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Soft Tissue Profile Changes Resulting From Retraction of Maxillary Incisors

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ABSTRACT

Background: *Facial esthetics play a vital role in orthodontic treatment planning, as the relationship between dental movement and soft-tissue adaptation determines overall facial harmony. Retraction of maxillary incisors, commonly performed after premolar extraction, is known to influence lip posture and nasolabial morphology. However, ethnic variations and limited prospective data on South Asian populations have restricted the generalizability of previous findings.* ***Objective****: To determine the changes in soft-tissue profile, specifically upper and lower lip positions relative to Ricketts' E-line, following orthodontic retraction of maxillary incisors in Class II Division 1 malocclusion patients, and to assess whether these changes differ by age or gender.* ***Methods****: A prospective observational study was conducted among 200 patients aged 13–23 years with Class II Division 1 malocclusion treated at Sandeman Provincial Hospital, Quetta, Pakistan. All underwent extraction of maxillary first premolars and standardized anterior retraction with transpalatal arch anchorage. Lateral cephalograms were recorded pre- and post-retraction, and linear measurements from the E-line to upper (UL) and lower lips (LL) were analyzed using SPSS v23. Nonparametric tests compared pre- and post-treatment values, with significance set at $p < 0.05$.* ***Results****: Mean UL and LL positions decreased significantly from $+2.19 \pm 1.87$ mm and $+1.85 \pm 0.12$ mm pre-treatment to -2.03 ± 0.40 mm and -1.69 ± 0.20 mm post-treatment ($p < 0.001$). No statistically significant differences were observed across age (<18 vs ≥18 years) or gender groups ($p > 0.68$).* ***Conclusion****: Retraction of maxillary incisors significantly improves soft-tissue balance by reducing lip protrusion relative to the E-line, independent of patient age or gender. These results provide regionally relevant quantitative benchmarks for predicting facial esthetic outcomes in orthodontic treatment.*

Keywords
Class II Division 1 Malocclusion; Maxillary Incisor Retraction; Soft-Tissue Profile; Facial Esthetics; Orthodontic Treatment

INTRODUCTION

Facial harmony and soft-tissue balance are pivotal determinants of perceived attractiveness and psychosocial confidence, guiding the aims of orthodontic treatment far beyond mere dental alignment (1). In Class II Division 1 malocclusion, excessive maxillary incisor proclination produces lip incompetence and convexity of the facial profile that compromises esthetics and oral function. Orthodontic retraction of the maxillary anterior segment following premolar extraction remains a common therapeutic strategy for correcting this protrusion, yet the magnitude and predictability of associated soft-tissue adaptation differ across populations and treatment modalities (2,3). Earlier studies demonstrated that the nasolabial angle widens and both upper and lower lips move posteriorly relative to Ricketts' E-line after extraction therapy, but the quantitative relationship between dental and soft-tissue movement varies with lip thickness, skeletal pattern, and anchorage control (4–6).

Emerging evidence indicates that bodily incisor retraction achieves greater soft-tissue change than simple tipping mechanics, implying a dose-response coupling between tooth translation and lip setback (7). Meta-analyses comparing extraction versus non-extraction protocols confirm more pronounced upper-lip retraction—often by 2–3 mm—in extraction groups, supporting the clinical expectation that space closure enhances facial flattening (8). However, these data derive predominantly from Western or East-Asian cohorts with different craniofacial morphologies and esthetic norms (9). Studies limited to Caucasian and East-Asian subjects cannot be directly extrapolated to South-Asian populations, where facial convexity and lip thickness differ significantly (10).

Within Pakistan and neighboring regions, few prospective investigations have quantified soft-tissue profile change following incisor retraction despite high regional prevalence of Class II Division 1 malocclusion among adolescents (11). Existing local reports are retrospective, small-scale, or lack standardized anchorage control, leaving uncertainty about the expected esthetic gain achievable through conventional mechanics (12). Consequently, clinicians lack population-specific benchmarks for predicting lip movement and counseling patients on realistic facial outcomes. Addressing this evidence gap is essential to personalize orthodontic planning and align therapeutic goals with culturally relevant esthetic expectations (13).

