

Correlation of occlusal characteristics with mentolabial sulcus in patients at a tertiary care hospital: A cross-sectional study

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Abstract

Objective: To find correlation of mentolabial sulcus depth and mentolabial sulcus angle with skeletal and dental characteristics.

Method: The observational, cross-sectional study was conducted at the Department of Orthodontics, Bahria University Health Sciences, Karachi, from October 7, 2023, July 31, 2024, and comprised patients of either gender aged 18-25 years with having complete permanent dentition except third molars. Different skeletal, dental and soft tissue variables were measured from cephalometric radiograph. including mentolabial sulcus depth and mentolabial sulcus angle. Overjet, overbite, curve of Spee, incisor, canine and molar relationship were measured from the dental cast. The patients were divided into three groups on basis of mentolabial sulcus depth and mentolabial sulcus angle. Mentolabial sulcus depth was divided into Shallow, Average and Deep depth subgroups, while mentolabial sulcus angle was divided into Shallow, Average and Deep angle subgroups. Data was analysed using SPSS 23.

Result: Of the 148 patients, 104(70.3%) were females and 44(29.7%) were males. The overall mean age was 20.75 ± 2.47 years. The mean mentolabial sulcus depth was 5.86 ± 2.10 mm and mean mentolabial sulcus angle was $106.22 \pm 25.11^\circ$. The mean mentolabial sulcus depth was deeper in males than females ($p < 0.05$). Overjet, class II canine and molar relationship, retruded mandible and bimax proclination were associated with deep mentolabial sulcus depth ($p < 0.05$). When Shallow Angle was compared with Average and Deep angles, all vertical values were found increased in the Shallow Angle group ($p < 0.05$).

Conclusion: Male gender, class II malocclusion, increased overbite, bimax proclination and low facial height were associated with deep mentolabial sulcus, whereas increased facial height was associated with shallow mentolabial sulcus depth.

Key Words: Mentolabial sulcus depth, Mentolabial sulcus angle, Class II malocclusion, Overbite, Overjet.

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Introduction

The treatment planning of orthodontic patients is based primarily on soft tissues in the current paradigm¹, but the importance of skeletal characteristics based on cephalometric analysis cannot be ignored as it facilitates the diagnosis and final treatment plan.² The soft tissues may correlate with the underlying skeletal tissue, but not all areas of the soft tissue profile directly follow skeletal structures, and in some areas the contours of the facial tissue deviate from the basic skeletal structures.³ In many instances, the difference in soft tissue contours from that of underlying skeleton may camouflage the underlying problem. It is therefore important to analyse which skeletal and dental characteristics are correlated with soft tissue thickness.

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Mentolabial sulcus (MLS) or groove is a curve formed between the lower lip and chin, and can be classified as deep, normal and shallow on the basis of its depth.⁴ MLS not only varies due to demographic factors, but various skeletal and occlusal characteristics also affect the depth of sulcus, either in isolation or cumulatively.⁵ A study⁶ showed that mentolabial sulcus depth (MLSD) was significantly increased in men compared to women in Circassian population.

Studies have correlated a shallow/obtuse MLS with a class III malocclusion, whereas a deep/acute MLS is found in patients with class II malocclusion.⁷ Patients with bimaxillary protrusion present with shallow MLS, whereas those with adenoid facies due to mouth breathing are also shown to have increased facial convexity and MLSD.^{8,9}

Assessment of MLS can be done by clinical examination, photographic examination/measurement or cephalometric measurement.^{10, 11} Soft tissue analysis by Legan-Burstone⁶ measure the MLSD by measuring the millimetric distance from soft tissue B point to a line

joining the labrale inferius (Li) and soft tissue-pogonion (s-Pog).

The correlation of skeletal and dental characteristics with MLSD can help the orthodontist plan cases that can improve the MLS, and therefore the soft tissue profile. The current study was planned to correlate the occlusal and cephalometric variables with depth and angle of MLS.

