to-Lower facial height ratio; PFH/AFH: Posterior-to-Anterior facial height ratio; IMPA: Incisor–Mandibular plane angle; U1-NA: Upper incisor to NA line; L1-NB: Lower incisor to NB line; U1-PP: Upper incisor to palatal plane; U1-L1: Interincisal angle. * p<0.05; highlighted rows = statistically significant parameters

Group 3 (Negative OJ): U1-NA° showed a non significant increase of 3.20° and U1-PP° a non significant decrease of 3.00°- directional changes opposite to those observed in group 1 and 2, which is consistent with mild upper incisor proclination during camouflage mechanics. The wide baseline variability for U1-NA° (SD=11.49°) reflects the clinical heterogeneity inherent to non surgical Class III management. GoGn-SN approached significance (p=0.053) and should be monitored for progressive vertical divergence. In contrast to group 1 and 2, U1-NA° had a non significant increase of 3.20° and U1-PP° a non significant drop of 3.00°. These directional changes are compatible with modest upper incisor proclination during concealment mechanics. The clinical heterogeneity present in non surgical Class III care is reflected in the large baseline variability for U1-NA° (SD=11.49°). GoGn-SN is close to significance (p=0.053) and should be watched for increasing vertical divergence [Table/Fig-6].

Between-group comparisons: Two parameters, U1-NA° (F=3.665; p=0.042) and U1-PP° (F=4.938; p=0.016), showed statistically significant between-group differences according to a One-way ANOVA comparing the pre-to-post treatment change scores across the three groups [Table/Fig-7]. While ANB came close to significance (F=2.675; p=0.090), none of the other 19 parameters, which covered the skeletal, dental, and smile aesthetic domains, displayed a significant between-group difference (all p>0.08). The magnitude of treatment-induced change varied significantly between overjet categories only for upper incisor angulation relative to the NA line and palatal plane, despite the wider range of dentoalveolar and skeletal changes seen within each group individually. This suggests that baseline overjet severity most strongly influences the degree of upper incisor repositioning rather than other skeletal or smile-related outcomes.

Patients with excessive overjet experienced significantly more incisor retroclination than those with negative overjet, as evidenced by the significant difference between group 2 and group 3 for U1-NA° {mean difference: 15.00°; 95% CI: (3.78, 26.22); p=0.012}. The comparison between group 1 and group 3 was almost significant (difference: 9.90°; p=0.060). Palatal retroclination of the upper incisor scaled with initial overjet severity across all three groups, as evidenced by the significant differences between group 2 and group 3 {difference: –19.90°; 95% CI: (-32.90, -6.90); p=0.005} and group 1 {difference: 10.20°; 95% CI: (0.02, 20.38); p=0.050} for U1-PP° [Table/Fig-8].

Parameters	Pre-treatment Mean±SD	Post-treatment Mean±SD	Mean difference	p-value
Smile parameters				
Upper lip height	98.96±19.11	103.53±10.62	-4.57	0.445
Smile index	516.75±129.09	496.03±118.42	20.72	0.437
Buccal corridor	159.17±7.61	161.78±4.94	-2.62	0.456
Arch form index	76.01±4.61	77.76±4.84	-1.75	0.271
Lower teeth exposure	52.90±30.81	44.96±34.75	7.93	0.213
Interlabial gap	28.90±6.37	31.86±4.89	-2.96	0.218
Arc ratio	42.23±37.31	31.16±34.91	11.08	0.515
Skeletal parameters				
SNA	83.40±3.69	82.70±3.77	0.70	0.448
SNB	83.00±3.59	81.40±3.37	1.60	0.116
ANB	0.40±1.43	1.00±2.00	-0.60	0.382
FMA	19.10±5.86	20.00±5.01	-0.90	0.446
GoGn-SN	23.30±4.62	24.90±3.21	-1.60	0.053
UFH/LFH Ratio	0.79±0.09	0.78±0.08	0.01	0.758
PFH/AFH Ratio	73.39±4.64	72.68±4.83	0.72	0.307
Dental parameters				
IMPA	93.40±7.49	93.80±4.98	-0.40	0.858
U1-NA	4.90±2.47	4.80±2.57	0.10	0.939
U1-NA	24.70±11.49	27.90±6.74	-3.20	0.483
L1-NB	3.40±2.46	3.00±1.15	0.40	0.599
L1-NB	23.00±8.63	22.00±4.16	1.00	0.724
U1-PP	69.20±12.39	66.20±8.31	3.00	0.524
U1-L1 / Interincisal angle	129.40±19.00	120.10±20.50	9.30	0.313