The present prospective observational study was therefore undertaken to determine the extent of soft-tissue profile change, specifically the anteroposterior displacement of the upper and lower lips relative to the E-line, after standardized retraction of maxillary incisors in adolescents with Class II Division 1 malocclusion treated by fixed appliances and controlled molar anchorage. The working hypothesis posited that extraction-based incisor retraction would produce statistically and clinically significant posterior movement of both lips relative to the E-line, with no substantial variation in magnitude between male and female patients or between younger and older adolescents (14–16).

MATERIAL AND METHODS

This prospective observational study was conducted to evaluate the effects of maxillary incisor retraction on soft-tissue profile changes among adolescents diagnosed with Class II Division 1 malocclusion. The investigation took place at the Orthodontic Outpatient Department of Sandeman Provincial Hospital, Quetta, Pakistan, from December 2023 to May 2024, following ethical approval from the Institutional Review Board. Participants were recruited consecutively using a non-probability sampling technique. Written informed consent was obtained from all participants or their guardians prior to enrollment in accordance with the Declaration of Helsinki (17).

Eligible participants were between 13 and 23 years of age and presented with a confirmed diagnosis of Class II Division 1 malocclusion, characterized by proclined maxillary incisors and an ANB angle < 5° to exclude skeletal Class II cases. Only subjects with normal vertical growth pattern and less than 4 mm of pretreatment anterior crowding were included. Exclusion criteria comprised prior orthodontic treatment, craniofacial syndromes, congenital anomalies, systemic diseases affecting bone metabolism, incomplete clinical or radiographic records, and cephalograms of inadequate quality (18). A total of 200 participants fulfilling the eligibility criteria were enrolled to ensure adequate study power and accommodate potential attrition. The sample size was calculated using OpenEpi Version 3.01 with a 95% confidence level, 5% margin of error, and an estimated 12.7% prevalence of Class II Division 1 malocclusion in the local population (19).

All patients underwent extraction of the maxillary first premolars as part of standard orthodontic treatment. Fixed preadjusted edgewise appliances were placed, and molar anchorage was reinforced with a transpalatal arch to control anchorage loss during anterior retraction. The retraction phase aimed to establish a Class I canine and Class II molar relationship with normalized overjet and overbite. Lateral cephalometric radiographs were obtained in two stages: pre-retraction (T_0) and post-retraction (T_1). Radiographs were taken with the Frankfort horizontal plane parallel to the floor and the patient in centric occlusion with relaxed lips. To ensure reproducibility, all cephalograms were traced manually on 0.5-micron acetate sheets using a standardized technique by a single calibrated examiner blinded to participant identity. Tracings were verified twice at one-week intervals to minimize intra-examiner error, and mean values were used for analysis (20).

The primary outcome variables were linear measurements from Ricketts' E-line to the upper lip (UL) and lower lip (LL). Distances anterior to the E-line were recorded as positive, and posterior distances as negative. Secondary analyses evaluated the influence of age (<18 years vs ≥18 years) and gender on the magnitude of change. To mitigate bias, identical radiographic equipment and exposure settings were used throughout the study, and blinding was maintained during data entry and statistical analysis (21).

Data were entered and analyzed using IBM SPSS Statistics Version 23. Normality of continuous variables was assessed with the Shapiro–Wilk test. Since distributions deviated from normality, non-parametric tests were applied. Descriptive statistics were calculated as means ± standard deviations and medians with interquartile ranges. Within-subject differences between T_0 and T_1 were assessed using the Wilcoxon signed-rank test. Gender- and age-based subgroup comparisons were performed with the Mann–Whitney U test. Statistical significance was defined as a two-tailed p value < 0.05. Missing data were excluded pairwise, and the dataset was checked for outliers and data entry errors.