Materials and Methods

The observational, cross-sectional study was conducted at the Department of Orthodontics, Bahria University Health Sciences, Karachi from October 7, 2023, July 31, 2024, and comprised patients of either gender aged 18-25 years with having complete permanent dentition except third molars. After approval from the institutional ethics review board, the sample size was calculated using

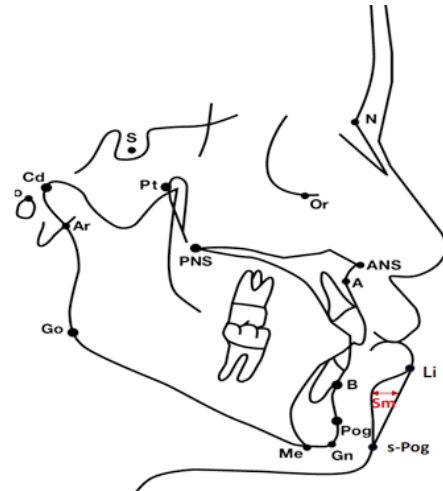


Figure-1: Measurement of mentolabial sulcus depth.

Table-1: Cephalometric analysis.

SKELETAL VARIABLES

Sella–Nasion–Point A angle SNA (°)

SNB (°)

ANB (°)

Wit's appraisal (mm)

N⊥– A (mm)

N⊥– Pog (mm)

Facial Angle (°)

VERTICAL VARIABLE

SSNMP (°)

FMA (°)

MMA (°)

Y-axis (°)

Facial axis (°)

Posterior facial height (PFH %)

Lower anterior facial height (LAFH %)

DENTAL VARIABLES

UI-SN (°)

IMPA (°)

I-I (°)

UI-NA (°)

UI-NA (mm)

LI-NB (°)

LI-NB (mm)

Holdaway ratio (mm)

SOFT TISSUE VARIABLES

Nasolabial angle (°)

Mentolabial sulcus depth (MLSD mm)

Mentolabial sulcus Angle (MLSA °)

Z angle (°)

E-line (mm)

S-line (mm)

Chin projection (mm)

Angle between Sella to nasion plane (SN) and N-A line

Angle between SN and N-B line

ANB= SNA-SNB Distance between points of A and B to the occlusal plane.

Distance between point A and a line drawn perpendicular to FH from point N.

Distance between pogonion point and a line drawn perpendicular to FH from point N.

Angle formed between line N and hard tissue- Pogonion (Pog) and FH

Angle between Sella to nasion plane (SN) and mandibular plane. Angle between FH and mandibular plane.

Angle between maxillary and mandibular planes.

Angle between S-Gn and SN plane.

Angle formed between N-Ba line and PTM-Gn line.

Ratio between posterior facial height and total facial height

Ratio between lower anterior facial height and total facial height

Angle formed between SN and maxillary incisor axis.

Angle formed between Go – Me and the mandibular incisor axis.

Angle formed by the intersection of the mandibular incisor axis to the maxillary incisor axis.

Angle formed by the intersection of the maxillary incisor axis to the plane between points N and A

Perpendicular distance from the tip of the maxillary incisor to the plane between points N and A

Angle formed by the intersection of the mandibular incisor axis to the plane between points N and B

Perpendicular distance from the tip of the mandibular incisor to the plane between points N and B

Ratio between distance from labial surface of mandibular incisor to NB and Pog-NB

Angle determined by points columella, SN and upper lip.

Distance from deepest point of mentolabial sulcus (Sm) and labrale inferius (Li) to s-Pog line.

Angle between the lines drawn from Li to Sm and from this point to the soft tissue-Pogonion (s-Pog).

Angle formed between FH and line from s-Pog and most prominent lip

Distance of upper and lower lips from E-line

Distance of upper and lower lips from S-line

Distance of s-Pog from line perpendicular to soft tissue Na and FH

Sella–Nasion–Point A angle (SNA), Sella–Nasion–Point B angle (SNB), Angle between SNA and SNB (ANB), Nasion perpendicular to point A (N⊥– A), Nasion perpendicular to Pogonion (N⊥– B), Sella-Nasion-mandibular plane angle (SNMP), Frankfort-mandibular plane angle (FMA), Maxillomandibular Angle (MMA), Posterior Facial Height (PFH), Lower Anterior Facial Height (LAFH), Upper Incisor to Sella–Nasion angle (UI-SN angle), Incisor–Mandibular Plane Angle (IMPA), Interincisal Angle (I-I angle), Upper Incisor to Nasion–A line (UI-NA distance), Upper Incisor to Nasion–A line (UI-NA angle), Lower Incisor to Nasion–B line (LI-NB distance), Lower Incisor to Nasion–B line (LI-NB angle)