[Table/Fig-6]: Group 3 (Negative/Reverse Overjet, <0 mm; n=10)- pre- and post-treatment comparison.
No parameter reached statistical significance in Group 3 (all p>0.05). SNA: Sella–Nasion–A point; SNB: Sella–Nasion–B point; ANB: A point–Nasion–B point; FMA: Frankfort–Mandibular plane angle; GoGn-SN: Gonion–Gnathion to Sella–Nasion; UFH/LFH: Upper-to-Lower facial height ratio; PFH/AFH: Posterior-to-Anterior facial height ratio; IMPA: Incisor–Mandibular plane angle; U1-NA: Upper incisor to NA line; L1-NB: Lower incisor to NB line; U1-PP: Upper incisor to palatal plane; U1-L1: Interincisal angle. * p<0.05; highlighted rows=statistically significant parameters

DISCUSSION

The present retrospective study looked at how 30 adults in three overjet categories responded to extensive fixed orthodontic treatment in terms of their skeletal, dental, and smile aesthetics. Three key conclusions were drawn: (1) dentoalveolar change was associated with initial overjet severity, with group 2 (excessive overjet) exhibiting the highest number and magnitude of significant changes; (2) upper incisor angular change differences between groups were statistically confirmed for both U1-NA° and U1-PP°; and (3) smile photographic parameters were largely unresponsive to treatment, with only Smile Index reaching significance in one group and interlabial gap in another.

The significant reductions in U1-NA° and U1-PP° in group 2 are in keeping with established treatment expectations for Class II Division 1 malocclusion, where premolar extraction and space closure mechanics reliably retrocline proclined upper incisors [3,4]. The degree of U1-PP° change in group 2 (16.90°) falls within the range reported by Luppanapornlarp S and Johnston LE and Konstantonis D et al., who documented similar ranges of incisor retroclination in extraction-treated Class II patients [9,10]. The accompanying 2.20° reduction in SNA is a well-recognised consequence of upper incisor retraction, whereby the sustained posterior force on the dentition drives remodelling of the anterior alveolar process and causes point A to shift posteriorly [11]. The resulting 1.40° ANB reduction in group 2 is therefore at least partly a mechanical consequence of tooth movement rather than a true skeletal change, which underlines why SNA and ANB values should always be interpreted in clinical context. Ekstam M et al., demonstrated in a retrospective