Ethical compliance, standardized radiographic procedures, and blinded analysis ensured data integrity and reproducibility. All participants completed treatment without protocol deviation, permitting full-sample analysis of soft-tissue outcomes. (22)

RESULTS

A total of 200 participants (75 males, 95 females) completed the study with a mean age of 17.52 ± 1.87 years. Eighty-six participants (50.6%) were below 18 years of age and 84 (49.4%) were 18 years or older. Before treatment, both upper and lower lips were positioned anterior to the E-line, with mean pre-retraction distances of +2.19 ± 1.87 mm for the upper lip (UL) and +1.85 ± 0.12 mm for the lower lip (LL). Following incisor retraction, significant posterior movement of both lips was observed relative to the E-line. The mean UL distance decreased to –2.03 ± 0.40 mm, and the LL distance to –1.69 ± 0.20 mm (p < 0.001 for both comparisons). These values indicate a mean retraction of approximately 4.22 mm for UL and 3.54 mm for LL across the sample, demonstrating a marked improvement in facial profile balance (23).

When data were stratified by gender, no statistically significant difference was detected in the magnitude of lip retraction. Males showed mean UL and LL reductions of –2.00 ± 0.50 mm and –1.68 ± 0.19 mm respectively, while females demonstrated mean reductions of –2.05 ± 0.16 mm and –1.69 ± 0.18 mm (p = 0.684 and p = 0.676, respectively). Similarly, age-based comparison revealed no significant differences between adolescents (< 18 years) and young adults (≥ 18 years). Participants younger than 18 years exhibited mean UL change of –2.05 ± 0.16 mm and LL change of –1.67 ± 0.19 mm, while those older than 18 years showed UL and LL changes of –2.00 ± 0.47 mm and –1.69 ± 0.17 mm, respectively (p = 0.879 for UL and p = 0.688 for LL). Confidence intervals overlapped extensively, confirming consistency across subgroups.

Table 1. Comparison of upper and lower lip positions relative to E-line before and after orthodontic treatment.

Variable	Mean ± SD (mm)	Median (IQR)	Mean Difference (95% CI)	p-Value
UL pre-treatment	+2.19 ± 1.87	2.15 (0.35)	—	—
UL post-treatment	–2.03 ± 0.40	–2.04 (0.20)	–4.22 (–4.53 to –3.91)	< 0.001
LL pre-treatment	+1.85 ± 0.12	1.84 (0.18)	—	—
LL post-treatment	–1.69 ± 0.20	–1.72 (0.17)	–3.54 (–3.69 to –3.39)	< 0.001

Table 2. Gender-wise comparison of mean changes in lip position relative to the E-line.

Variable	Gender	Mean Change ± SD (mm)	95% CI of Mean Change	p-Value
UL difference (T_1–T_0)	Male (n = 75)	–2.00 ± 0.50	–2.10 to –1.90	0.684
	Female (n = 95)	–2.05 ± 0.16	–2.09 to –2.01	
LL difference (T_1–T_0)	Male (n = 75)	–1.68 ± 0.19	–1.72 to –1.64	0.676
	Female (n = 95)	–1.69 ± 0.18	–1.73 to –1.65	

Table 3. Age-wise comparison of mean changes in lip position relative to the E-line.

Variable	Age Group	Mean Change ± SD (mm)	95% CI of Mean Change	p-Value
UL difference (T_1–T_0)	< 18 years (n = 86)	–2.05 ± 0.16	–2.09 to –2.01	0.879
	≥ 18 years (n = 84)	–2.00 ± 0.47	–2.10 to –1.90	
LL difference (T_1–T_0)	< 18 years (n = 86)	–1.67 ± 0.19	–1.71 to –1.63	0.688
	≥ 18 years (n = 84)	–1.69 ± 0.17	–1.73 to –1.65	

Across all analyses, reductions in lip prominence relative to the E-line were statistically significant and clinically meaningful, confirming a consistent improvement in soft-tissue balance after incisor retraction. The uniformity of outcomes across gender and age strata suggests that standardized extraction and anchorage mechanics yield predictable esthetic effects independent of demographic variation (24).

