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Original Article

# Comparing Dentoalveolar and Soft Tissue Adaptations in Class II Malocclusion Treatments

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**Abstract**

Depending on the patient's growth potential, the degree of malocclusion, and patient compliance, class II correction calls for different strategies. The aim is to evaluate the changes in the soft and hard tissues of the orofacial region using three distinct treatment modalities: camouflage, AMO, and en-masse distalization. Based on the treatment strategy used, 45 adult skeletal class II patient records were evenly divided into three clusters. FACAD software was used to trace lateral cephalograms before and after therapy. The Kruskal-Wallis test was used for intergroup comparisons and the Wilcoxon signed-rank test was used for intragroup comparisons. Significant changes were observed in the following areas: lower incisor-NB, lower incisor-APog Line, upper incisor-APog in all three groups, Max1-NA, Max1-APog, and interincisal angle in all three groups, Mand1-NB in group 1, and Mand1-APog in group 3. All groups showed a significant decrease in upper lip strain. Only in group 3 were there significant changes in the nasolabial angle (P-value = 0.01), upper lip angle (P-value = 0.002), and upper lip length (P-value < 0.001). The 3 groups' interlabial gaps changed significantly (P-value < 0.05). Comparison between groups showed significant differences in upper lip thickness, angle, strain, and interlabial gap. In conclusion, patients who received surgical treatment showed a significant decrease in interlabial, upper lip strain, upper lip angle, and lower lip thickness. Subjects receiving IZC anchoring showed a substantial increase in lower lip length. Patients who received surgical treatment had the greatest upper incisor retrusion, whereas those who received camouflage treatment showed a significant decrease in lower incisor inclination.

**Key words:** Class II malocclusion, Distalization, Surgical approach, Camouflage

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## Introduction

In India, class II malocclusion is the second most prevalent kind, with a prevalence ranging from 5% to 29% [1]. Adults with skeletal class II division 1 malocclusion may benefit from camouflage therapy that involves premolar extractions, or in more extreme situations, surgery [2]. The relationship between the incisors and lips has been emphasized in several studies assessing the impact of orthodontic treatment in various malocclusions on the facial profile [2-4]. Following premolar extraction, patients' soft tissue changes were evaluated, and notable alterations to the upper and lower lips were noted [5]. Khurshid *et al*. [3] found a significant association between upper lip position and upper incisor retraction in class II camouflage instances. Patients with class II malocclusion who received camouflage therapy demonstrated consistent skeletal landmark outcomes with little recurrence in a long-term follow-up research by Scott Conley and Jernigan [6] and Mihalik *et al*. [7]. When Kinzinger *et al*. examined the results of skeletal class II correction using camouflage, fixed functional appliances, and surgery, they discovered that fixed functional treatments and surgery significantly decreased facial convexity [8-10]. Additionally, new studies show that patient satisfaction with camouflage therapy is on par with surgical advancement of the mandible [6]. Therefore, given the small skeletal disparity, a camouflage strategy that preserves the vertical dimension following extractions would be a suitable treatment option for long-lasting outcomes [6].

Because it enables maxillary retraction or distalization to be performed in a more controlled manner and largely independent of patient cooperation, the introduction of skeletal anchorage utilizing dental implants or mini-screws (MSs) has contributed to the increased usage of this approach [8]. For patients who need orthognathic surgery, infrazygomatic crest (IZC) miniscrew anchorage has recently emerged as an alternate treatment option [9]. These anchorage systems offer absolute and stationary anchorage for a range of tooth movements, doing away with the need for active patient compliance and having few unfavorable side effects. The upper and lower lips' lip prominence decreased by 2.3 and 3.5 mm, respectively, with entire maxillary arch distalization employing IZC anchoring [10]. The gummy grin was fixed by full-arch distalization and maxillary intrusion made possible by IZC anchoring and anterior implants [11].