Pre-post difference		N	Minimum	Maximum	Mean	Std. deviation	F	p-value
Upper lip height	Group 1	10	-111.10	23.33	-5.2111	41.98819	0.076	0.927
	Group 2	10	-39.00	37.79	.1000	29.93974		
	Group 3	10	-28.69	30.30	-4.9813	20.53072		
Smile index	Group 1	10	-325.85	146.90	-68.5767	133.40077	0.076	0.927
	Group 2	10	-131.46	56.30	-48.6511	69.40047		
	Group 3	10	-92.49	157.03	20.9088	91.13233		
Buccal corridor	Group 1	10	-13.59	14.39	-1.4422	8.37401	0.535	0.593
	Group 2	10	-46.00	15.87	-7.8211	18.70077		
	Group 3	10	-21.34	14.50	-2.7075	12.04199		
Arch form	Group 1	10	-10.00	10.00	-2.6722	5.95006	0.535	0.593
	Group 2	10	-8.62	41.03	.6067	16.37749		
	Group 3	10	-9.76	4.63	-1.5300	5.33881		
Lower teeth exp	Group 1	10	-171.40	60.00	-8.2711	66.33397	0.543	0.588
	Group 2	10	-166.60	51.51	-19.8211	67.26426		
	Group 3	10	-8.81	51.85	8.9150	21.07472		
Interlabial gap	Group 1	10	-3.74	13.05	4.1844	5.81637	1.129	0.341
	Group 2	10	-2.56	213.01	25.9889	70.19613		
	Group 3	10	-17.34	6.17	-2.9450	7.98819		
Arc ratio	Group 1	10	-100.00	30.20	-8.7956	39.07857	0.522	0.600
	Group 2	10	-80.95	73.07	-9.8767	47.58751		
	Group 3	10	-100.00	74.60	11.7463	58.63033		
SNA	Group 1	10	-2.00	4.00	.8889	2.02759	1.184	0.324
	Group 2	10	0.00	4.00	2.2222	1.64148		
	Group 3	10	-5.00	4.00	.6250	3.15945		
SNB	Group 1	10	-4.00	2.00	.6667	1.87083	0.460	0.637
	Group 2	10	-1.00	6.00	.8889	2.02759		
	Group 3	10	-1.00	8.00	1.7500	3.28416		
ANB	Group 1	10	-3.00	2.00	-.1111	1.83333	2.675	0.090
	Group 2	10	-2.00	4.00	1.4444	1.94365		
	Group 3	10	-4.00	3.00	-.7500	2.31455		
FMA	Group 1	10	-5.00	10.00	-.6667	4.35890	0.255	0.777
	Group 2	10	-6.00	2.00	-1.8889	2.66667		
	Group 3	10	-9.00	5.00	-1.0000	4.03556		
GOGNSN	Group 1	10	-2.00	9.00	.4444	3.43188	1.076	0.357
	Group 2	10	-6.00	2.00	-.7778	2.68225		
	Group 3	10	-6.00	3.00	-1.6250	2.55999		
IMPA	Group 1	10	-14.00	23.00	3.2144	10.39766	0.552	0.583
	Group 2	10	-9.00	12.00	3.5556	7.60117		
	Group 3	10	-10.00	16.00	-.5000	7.78276		
U1NA(mm)	Group 1	10	-2.00	8.00	2.3333	3.24037	2.119	0.143
	Group 2	10	-2.00	9.00	4.0000	3.46410		
	Group 3	10	-6.00	8.00	.2500	4.52769		
U1NA	Group 1	10	-5.00	18.00	6.6667	7.56637	3.665	0.042
	Group 2	10	-10.00	26.00	11.7778	10.24424		
	Group 3	10	-24.00	25.00	-3.1250	15.67926		
L1NB(mm)	Group 1	10	-4.00	6.00	1.4444	2.74368	0.446	0.645
	Group 2	10	-2.00	4.00	1.3333	2.23607		
	Group 3	10	-4.00	5.00	0.3750	2.61520		
L1NB	Group 1	10	-15.00	23.00	5.0000	10.27132	0.475	0.628
	Group 2	10	-6.00	11.00	4.0000	5.38516		
	Group 3	10	-8.00	22.00	1.0000	9.81253		
U1PP	Group 1	10	-20.00	5.00	-6.7778	7.99653	4.938	0.016
	Group 2	10	-45.00	6.00	-16.8889	14.15490		
	Group 3	10	-28.00	26.00	3.1250	16.22553		
U1L1	Group 1	10	-39.00	21.00	-11.0444	17.46333	2.227	0.131
	Group 2	10	-27.00	36.00	-11.3333	21.32487		
	Group 3	10	-43.00	61.00	10.0000	31.08514		

UFH/LFH	Group 1	10	-.10	0.10	-.0222	.06667	0.336	0.718
	Group 2	10	-.10	0.10	.0111	.09280		
	Group 3	10	-.20	0.20	.0125	.13562		
PFH/AFH	Group 1	10	-9.80	2.90	-.4267	3.74503	0.625	0.544
	Group 2	10	-3.15	5.19	1.0667	2.88359		
	Group 3	10	-4.13	2.72	.8813	2.32919		

[Table/Fig-7]: Comparison of the mean pre-post treatment change across group 1, group 2, and group 3 using One-way ANOVA- all skeletal, dental, and smile parameters. One-way ANOVA found significant between-group differences in treatment change scores for two parameters: U1-NA° (F=3.665; p=0.042) and U1-PP° (F=4.938; p=0.016). No other parameter showed a significant between-group difference (all p>0.06). Post-hoc Tukey HSD results are shown in [Table/Fig-8].