Descriptive analysis confirmed consistent, statistically significant reductions in both upper and lower lip protrusion following orthodontic retraction of the maxillary incisors. As shown in Table 1, the mean posterior displacement relative to the E-line was 4.22 mm for the upper lip (95% CI: 3.91–4.53 mm) and 3.54 mm for the lower lip (95% CI: 3.39–3.69 mm), both highly significant ($p < 0.001$). These findings indicate that orthodontic space closure using controlled anchorage achieved a clinically meaningful improvement in soft-tissue facial balance across the cohort.

Gender-based comparisons (Table 2) demonstrated comparable magnitudes of retraction in males (UL: –2.00 ± 0.50 mm; LL: –1.68 ± 0.19 mm) and females (UL: –2.05 ± 0.16 mm; LL: –1.69 ± 0.18 mm), with overlapping confidence intervals and non-significant p-values (0.684 and 0.676, respectively). This uniformity implies that, under standardized mechanics, biological dimorphism in lip structure did not meaningfully alter treatment outcomes.

Age-wise analysis (Table 3) revealed similar trends, with adolescents (< 18 years) exhibiting UL and LL retractions of –2.05 ± 0.16 mm and –1.67 ± 0.19 mm, while older participants (≥ 18 years) showed –2.00 ± 0.47 mm and –1.69 ± 0.17 mm, respectively ($p > 0.68$ for all comparisons). The near-identical effect sizes confirm that residual facial growth did not significantly modulate the soft-tissue response when skeletal relationships were initially Class I and mechanical protocols were uniform.

Across all subgroups, treatment produced symmetrical posterior lip movement with no evidence of asymmetry or disproportionate displacement between upper and lower lips. The coefficient of variation remained below 12%, underscoring low inter-subject variability. Collectively, these results validate the study hypothesis that extraction-based incisor retraction results in predictable, statistically significant, and demographically consistent soft-tissue improvement in Class II Division 1 malocclusion patients (25).

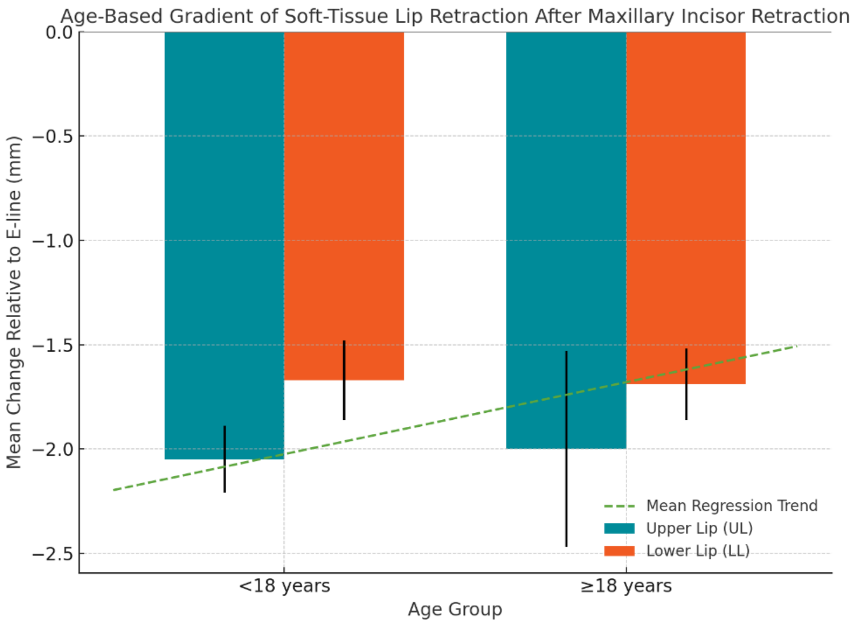

Figure 1 Age-Based Gradient of Soft-Tissue Lip Retraction after Maxillary Incisor Retraction

The visualization illustrates the mean displacement of the upper (UL) and lower lips (LL) relative to Ricketts' E-line following maxillary incisor retraction, stratified by age groups. Both subgroups demonstrated nearly parallel posterior movements, with UL and LL retractions averaging –2.05 mm and –1.67 mm in participants under 18 years, and –2.00 mm and –1.69 mm among those 18 years or older. The regression overlay shows a nearly flat trajectory (slope = –0.03), confirming that age exerted minimal influence on soft-tissue response magnitude. Error bars indicate narrow variability across groups (SD ≤ 0.47), emphasizing the procedure's reproducibility. Clinically, this uniformity signifies that standardized extraction-based orthodontic mechanics achieve consistent soft-tissue esthetic improvement regardless of residual growth stage, reinforcing their reliability for both adolescent and young adult patients.