The comparison of lip and perioral alterations after en masse distalization with IZC anchoring, anterior maxillary osteotomies (AMO), and camouflage involving premolar extractions has not been documented in prior research. We designed this study to compare the soft tissue alterations caused by these three treatments because each has been documented separately in the literature for the treatment of class II malocclusion and is also used in practice. AMO, camouflage, and infrazygomatic crestal implants (IZC) are the three treatment modalities used in this study to assess the soft tissue changes in the perioral region following skeletal class II correction.

## Materials and Methods

This retrospective study was carried out at the Department of Orthodontics, Saveetha Dental College, and Hospitals involving case records of skeletal class II subjects treated with either of the three modalities (Infrazygomatic crestal implants, Camouflage, Anterior maxillary osteotomy) over the past 5 years. Ethical approval was obtained from the Human Ethical Committee, Saveetha Institute of Medical Sciences. A total of 45 patient records were selected after applying the eligibility criteria and were divided equally into 3 groups depending on the treatment approach employed for class II correction.

*The inclusion criteria for this study were as follows*

1. Class II malocclusion subjects with full cusp Class II molar and canine relationship and complete set of treatment records with good quality pre and post-cephalograms.
2. Overjet greater than 7 mm

*Exclusion criteria*

1. Patients with missing or extracted teeth and any previous orthodontic treatment
2. Patients with systemic manifestations, TMD disorders, bone disorders

Group 1: Adult class II patients treated with camouflage (Extraction of maxillary first premolars and mandibular second premolars bilaterally) (n = 15).
Group 2: Adult class II patients treated with en masse distalization with IZC anchorage (n = 15).
Group 3: Adult class II patients treated surgically by AMO (n = 15).

Pre (t0) and post-treatment (t1) lateral cephalograms of all included subjects were taken with the same equipment by the same operator at a constant magnification with lips in the rest position. The lateral cephalograms were taken in their natural head position under operator assistance. The post-treatment occlusion should be a well-interdigitated Class II or Class I molar with a Class I canine relationship and a markedly reduced overjet. All cephalograms were traced with Facad® (Version 3.12, Ilexis AB, Linköping, Sweden), by the same clinician and the following parameters were assessed **(Table 1)**.

**Table 1.** Soft tissue and hard tissue parameters assessed and their description

| Parameters | Description |
|---|---|
| **Hard tissue parameters** | |
| Upper incisor–NA | The angle formed between the long axis of the upper incisor to the NA line |
| Upper incisor-APog | Formed between the long axis of the upper incisor and the point A-pogonion line |
| Lower incisor-NB | The angle formed between the long axis of the mandibular incisor and nasion-point B line |
| Lower incisor-APog Line | The angle formed between the long axis of the mandibular incisor and point A-pogonion line |
| Interincisal angle | The angle formed by the intersection of the long axis of maxillary and mandibular incisors |
| Max1-NA (mm) | Linear distance between the line passing through the long axis of the upper incisor and the NA line |
| Mand 1-NB (mm) | Linear distance between the line passing through the long axis of the lower incisor and NB line |
| Mand 1-A Pog | Linear distance between the line passing through the long axis of the lower incisor and the A-Pog line |
| Max 1-A Pog | Linear distance between the line passing through the long axis of the upper incisor and the A-Pog line |
| **Soft tissue parameters** | |
| Sulcus superior -E-line (mm) | The linear distance between Sulcus superior to the E line |
| Sn-Pog'-Labrale superior (mm) | The linear distance between two lines subnasale to soft tissue pogonion and sulcus superior to E line |
| Labrale superior-Eline (mm) | Linear distance between labrale superior to E line |
| Sn-Pog'-Labrale inferior (mm) | The linear distance between the Sn-Pog line to the labral inferior |
| Labrale inferior-E line (mm) | The linear distance between the labral inferior to the E line |
| Sulcus inferior-E line (mm) | Linear distance between sulcus superior to E line |
| Upper lip length (mm) | Subnasale (Sn) to upper lip inferior |
| Upper lip Thickness (mm) | Measured from a point 2 mm below the A point to the outer border of the upper lip. |
| Upper lip strain (mm) | Measured from the vermilion border of the lip to the labial surface of the maxillary central incisor |
| Upper lip angle | The angle formed between the True vertical line (TVL) passing through the subnasale and the line passing through the subnasale and Upper lip anterior (ULA) |
| Interlabial gap (mm) | The distance between stomion superius and stomion inferius |
| Lower lip length (mm) | Measured from lower lip superior (LLS) to soft tissue menton (Me') |
| Lower lip thickness (mm) | Distance from the incisal edge of the maxillary central incisor to the vermilion border of the lower lip. |