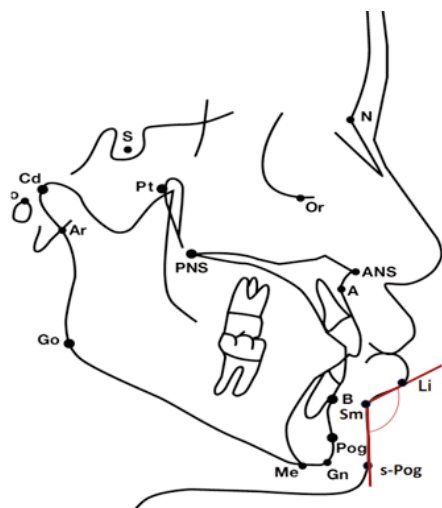


Figure-2: Measurement of mentolabial sulcus angle.

OpenEpi Version 3.01 in the light of literature⁹ while keeping two-sided significance level 95%, power 80% and odds ratio 0.35. The sample was raised using random sampling technique from among the patients coming for orthodontic treatment. Informed consent was obtained from all the subjects. Those having a history of orthodontic treatment or orthognathic surgery, history of trauma to maxillofacial structures, compromised periodontium, previous extraction, incompetent lips were excluded, and so were syndromic patients including cleft lip and palate.

Before starting the orthodontic treatment, the patients were subjected to a cephalometric radiograph done in the radiology department by a calibrated technician. It was taken with patient's head in the natural head position and parallel to Frankfort horizontal (FH). Lateral cephalograms were traced manually on acetate paper, and skeletal, vertical, dental and soft tissue variables were then measured, including Sella–Nasion–Point A angle (SNA), Sella–Nasion–Point B angle (SNB), Angle between SNA and SNB (ANB), Wits appraisal, Nasion perpendicular to point A (N \perp - A), Nasion perpendicular to Pogonion (N \perp - B), Facial Angle, Sella-Nasion-mandibular plane angle (SNMP), Frankfort-mandibular plane angle (FMA), Maxillomandibular Angle (MMA), Y-axis, Facial Axis, Posterior Facial Height (PFH), Lower Anterior Facial Height (LAFH), Upper Incisor to Sella–Nasion angle (UI-SN angle), Incisor–Mandibular Plane Angle (IMPA), Interincisal Angle (I-I angle), Upper Incisor to Nasion–A line (UI-NA distance), Upper Incisor to Nasion–A line (UI-NA angle), Lower Incisor to Nasion–B line (LI-NB distance), Lower Incisor to Nasion–B line (LI-NB angle), Holdaway ratio, nasolabial angle, MLSD, mentolabial sulcus angle (MLSA), Z-angle, chin projection and the relationship of upper and lower

lips with respect to the E and S planes (Table 1). MLSD was measured by drawing a line from the landmarks, that is, Li to s-Pog, and the deepest point in the sulcus that is submentale (Sm) showed MLSD (Figure 1). Normal MLSD has been reported to be 4 ± 2 mm.¹⁰ MLSA was measured as the angle between the lines drawn from Li to Sm, and from this point to Pog (Figure 2). Overjet, overbite, curve of Spee (COS), incisor, canine and molar relationship were measured using dental cast that was taken at time of pre-treatment records. All the measurements were taken by a single calibrated examiner.

The sample was divided into groups based on severity of MLSD and MLSA to correlate the depth and angle with each cephalometric and occlusal variable. MLSD was measured in line with the values given by Naini et al¹¹, with shallow depth (SD) = <2 mm, average depth (AD) = 4 ± 2 mm, and deep depth (DD) = >6 mm. Classification of MLSA by Rokaya et al.¹² was used to divide patients based on their MLSA, and this division was further divided on basis of gender; in females deep angle (DA) = $90-110^\circ$, average angle (AA) = $111-131^\circ$ and shallow angle (SA) = $132-152^\circ$, whereas in males DA = $99-114^\circ$, A = $115-130^\circ$ and SA = $131-146^\circ$.¹² Initially, data was collected using random sampling technique, but the number of patients in SD and SA groups were low, so purposive sampling was opted to add more patients in these groups so that statistical tests could be applied. In MLSD analysis, the number of patients in SD group was still low for the application of statistical tests, and, therefore, comparison was only done between AD and angled groups.

Data was analysed using SPSS 23. All cephalometric variables and canine and molar relationships were reported as numerical variables. A class I relation was denoted as 0mm, half cusp molar was denoted as 3mm, a full cusp class II molar was denoted as 6mm, and a full cusp class III molar was denoted as -6mm. This was done

Table-2: Gender-based comparison of mean mentolabial sulcus depth (MLSD) and mentolabial sulcus angle (MLSA).