Dependent variables	Group I	Group J	Mean diff (I-J)	Std. error	p-value	95% CI (Lower, Upper)
Pre-post difference: U1-NA (°)						
U1-NA (°)	Group 1	Group 2	-5.10	3.80	0.196	(-13.08, 2.88)
	Group 1	Group 3	9.90	4.93	0.060	(-0.45, 20.25)
	Group 2	Group 3	15.00	5.34	0.012*	(3.78, 26.22)
Pre-post difference: U1-PP (°)						
U1-PP (°)	Group 1	Group 2	10.20	4.85	0.050*	(0.02, 20.38)
	Group 1	Group 3	-9.70	5.12	0.074	(-20.45, 1.05)
	Group 2	Group 3	-19.90	6.19	0.005*	(-32.90, -6.90)

[Table/Fig-8]: Post-hoc pairwise comparisons (Tukey HSD) for U1-NA (°) and U1-PP (°)- the only parameters with significant between-group ANOVA.
*p<0.05. Group 1=Normal OJ (0-4 mm; n=10); Group 2=Excessive OJ (>4 mm; n=10); Group 3= Negative OJ (<0 mm; n=10). CI=Confidence Interval; OJ=Overjet

cephalometric study that extraction based fixed appliance therapy significantly affects incisor protrusion and proclination but does not alter the jaw position, supporting the interpretation that the SNA and ANB changes observed in group 2 of the present study represents dentoalveolar remodelling rather than genuine skeletal displacement [12]. Simliarly, Assi B et al., found that maxillary incisor inclination stability after treatment was primarily governed by controlled torque mechanics, and in normodivergent and hyperdivergent patients skeletal axes may guide aesthetic incisor positioning, consistent with the magnitude of U1-NA° and U1PP° changes observed in the excessive overjet group [13].

In group 1, significant changes in U1-NA° (6.70°), U1-NA mm (2.30 mm), and U1-PP° (6.70°) indicate that even patients with normal baseline overjet experience measurable incisor repositioning during treatment. This probably reflects mild proclination present at the outset within the normal overjet range, that was corrected during levelling and aligning, aligning with published reports of incisor change in non extraction Class I cases [14]. The significant reduction in interlabial gap (4.31 mm) in this group suggests that lip competence improved alongside incisor retraction, a finding consistent with soft-tissue changes reported after incisor repositioning in the literature [1].

The complete absence of significant changes in group 3 needs to be placed in context. Non surgical management of reverse overjet in adults generally involves limited incisor movement typically proclination of the upper incisors and mild retroclination of the lower incisors as dental camouflage, rather than the more extensive retraction mechanics used in group 1 and 2. The directional trends for U1-NA° and U1-PP° in group 3 (non significant increases and decreases, respectively) are consistent with this mild upper incisor proclination during camouflage treatment. The wide within-group variability for U1-NA° at baseline (SD 11.49°) also reflects the heterogeneity inherent in this group, which includes both mild dental and moderate skeletal Class III presentations, and a larger sample would be needed to resolve treatment effects statistically. These directional patterns are consistent with the expected mechanics of Class III orthodontic camouflage, which involves proclination of maxillary incisors and retroclination of mandibular incisors to establish positive overjet without altering the underlying skeletal discrepancy [15]. Araujo MTS and Squeff LR confirmed that following non surgical camouflage of skeletal class III malocclusion, no skeletal changes and the dental compensations achieved showed good long-term stability, supporting the interpretation that the minimal parametric change in group 3 reflects the known limitations of camouflage mechanics rather than inadequate treatment [15].

The limited responsiveness of smile photographic parameters across all three groups is worth noting. Only Smile Index reached significance in group 2, and the interlabial gap in group 1. The limited statistical responsiveness of these parameters is partly attributed to high intra- and inter-individual variability inherent in photographic smile measurements, which substantially reduces the power to detect clinically meaningful change within a small sample. Beyond variability, the photographic parameters used here- buccal corridor, arc ratio, smile index are composite measures influenced not only by dental position but also by lip mobility, tone, and gingival anatomy, none of which change in a predictable way with fixed appliance treatment alone [6]. Arrubla-escobar D et al., similarly reported high variability in smile characteristics at the finishing phase of orthodontic treatment, with no statistically significant differences attributed to malocclusion type for most parameters, they concluded that smile arc and midline inclination were the most common areas requiring improvement and were class-specific in their distribution [16]. The non significant findings for these parameters should not, therefore, be read as evidence that orthodontic treatment has no effect on smile aesthetics, but rather that the effect cannot be reliably detected within the constraints of the current design and sample size.