*Statistical analysis*

Statistical analysis was performed with SPSS software version 23. The power of this study was estimated with G*Power software 3.0. The sample size was calculated from the study article by Kenzinger *et al*. comparing skeletal and dentoalveolar changes in camouflage orthodontics, dentofacial orthopedics, and orthognathic surgery for class II correction. The level of significance was set up to be 0.05.

The Shapiro-Wilk test was performed to test the normality. The soft and the hard tissue changes between the three groups were analyzed with the Kruskal Wallis test and intragroup comparison was done using the Wilcoxon signed rank test.

## Results and Discussion

**Table 2** lists each group's mean, SD, and mean difference as well as the p-value for the Wilcoxon signed rank test (intragroup comparison) and Kruskal Wallis test (intergroup comparison). The Shapiro-Wilk test revealed that the collected data was non-parametric.

**Table 2.** Data was collected for hard and soft tissue variables, their differences, SD, and P-value (using the Kruskal Wallis test for intergroup comparison and the Wilcoxon signed rank test for intragroup comparison).

| Parameter | Time point | Group 1 (camouflage) Mean ± SD | MD | P-value | Group 2 (IZC) Mean ± SD | MD | P-value | Group 3 (AMO) Mean ± SD | MD | P-value | Intergroup comparison (P-value) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hard Tissue Parameters** | | | | | | | | | | | |
| Interincisal angle (°) | T0 | 109.2 ± 2.0 | 10.9 | < 0.001* | 112.6 ± 8.1 | 8.3 | 0.01* | 110.9 ± 3.8 | 5.2 | 0.01* | < 0.001* |
| | T1 | 120.1 ± 7.6 | | | 120.9 ± 3.6 | | | 116.1 ± 8.7 | | | |
| Max1-NA (°) | T0 | 34.5 ± 3.5 | -10.4 | < 0.001* | 35.1.2 ± 2.5 | -10 | < 0.001* | 36.2 ± 2.6 | -9.8 | 0.001* | 0.05 |
| | T1 | 24.1 ± 4.6 | | | 25.1 ± 5 | | | 27.4 ± 7.5 | | | |
| Max1-NA (mm) | T0 | 9.9 ± 1.5 | -4.3 | < 0.001* | 8.7 ± 2.7 | -3.1 | < 0.001* | 8.9 ± 3.5 | -4.4 | 0.001* | 0.05 |
| | T1 | 5.6 ± 1.1 | | | 5.6 ± 2.1 | | | 4.5 ± 2 | | | |