Gender	Mean \pm SD		p- value
	Female	Male	
Mean mentolabial sulcus depth (mm)	5.70 \pm 1.84	6.22 \pm 2.60	0.003*
Mean mentolabial sulcus angle (degree)	106.83 \pm 25.2	105.07 \pm 25.3	0.085

SD: Standard deviation.

to accurately describe the extent of molar relationship in mm terms. Descriptive analysis was used for all qualitative data. Kolmogorov-Smirnov test was used to check normal data distribution. The data was found to have a non-normal distribution, and, hence, non-parametric Mann

Table-3: Correlation of occlusal and cephalometric variables in deep and average mentolabial sulcus depth (MLSD).

Variables	MLSD Group Mean \pm SD		p-value
	Average(n=80)	Deep (n=66)	
Occlusal variables			
Incisor relationship	2.09 \pm 1.7	1.59 \pm 0.5	0.228
Overjet (mm)	4.04 \pm 3.5	8.92 \pm 19.1	0.002*
Overbite (%)	45.76 \pm 31.6	50.96 \pm 28.3	0.285
Curve of Spee (mm)	1.77 \pm 1.0	1.81 \pm 0.9	0.973
Right canine relationship (mm)	1.48 \pm 1.7	2.31 \pm 2.6	0.020*
Left canine relationship (mm)	1.26 \pm 1.9	2.06 \pm 1.9	0.017*
Right molar relationship (mm)	1.46 \pm 2.4	2.60 \pm 2.6	0.017*
Left molar relationship (mm)	0.95 \pm 1.9	3.06 \pm 10.1	0.033*
Cephalometric variables			
Chin Projection (mm)	-2.24 \pm 7.6	-4.69 \pm 7.9	0.052
SNA ($^{\circ}$)	81.77 \pm 4.2	82.39 \pm 4.7	0.367
SNB ($^{\circ}$)	78.18 \pm 4.7	76.74 \pm 9.7	0.357
ANB ($^{\circ}$)	3.33 \pm 3.17	4.69 \pm 3.5	0.005*
WITTS (mm)	1.64 \pm 4.4	3.96 \pm 5.0	0.011*
N A (mm)	-0.61 \pm 5.0	-0.14 \pm 4.3	0.769
N POG (mm)	-3.38 \pm 7.7	-4.09 \pm 8.7	0.306
Facial angle ($^{\circ}$)	86.65 \pm 5.8	85.83 \pm 5.2	0.259
SNMP ($^{\circ}$)	30.67 \pm 8.9	30.55 \pm 7.9	0.642
FMA ($^{\circ}$)	25.17 \pm 8.8	24.55 \pm 6.5	0.682
MMA ($^{\circ}$)	24.57 \pm 7.2	24.73 \pm 7.6	0.821
Y axis ($^{\circ}$)	62.15 \pm 10.2	63.39 \pm 9.9	0.495
Facial axis ($^{\circ}$)	90.17 \pm 6.9	89.76 \pm 8.0	0.914
PFH (%)	66.29 \pm 6.9	65.57 \pm 10.4	0.818
LAFH (%)	55.16 \pm 3.9	57.58 \pm 5.4	0.044*
UI-SN ($^{\circ}$)	109.77 \pm 14.8	114.04 \pm 11.8	0.027*
IMPA ($^{\circ}$)	99.48 \pm 8.0	103.10 \pm 9.2	0.010*
I-I angle ($^{\circ}$)	116.80 \pm 17.1	111.69 \pm 15.9	0.002*
Z angle ($^{\circ}$)	70.35 \pm 5.27	67.91 \pm 6.7	0.063*
Nasolabial angle ($^{\circ}$)	100.98 \pm 12.5	99.25 \pm 10.9	0.372
Sella-Nasion-Point A angle (SNA), Sella-Nasion-Point B angle (SNB), Angle between SNA and SNB (ANB), Nasion perpendicular to point A (N \perp -A), Nasion perpendicular to Pogonion (N \perp -B), Sella-Nasion-mandibular plane angle (SNMP), Frankfort-mandibular plane angle (FMA), Maxillomandibular Angle (MMA), Posterior Facial Height(PFH), Lower Anterior Facial Height (LAFH), Upper Incisor to Sella-Nasion angle (UI-SN angle), Incisor-Mandibular Plane Angle (IMPA), Interincisal Angle (I-I angle)			
Data is presented as Mean \pm standard deviation (SD), Mann Whitney U test analysis, N=146, Level of significance p= <0.05*			

Whitney test was used to compare AD and DD for MLSD, and Kruskal Wallis test was used to analyse SA, AA and DA for MLSA. The significance of intergroup comparisons was checked using Dunn's post-hoc test. P<0.05 was considered statistically significant.