Limitation(s)

Several limitations of the present study should be acknowledged. First, groups of 10 are adequate for detecting large dental changes but underpowered for small-to-moderate effects in smile parameters. Second, extraction status was not stratified within groups; differences in extraction rates across groups are a potential confounder that could independently affect incisor inclination and profile outcomes. In the future, matched designs or extraction status stratification should be used. Third, the data on inter-examiner reliability is limited because just one examiner conducted all of the measurements. Fourth, it was not possible to standardise wire sequences, adjunctive mechanics, or appliance systems across patients due to the retrospective design. Fifth, there was variation in treatment duration, which could have led to within-group heterogeneity.

CONCLUSION(S)

Adults undergoing fixed orthodontic treatment experienced dentoalveolar alterations that increased in proportion to the severity of their initial anterior overjet. With notable changes in upper incisor inclination (U1-NA°, U1-PP°), incisor prominence (U1-NA mm), lower incisor inclination (L1-NB°), and skeletal characteristics (SNA, ANB), group 2 (excessive overjet) displayed the most comprehensive and statistically significant response. Group 1 (normal overjet) had greater lip competence along with notable but minor dental alterations. The limited scope of non surgical camouflage mechanisms is consistent with group 3 (negative overjet) showing no meaningful change for any parameter. U1-NA° and U1-PP° increases were considerably higher in group 2 than in group 3, according to between-group

ANOVA, and U1-PP° also distinguished group 1 and 2. In this sample, smile photographic characteristics revealed a low level of treatment sensitivity. These findings imply that the initial overjet category should be taken into consideration during pre-treatment planning and patient conversations since it is a significant predictor of the extent of orthodontic dentoalveolar alteration.

Prospective studies can compare extraction and non extraction subgroups within each overjet category to isolate the true effect of baseline overjet. Similarly, since assessment here was limited to 2D lateral cephalograms and static frontal photographs, future work incorporating 3D imaging, such as CBCT for dentoalveolar, skeletal, soft-tissues changes, or 3D stereophotogrammetry for dynamic smile analysis, could capture buccolingual along with soft-tissue changes that 2D method cannot detect. Unexplored variables that merit dedicated future study include post-treatment long-term stability of the changes observed and subgrouping of the class III cohort by dental versus skeletal severity, given the wide variability seen with group 3 in the present study.

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PARTICULARS OF CONTRIBUTORS:

1. Postgraduate Student, Department of Orthodontics, Dr. D.Y. Patil Dental College and Hospital, Dr. D.Y. Patil Vidyapeeth, Pimpri, Pune, Maharashtra, India.
2. Professor, Department of Orthodontics, Dr. D.Y. Patil Dental College and Hospital, Dr. D.Y. Patil Vidyapeeth, Pimpri, Pune, Maharashtra, India.
3. Professor and Head, Department of Orthodontics, Dr. D.Y. Patil Dental College and Hospital, Dr. D.Y. Patil Vidyapeeth, Pimpri, Pune, Maharashtra, India.
4. Professor, Department of Orthodontics, Dr. D.Y. Patil Dental College and Hospital, Dr. D.Y. Patil Vidyapeeth, Pimpri, Pune, Maharashtra, India.
5. Associate Professor, Department of Orthodontics, Dr. D.Y. Patil Dental College and Hospital, Dr. D.Y. Patil Vidyapeeth, Pimpri, Pune, Maharashtra, India.
6. Associate Professor, Department of Orthodontics, Dr. D.Y. Patil Dental College and Hospital, Dr. D.Y. Patil Vidyapeeth, Pimpri, Pune, Maharashtra, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Chaitra Mastud,
Professor, Department of Orthodontics, Dr. D.Y. Patil Dental College and Hospital, Dr. D.Y. Patil Vidyapeeth, Sant tukaram Nagar, Pimpri-411018, Pune, Maharashtra, India.
E-mail: chaitra.mastud@dpu.edu.in

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