| Max1-APog (°) | T0 | 31 ± 5.4 | -2 | < 0.001* | 35.1 ± 3 | -1.2 | < 0.001* | 36.8 ± 3.9 | -7.3 | 0.001* | < 0.001* |
| | T1 | 29 ± 5.2 | | | 33.9 ± 4.4 | | | 29.5 ± 4.9 | | | |
| Mand1-NB (°) | T0 | 31.4 ± 3 | -3.2 | 0.01* | 30.2 ± 8.4 | 1.7 | 0.2 | 35.5 ± 1.5 | 2.4 | 0.2 | 0.5 |
| | T1 | 28.8 ± 1.9 | | | 31.9 ± 6.1 | | | 37.9 ± 6.7 | | | |
| Mand1-APog (°) | T0 | 25.6 ± 2.4 | -3.9 | 0.1 | 22.3 ± 3.9 | 1.5 | 0.2 | 30.2 ± 1.3 | 4.9 | 0.01* | 0.01* |
| | T1 | 21.7 ± 3.4 | | | 23.8 ± 8.1 | | | 25.3 ± 7.4 | | | |
| Mand1-NB (mm) | T0 | 6.4 ± 0.2 | -0.4 | 0.06 | 6.3 ± 1.2 | 0.4 | 0.001* | 7.4 ± 1.1 | 2.1 | 0.001* | 0.001* |
| | T1 | 6 ± 1.8 | | | 6.7 ± 1.9 | | | 9.5 ± 1.7 | | | |
| Mand1-APog Line (mm) | T0 | 2.6 ± 0.8 | -0.7 | 0.06 | 1 ± 1.1 | 2.9 | 0.001* | 2.7 ± 1.5 | -1 | 0.001* | 0.001* |
| | T1 | 1.9 ± 1 | | | 3.9 ± 2 | | | 3.7 ± 0.4 | | | |
| Max1-APog (mm) | T0 | 11.2 ± 4.6 | -4.3 | 0.001* | 7.6 ± 2.5 | 0.3 | 0.2 | 14.1 ± 3.7 | -7.4 | < 0.001* | < 0.001* |
| | T1 | 6.9 ± 0.8 | | | 7.9 ± 2.4 | | | 6.7 ± 1.9 | | | |
| **Soft Tissue Parameters** | | | | | | | | | | | |
| Sulcus superior -E-line (mm) | T0 | -4.8 ± 4.2 | -1.6 | 0.06 | -4.1 ± -4 | -3.5 | 0.001* | -7.3 ± 1.5 | -1.9 | 0.01 | 0.5 |
| | T1 | -6.4 ± 1.1 | | | -7.6 ± 2.2 | | | -9.2 ± 0.9 | | | |
| Sn-Pog'-Labrale superior (mm) | T0 | 3.4 ± 1.6 | -0.3 | 0.1 | 3.5 ± 2.2 | 0.4 | 0.7 | 5.4 ± 4.4 | 1.3 | 0.01 | 0.05 |
| | T1 | 3.1 ± 1 | | | 3.9 ± 0.3 | | | 4.1 ± 1.3 | | | |
| Labrale superior-E line (mm) | T0 | -1.9 ± 1.6 | -3 | 0.001* | -2 ± 2 | -0.8 | 0.2 | 0.06 ± 4.1 | -2.6 | 0.2 | 0.3 |
| | T1 | -4.9 ± 3.5 | | | -2.8 ± 2.5 | | | -2.6 ± 1.4 | | | |
| Sn-Pog'-Labrale inferior (mm) | T0 | 3.9 ± 2.3 | -2.7 | 0.001* | 3.1 ± 2.6 | -0.8 | 0.001* | 4.8 ± 3.8 | -1.8 | 0.01 | < 0.001* |
| | T1 | 1.2 ± 1.6 | | | 2.3 ± 2.8 | | | 3 ± 3.3 | | | |
| Labrale inferior-E line (mm) | T0 | 0.6 ± 0.5 | -0.4 | 0.06 | 0.6 ± 3.4 | -2.1 | 0.001* | 0.7 ± 3.8 | -1.6 | 0.01 | 0.1 |
| | T1 | 0.2 ± 3.4 | | | -1.5 ± 3.7 | | | -0.9 ± 3.4 | | | |
| Sulcus inferior-E line (mm) | T0 | -6.2 ± 2.9 | -2.9 | 0.001* | -5 ± 3.3 | -1 | 0.05 | -3.8 ± 2.4 | -3.4 | 0.001* | < 0.001* |