Results

Of the 148 patients, 104(70.3%) were females and 44(29.7%) were males. The overall mean age was 20.75 \pm 2.47 years. The mean MLSD was 5.86 \pm 2.10mm and mean MLSA was 106.22 \pm 25.11 $^{\circ}$. Mean MLSD for females was 5.70 \pm 1.84mm compared to 6.22 \pm 2.60mm for males (p<0.05). The difference was not significant with respect

Table-4: Correlation of occlusal and cephalometric variables among three angles of mentolabial sulcus angle (MLSA).

Variables	MLSD Group Mean \pm SD			p-value
	Shallow (n=30)	Average (n=30)	Deep (n=88)	
Occlusal variables				
Incisor relationship	2.16 \pm 2.6	1.74 \pm 1.0	1.88 \pm 0.6	0.026*
Overjet (mm)	1.83 \pm 1.8	3.53 \pm 2.2	8.68 \pm 16.7	0.000**
Overbite (%)	30.7 \pm 23.9	47.19 \pm 30.0	53.96 \pm 30.4	0.002*
Curve of Spee (mm)	1.34 \pm 1.0	1.88 \pm 0.8	1.91 \pm 0.9	0.023*
Right canine relationship (mm)	2.04 \pm 2.5	0.64 \pm 1.1	2.21 \pm 1.8	0.000**
Left canine relationship (mm)	1.09 \pm 2.1	0.56 \pm 1.4	2.20 \pm 1.9	0.000**
Right molar relationship (mm)	1.75 \pm 2.7	0.46 \pm 1.9	2.56 \pm 2.4	0.000**
Left molar relationship (mm)	0.11 \pm 2.1	0.17 \pm 1.4	3.13 \pm 8.8	0.000**
Sella-Nasion-Point A angle (SNA), Sella-Nasion-Point B angle (SNB), Angle between SNA and SNB (ANB), Nasion perpendicular to point A (N \perp -A), Nasion perpendicular to Pogonion (N \perp -B), Sella-Nasion-mandibular plane angle (SNMP), Frankfort-mandibular plane angle (FMA), Maxillomandibular Angle (MMA), Posterior Facial Height(PFH), Lower Anterior Facial Height (LAFH), Upper Incisor to Sella-Nasion angle (UI-SN angle), Incisor-Mandibular Plane Angle (IMPA), Interincisal Angle (I-I angle)				
Data is presented as Mean \pm standard deviation (SD), Kruskal Wallis test analysis, N=148, Level of significance p=< 0.05*, p=<0.00**				

Table-5: Pairwise comparison of occlusal and cephalometric variables among mentolabial sulcus angle (MLSA) groups.

Variables	MLSA Groups		
	Shallow-Deep	Average-Shallow	Deep-Average
Occlusal Variables			
Incisor Relationship	0.031*	1.000	0.398
Overjet (mm)	0.000**	0.038*	0.003*
Overbite (%)	0.001*	0.123	0.825
Curve of Spee (mm)	0.025*	0.077	1.000
Right Canine Relationship (mm)	0.486	0.038*	0.000**
Left Canine Relationship (mm)	0.064	0.500	0.000**
Right Molar Relationship (mm)	0.217	0.210	0.000**
Left Molar Relationship (mm)	0.000**	1.000	0.000**
Cephalometric variables			
Chin Projection	0.048*	0.105	1.000
SNA ($^{\circ}$)	0.065	0.009*	0.563
SNB ($^{\circ}$)	0.206	0.000**	0.013*
ANB ($^{\circ}$)	0.486	0.967	0.028*
Facial angle ($^{\circ}$)	0.801	0.007*	0.029*
SNMP ($^{\circ}$)	0.000**	0.000**	1.000
FMA ($^{\circ}$)	0.001*	0.059	1.000
MMA ($^{\circ}$)	0.003*	0.054	1.000
Yaxis ($^{\circ}$)	0.025*	0.016*	1.000
Facial axis ($^{\circ}$)	0.008*	0.164	1.000
PFH (%)	0.000**	0.001*	1.000
UI-SN ($^{\circ}$)	0.000**	0.073	0.291
Z angle ($^{\circ}$)	0.046*	0.099	1.000
Sella-Nasion-Point A angle (SNA), Sella-Nasion-Point B angle (SNB), Angle between SNA and SNB (ANB), Sella-Nasion-mandibular plane angle (SNMP), Frankfort-mandibular plane angle (FMA), Maxillomandibular Angle (MMA), Posterior Facial Height (PFH), Upper Incisor to Sella-Nasion angle (UI-SN angle)			
Data is presented as p-value, Dunn's post hoc test, N=148 Level of significance p= <0.05*, p=<0.00**			