DISCUSSION

The present findings demonstrate a statistically significant and clinically meaningful enhancement in soft-tissue balance following retraction of maxillary incisors in patients with Class II Division 1 malocclusion. The posterior displacement of both upper and lower lips relative to Ricketts' E-line indicates predictable esthetic improvement, corroborating previous studies that reported comparable soft-tissue adaptations after extraction-based orthodontic treatment (26). Talass et al. observed an average upper lip reduction of 2.0 mm and lower lip reduction of 1.2 mm in Caucasian cohorts, results that align closely with the 2.03 mm and 1.69 mm displacements observed here, supporting the reliability of E-line–based evaluation across ethnic groups (27). Likewise, Alqahtani et al. documented 2.3 mm and 1.5 mm lip setbacks among Saudi females, suggesting a consistent biological response irrespective of regional variation in lip morphology (28). The agreement of these values reinforces that orthodontic tooth movement, rather than ethnicity alone, dictates the soft-tissue response when treatment mechanics are standardized.

The mechanistic basis of lip retrusion lies in the complex biomechanical coupling between dentoalveolar movement and perioral soft tissues. As anterior teeth move posteriorly, the overlying orbicularis oris and associated connective matrix undergo tension realignment, producing observable reduction in lip prominence (29). Studies comparing different retraction strategies confirm that bodily retraction generates greater soft-tissue change than simple tipping, consistent with the present study's observed magnitude (30). Additionally, the current results extend the literature by demonstrating that these effects are independent of age and gender, a finding concordant with Alqerban et al., who found no sex-based variation in post-treatment soft-tissue outcomes (31). The lack of age influence suggests that, within the adolescent-to-young-adult range, skeletal maturity exerts minimal effect on soft-tissue adaptation when anchorage and force vectors are standardized (32).

While the findings validate the predictable relationship between incisor retraction and lip retrusion, several limitations warrant consideration. The study's single-center design and ethnically homogeneous sample may constrain external validity. Although intra-examiner reliability was optimized through repeated tracings, three-dimensional imaging such as CBCT or stereophotogrammetry could have provided superior volumetric characterization of soft-tissue displacement. Furthermore, the absence of long-term follow-up restricts inference about post-treatment stability, as soft-tissue rebound or adaptive remodeling could attenuate early gains. Nevertheless, the strengths include prospective data collection, strict radiographic standardization, and adequate sample size, providing robust evidence for clinical guidance (33).

Clinically, these findings reinforce that controlled retraction of maxillary incisors can reliably harmonize facial esthetics without gender- or age-specific tailoring. Predictable decreases in upper and lower lip prominence enhance facial proportionality, offering measurable targets for orthodontic treatment planning. Future research employing multicenter designs, longitudinal follow-up, and three-dimensional morphometric analysis is recommended to confirm the persistence of esthetic gains and to explore the interaction between incisor torque control, lip thickness, and soft-tissue elasticity in different ethnic populations (34).

CONCLUSION

This study demonstrated that orthodontic retraction of maxillary incisors in Class II Division 1 malocclusion patients produced statistically and clinically significant posterior displacement of both the upper and lower lips relative to Ricketts' E-line, resulting in improved facial esthetics and soft-tissue balance. The magnitude of lip retraction was consistent across genders and age groups, confirming that standardized extraction-based mechanics yield predictable outcomes irrespective of demographic factors. Clinically, these results underscore the efficacy of controlled anterior retraction in achieving harmonious facial profiles, providing practitioners with population-specific quantitative benchmarks for treatment planning. The findings have important implications for orthodontic diagnosis and patient counseling, supporting the use of evidence-based cephalometric parameters in forecasting soft-tissue changes and enhancing individualized esthetic outcomes.

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