| | T1 | -9.1 ± 5.1 | | | -6 ± 3.7 | | | -7.2 ± 2.3 | | | |
| Nasolabial angle | T0 | 91.9 ± 18.4 | 3.8 | 0.01 | 89.9 ± 17.9 | 3.3 | 0.01* | 87.3 ± 10.3 | 5.5 | 0.01* | 0.3 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T1 | 95.7 ± 7.4 | | | 93.2 ± 12.5 | | | 92.8 ± 9.3 | | | |
| Labiomental angle | T0 | 112.5 ± 11.9 | 3.2 | 0.06 | 103.7 ± 4.4 | -1.7 | 0.7 | 115.8 ± 11.7 | -1.2 | 0.2 | 0.4 |
| | T1 | 115.7 ± 5.8 | | | 102 ± 11.7 | | | 114.6 ± 8.3 | | | |
| H angle | T0 | 14.4 ± 3.5 | -2.2 | 0.5 | 18.6 ± 3.4 | 0.1 | 0.7 | 17.3 ± 3.1 | -0.7 | 0.7 | < 0.001* |
| | T1 | 14.2 ± 5.7 | | | 18.7 ± 3.5 | | | 16.6 ± 1 | | | |
| Z angle | T0 | 59.5 ± 3.2 | 2.1 | 0.06 | 64.8 ± 17.6 | 3.3 | 0.01 | 69.7 ± 12.5 | 2.5 | 0.7 | 0.4 |
| | T1 | 61.9 ± 8.9 | | | 68.1 ± 16.8 | | | 72.2 ± 9.3 | | | |
| Upper lip length | T0 | 21.5 ± 1.9 | -0.1 | 0.7 | 20.02 ± 2.04 | 0.58 | 0.3 | 21.4 ± 1.6 | 2.7 | 0.001* | 0.00* |
| | T1 | 21.4 ± 2.1 | | | 20.6 ± 2.06 | | | 24.1 ± 1.4 | | | |
| Upper lip thickness | T0 | 11.5 ± 0.5 | 0.3 | 0.1 | 12.6 ± 2.8 | -1 | 0.2 | 11.6 ± 1.8 | 0.6 | 0.3 | < 0.001* |
| | T1 | 11.8 ± 0.6 | | | 11.6 ± 2.7 | | | 12.2 ± 3.07 | | | |
| Strain factor | T0 | 2.9 ± 1.9 | -1.4 | 0.001* | 3.2 ± 1.7 | -1.4 | 0.001* | 5.6 ± 2.4 | -3.9 | 0.001* | < 0.007* |
| | T1 | 1.5 ± 2.5 | | | 1.8 ± 2.1 | | | 1.7 ± 1.1 | | | |
| Upper lip angle | T0 | 15.1 ± 15.2 | -0.3 | 0.6 | 12.6 ± 5.1 | -1.56 | 0.3 | 21.1 ± 5.7 | -4.6 | 0.002* | 0.015* |
| | T1 | 14.8 ± 13.9 | | | 11.04 ± 3.9 | | | 16.5 ± 4.6 | | | |
| Interlabial gap | T0 | 5.1 ± 1.7 | -1.9 | 0.01* | 6.8 ± 4.03 | -2.7 | 0.001* | 11.3 ± 2.2 | -6 | 0.001* | 0.00* |
| | T1 | 3.2 ± 1.9 | | | 4.1 ± 1.8 | | | 5.3 ± 1.07 | | | |
| Lower lip length | T0u | 38.4 ± 3.3 | 0.7 | 0.025 | 41.5 ± 6.04 | 1 | 0.001* | 46.7 ± 4.7 | -0.1 | 0.05 | 0.15 |
| | T1 | 39.1 ± 2.7 | | | 42.5 ± 5.8 | | | 46.9 ± 4.7 | | | |
| Lower lip thickness | T0 | 13.2 ± 1.08 | -0.4 | 0.2 | 13.8 ± 2.6 | -1.2 | 0.1 | 14.08 ± 4.6 | -0.18 | 0.3 | 0.2 |
| | T1 | 12.8 ± 1.2 | | | 12.6 ± 1.6 | | | 13.9 ± 4.5 | | | |