to MLSA (Table 2). The mean MLSD was 1.25 ± 0.35 mm in SD group, 4.54 ± 1.43 mm in AD, and 7.63 ± 1.28 mm in DD. Mean MLSA was $139.2 \pm 5.65^\circ$ in SA, $121.1 \pm 5.38^\circ$ in AA and $89.3 \pm 17.48^\circ$ in angled group.

AD and DD groups demonstrated significant differences with respect to overjet ($p=0.002$), canine and molar relationships ($p=0.05$), ANB ($p=0.005$), Wits appraisal ($p=0.011$), LAFH ($p=0.04$), UI-SN ($p=0.027$), IMPA ($p=0.010$), I-I angle ($p=0.002$) and Z-angle ($p=0.063$). A lower value of I-I angle and Z-angle was associated with DD group, whereas an increased value of overjet, canine and molar relationship, ANB, Wits appraisal, LAFH, UI-SN and IMPA led to an increase in depth of mentolabial sulcus (Table 3).

A significant difference was seen in MLSA groups with respect to chin projection ($p=0.039$), incisor relationship ($p=0.026$), overjet ($p=0.00$), overbite ($p=0.002$), COS ($p=0.023$), canine and molar relationship ($p=0.000$), SNA ($p=0.000$), SNB ($p=0.00$), ANB ($p=0.026$), facial angle ($p=0.006$), SNMP ($p=0.000$), FMA ($p=0.001$), MMA ($p=0.004$), Y-axis ($p=0.010$), facial axis ($p=0.011$), PFH ($p=0.000$), UI-SN ($p=0.000$), I-I angle ($p=0.029$) and Z-angle ($p=0.038$) (Table 4).

Comparison between SA and DA groups showed that chin projection, incisor relationship, overbite, COS, left molar relationship, SNMP, FMA, MMA, Y-axis, facial axis, PFH, UI-SN and Z-angle were significantly different ($p < 0.05$). Between AA and SA groups, overjet, right canine relationship, SNA, SNB, facial angle, SNMP, Y-axis and PFH were significantly different ($p < 0.05$). Between DA and AA groups, overjet, canine and molar relationship, SNB, ANB and facial angle were significantly different (Table 5).

Discussion

MLS separates lower lip from the chin, and is affected by skeletal and dental factors.¹² For proper diagnosis, MLSD and MLSA should be evaluated in each patient either through digital photograph or cephalometric radiograph. MB Nasar et al.¹³ compared linear and angular measurement for soft tissue analysis from radiograph and photograph, and found no significant difference between the measurements of both the groups. The depth and angle of MLS were measured using the cephalometric radiograph in the current study.

The average MLSA was $106.22 \pm 25.11^\circ$ in the current study compared to $117.19 \pm 12.28^\circ$ reported by Brindha MS et al.⁷ in a sample of Tamil students, indicating that race and ethnicity have an impact on MLS.⁷ Males had a deeper LSD than females in the current study, which suggests

that the difference in chin projection between the genders influences this disparity. Earlier studies^{6,14} reported similar results. Esmaeili S.¹⁵ reported that females with a slightly convex profile, deeper MLS, less prominent nose, and shorter maxilla and mandible were perceived as more attractive.