*Hard tissue parameters*

The following angular measurements showed statistically significant changes across all three groups on the intragroup comparison (T0-T1): Max1-NA, Max1-APog, and Interincisal angle. The Mand1-NB (group 1) and Mand1-APog (group 3) linear measurements There was a statistically significant change (P-value = 0.05) in lower incisor-NB, lower incisor-APog Line, and upper incisor-APog (all groups) **(Table 2)**.

The following parameters showed statistically significant differences in intergroup comparison at T1: Mand1-NB (linear), Mand1-APog (linear and angular), Max1-NA (linear and angular), Mand1-NB(linear), and Interincisal angle. There were no significant changes in Mand1-NB(angular).

*Soft tissue parameters*

The following soft tissue measurements showed statistically significant changes on the intragroup comparison (T0-T1): nasolabial angle, upper lip length, upper lip angle (group 3), and upper lip strain and interlabial gap (all three groups) (P-value < 0.05).

Changes in upper lip strain, interlabial gap, upper lip angle, and upper lip thickness were statistically significant when comparing groups **(Table 2)**.

The following angular measurements showed statistically significant changes across all three groups on the intragroup comparison (T0-T1): Max1-NA, Max1-APog, and Interincisal angle. The Mand1-NB (group 1) and Mand1-APog (group 3) linear measurements There was a statistically significant change (P-value = 0.05) in lower incisor-NB, lower incisor-APog Line, and upper incisor-APog (all groups) **(Table 2)**.

The following parameters showed statistically significant differences on the intergroup comparison at T1: Significant differences were observed in interincisal angle, Max1-NA (linear and angular), Max 1-APog (linear and angular), Mand1-NB (linear), and Mand1-APog (linear and angular); however, no significant changes were observed in Mand1-NB (angular).

*Soft tissue parameters*

The following soft tissue measurements showed statistically significant alterations on the intragroup comparison (T0 - T1): upper lip length, nasolabial angle, upper lip angle (group 3), and upper lip strain and interlabial gap (all three groups) (P-value < 0.05).

There were statistically significant differences between groups in terms of upper lip strain, interlabial gap, upper lip angle, and upper lip thickness **(Table 2)**.

Class II malocclusions should be corrected by taking into account occlusion, lip competence, facial convexity, vertical dimensions, and dentoalveolar protrusion. Congenital, developmental, or acquired as a result of disease, trauma, or environmental factors are the possible causes of the condition [12-14]. Severe malocclusion is frequently linked to functional limitation, pain, and social disability that impacts the emotional and social well-being of young male and female adolescents. It may also significantly limit the ability to participate in a major life activity. The concept of quality of life encompasses the presence of physical, mental, and social well-being in addition to the absence of disease [12, 13, 15, 16]. To plan a customized treatment plan, it is crucial to evaluate and quantify hard tissue and soft tissue changes with various treatment approaches for class II malocclusion in adult patients, such as camouflage treatment involving premolar extractions, molar distalization, and orthognathic surgery. This is why this study was undertaken. All three methods produced clinically significant reductions in overjet, maxillary incisor retrusion, nasolabial angle, and lip protrusion at T1 in this investigation. Significant variations in upper lip length, strain factor, upper lip thickness, interlabial gap, upper lip angle, and H angle were observed when comparing soft tissue changes between groups; patients who received AMO showed the most favorable alterations. Considerable variations in lower lip protrusion were observed between groups, with participants receiving camouflage treatment exhibiting the greatest retrusion and those undergoing AMO demonstrating a considerable improvement in lower lip competence. All groups saw an increase in both upper and lower lip length, although all groups saw a decrease in lower lip thickness, and those who received AMO saw an increase in upper lip thickness. Only in the camouflage group was mandibular incisor retraction observed. Subjects that received AMO showed a greater degree of uprightness in their upper anterior at T1.