The depth and angle of MLS are influenced by several soft tissue, dental and skeletal variables. Most cases of class II malocclusion, which is characterised by increased ANB, decreased SNB as a result of retrognathic mandible, increased overjet, class II canine and molar relationship, and short facial height are associated with deep MLS.^{12,16} In the current study, deep MLS showed significantly increased overjet, overbite, COS, canine and molar relationship showing class II relationship, SNA, ANB, Wits appraisal, PFH, UI-SN and IMPA. Variables like SNB, SNMP, FMA, MMA, Y-axis, facial axis, I-I angle and Z-angle were significantly decreased in deep MLS. A study¹⁷ evaluated 75 lateral cephalograms to measure and compare the soft tissue cephalometric values in various skeletal malocclusions of adult Kurnool population. The results showed class II malocclusion had increased facial contour angle and deeper MLS compared to class I and class III malocclusions. All vertical analysis values were considerably increased in the shallow MLS.

Increased SNA, ANB along with decreased SNB and facial angle were associated with retrognathic mandible, convex profiles and deep mentolabial sulcus. These results are supported by Al Taki et al.⁶ who reported that Circassian adults had a retruded pogonion ($p=0.002$), higher face convexity angle ($p=0.043$) and deeper MLS ($p=0.000$). In a study by Al-Gunaid et al.¹⁸ on a Yemini population, soft tissue analyses showed more retruded mandible with deep MLS compared to Caucasians. According to Basheer B et al.¹⁹, children with adenoid faces showed deeper MLS and increased facial convexity. A meta-analysis by Almayati DM et al.²⁰ reviewed three studies that examined mentolabial angle change after functional therapy, and showed an increase in mentolabial angle after the treatment. Tiwari R et al.²¹ evaluated perioral soft tissue changes after orthognathic surgical procedures, and reported that 1mm forward movement of mandible showed an increase in the mentolabial angle by 3.6° .

Overbite, COS and PFH have been found to be increased in angled, whereas SNMP, FMA MMA, facial axis and Y-axis are increased in SA. Patients who have a short lower face height typically have a deeper fold, whereas those who have a long lower facial height often have shallow MLS fold.^{22,23} The current study also showed that patients with shorter facial height had deeper MLS, while those with

longer facial height had shallow MLS. As mentioned by Naini et al.,¹² patients with reduced facial height have an abnormally deep MLS because of lower lip eversion and procumbency, which is a result of mandibular overclosure. It has been proposed that mentolabial angle can be increased and MLSD can be decreased by sagittally advancing and vertically increasing chin height.^{12,14} Ting Ho et al.²⁴ proposed that vertically reducing chin height deepens MLS.

According to Naini et al.,¹² increased maxillary incisor inclination affects the depth of MLS in patients with short anterior facial height as upper incisor impinges into lower lip, causing its eversion. Mirabella et al.²³ compared the effect of incisor inclination on lower lip position and soft tissue. Two groups in the study were divided according to maxillary incisor inclination; group 1 having palatally tipped incisor, and group 2 having labially tipped incisor. Results showed decreased MLSD in group 1, and increase in depth in group 2 ($p < 0.0001$). Increased UI-SN and IMPA and decreased I-I angle represent bimaxillary proclination which was seen in the DD group of MLSD in the current study. In contrast to these findings, Brindha et al.⁷ studying Tamil population revealed class II malocclusion with deep mentolabial depth, which was consistent with the current findings, but it also showed shallow MLSD in bimaxillary proclination. Based on study by Alqahtani et al.,⁸ who observed soft tissue changes as a result of premolar extraction in bimaxillary proclination patients, a 9.65° decrease in lower incisor inclination results in a 0.9mm decrease in MLSD, and an increase of 7.5° in MLSA. This finding supports the current finding by demonstrating that an increase in IMPA deepens MLS. According to Nazir SZ et al.,²⁵ mandibular incisor proclination during class III decompensation may have an impact on the upper component of the mentolabial angle, which causes proclination of the lower lip and thereby reduction of the mentolabial angle. Furthermore, according to Sadeghian R et al.,²⁶ Li has been more forwardly positioned in class II malocclusion because lower incisor protrusion causes increase in MLSD. All these studies support the current finding that MLSD increases with increase in IMPA.

The current study has limitations as it was a single-centre study. Also, purposive sampling had to be taken recourse to because the number of patients in SD and SA groups were low. Multicentre, large-scale studies are needed to validate the current findings.

Conclusion

Male gender, class II malocclusion, increased overbite, bimax proclination, and low facial height were associated

with deep MLS, whereas increased facial height was associated with shallow MLS.

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AAK: Data collection, methodology, writing-original draft preparation, investigation and correspondence.

SI: Concept, reviewing, editing and supervision.

TAQ: Resources, reviewing, editing, supervision and validation.