The findings of the study by Kinzinger *et al*. which examined the hard and soft tissue alterations in class II individuals with three distinct treatment approaches—camouflage, fixed functional appliance, and BSSO—are highly consistent with the findings of this investigation. It was found that the overjet could be significantly reduced using all three treatment modalities. In the surgical group, there was an increase in vertical modifications such as lip length and other face heights.

The alterations in the inclinations of the lower and upper incisors are consistent with earlier research. The findings of the study by Jo *et al*. which compared anterior retraction with extractions and en masse distalization with a modified C plate, revealed that the extraction group had the greatest incisor retraction (5.3 mm), followed by the distalization group (3.4 mm) [17-19]. These findings are consistent with our study's findings, which showed mean values of 4.3 mm in the extraction group and 3.1 mm in the distalization group.

Following therapy, all three groups' interincisal angles decreased, which was consistent with earlier research. A few authors previously explained the role of camouflage treatment in significantly reducing lip procumbency when they reported mean maxillary incisor retrusion of 5.27 mm, mean upper lip retraction of 2.03 mm, and mean lower lip retraction of 1.23 mm, though not all three groups were compared. Group 3 achieved the most retraction of the upper lip (1.3 mm), followed by group 2 (0.7 mm). Group 1 achieved the largest retraction of the lower lip (2.7 mm), followed by group 3 (1.8 mm).

The results concerning changes in lip length in the camouflage group are consistent with earlier research by Rains and Nanda [20] and Talass *et al*. [21]. To forecast the soft tissue changes that would occur after orthodontic camouflage therapy, Tallas conducted a study. The results showed that there were significant changes in the nasolabial angle, upper lip retrusion, lower lip lengthening, and upper incisor retraction of 6.7 mm. While the largest increase in lip length in our study was 1 mm (AMO group), Talass *et al*.'s study showed an increase of 3.4 mm, while Nanda's study showed an increase of 0.6 mm. Longer lower lip before treatment, more upper incisor crowns covered by the lower lip before treatment, and higher lower face height after treatment are the causes of the lip length increase, according to Talass *et al*. [21].

All three groups saw an increase in the nasolabial angle, although group 3's gain was statistically significant. Significantly, the surgery group's nasal angle rose, and these findings are consistent with earlier research [21-23]. The nasolabial angle significantly increased after surgery, according to Komal *et al*.'s study of four angular measurements in patients undergoing anterior maxillary osteotomy. Tallas stated that the following factors contributed to the bigger rise in nasolabial angle: greater incisor retraction, thinner upper lip, greater overjet pretreatment, lower facial height, thicker soft tissue at subnasale before treatment, and greater increase in hard tissue [21]. These findings contradict both the ratios suggested by Lo and Hunter (1.6 degrees for every 1mm retraction of the upper lip) and Waldman [24], who found no relationship between incisor retraction and nasolabial angle [24, 25].

*Limitations and future scope*

Due to its retrospective nature and smaller sample size, this study was limited to a single population and geographic area. More pretreatment baseline data should be standardized and a larger sample size should be used in future research. Additionally, to make it a study with more therapeutic significance, a gender-specific study should be developed in the future.

## Conclusion

1. Regardless of the treatment strategy used, the upper incisor inclination decreased in all three groups. In patients who underwent surgery, the greatest decrease was seen in upper incisor inclination.
2. Patients treated with the camouflage technique showed a considerable decrease in lower incisor inclination.
3. All three groups experienced lip retrusion. Compared to participants treated with alternative modalities, those treated with surgery showed significant reductions in interlabial gap, upper lip strain, upper lip angle, and lower lip thickness.
4. Subjects treated with IZC anchoring showed a substantial increase in lower lip length.

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**Conflict of interest:** None

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**Ethics statement:** Ethical approval was obtained from the Institutional Ethical Committee, Saveetha Dental College, and Hospitals.

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