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Comparative cephalometric evaluation of tongue position in subjects with skeletal class II division 1 and division 2 malocclusion

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Abstract

AIM AND OBJECTIVE: To evaluate and compare the position of the tongue from rest to centric occlusion in subjects with skeletal class II division 1 and skeletal class II division 2 malocclusions with subjects of skeletal class II normal occlusion.

MATERIAL AND METHODS: The study was conducted on 30 individuals equally divided into three groups of skeletal class II division (div) 1, skeletal class II div 2, and skeletal class I normal occlusion. The study was conducted on two lateral cephalograms for each subject: one taken at rest and one in centric occlusion.

RESULTS: On evaluation of tongue posture, a statistically significant difference was observed at the middle portion of the tongue in class II div 1 malocclusion, and at the posteromedial portion of the dorsum of the tongue in class II div 2 skeletal malocclusions as the tongue moved from rest to centric occlusion. While statistically significant differences were found between class II div 2 malocclusion and class I normal occlusion, no statistically significant differences were observed between class II div 1 and class II div 2 malocclusions.

CONCLUSION: Tongue position was observed to be the same in both class II div 1 and class II div 2 malocclusions, with no statistically significant differences. However, a great change was seen in the tongue position from rest to centric occlusion.

Keywords:

Centric occlusion, cephalometric study, skeletal class II division 1 malocclusion, skeletal class II division 2 malocclusion, skeletal malocclusions, tongue position

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Introduction

The concept of equilibrium of labio-lingual muscular forces along with the role of muscles in maintaining tooth position and arch stability has been gaining immense popularity amongst orthodontists.[1,2] The tongue is an agile, versatile, active, and extremely sensitive organ that performs on a complex muscle background. Various studies have emphasized the role of tongue posture and size in the development of different skeletal malocclusions.[3–7]

Based on previous studies of lip and tongue pressure, it has been suggested that pressures created at rest may influence the dental arch form and tooth position.[8,9] Graber believed muscle posture to be more important than muscle function in molding the hard tissues.[10] For the majority of the time, the tongue is in rest position and thus influences the dentoskeletal deformity. Forces from unintentional and habitual behavior, regarded as abnormal posture,

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can often lead to jaw deformity and malocclusion.[1] As abnormalities in either function or position of the tongue can lead to changes in the surrounding dentoalveolar structures, having a thorough knowledge of tongue posture is advantageous to better diagnose the etiology of malocclusion and plan an appropriate treatment plan, alongside preventing the chances of a relapse.

A lowered tongue posture is reported to be associated with skeletal class III compared to class I patients.[11] An enlarged tongue and a retracted tongue posture is related to class II division (div) 1 malocclusion.[2] On the other hand, Lowe *et al*.[12] showed a correlation between subjects with a short tongue length, forward pharyngeal wall, and a forward epiglottis and having upright maxillary central incisors. Class II div 2 malocclusion is characterized by having a class II molar relationship with retroclination of the upper front teeth. Even though the etiology of Class II div 2 malocclusion is considered to be the different facial pattern, anti-clockwise mandibular rotation and increased pressure on the maxillary incisors from the lower lip,[13] little is known about the tongue posture in such a malocclusion.

It is quite generally believed that the tongue is an important factor in the development of jaws and dental arches as abnormalities of either tongue posture or function could possibly contribute to the development of malocclusion and speech problems. However, it is also possible that the malocclusion and speech defects could be the causes of abnormal posture and function of the tongue. For this reason treatment planning in orthodontics all too often tends to be focused on the more easily assessed skeletal variations while ignoring the role of the muscular environment of the teeth in the etiology and prognosis of a malocclusion. Therefore, a dental professional must identify abnormal tongue postures and movements that might have an adverse effect on the dentofacial morphology and possibly halt the treatment progress or lead to relapse in some cases.

Thus, this study aimed to evaluate and compare the tongue position in rest and in centric occlusion and the changes seen in tongue posture as it moves from rest to centric occlusion in subjects of skeletal class II div 1 malocclusion, skeletal class II div 2 malocclusion, and skeletal class I normal occlusion.

Subjects and Methods

This study was approved by the Institutional Ethics Committee (EC/NEW/INST/2019/329). All the 30 individuals were informed about the study and signed a consent form voluntarily.

This was a prospective cephalometric study performed on 30 individuals having class II div 1, class II div 2, and class I malocclusions. As tongue formation in most individuals is completed by about 16 years of age[14] and age is seen to have an important bearing on the position of the tongue, the age group of 18–25 years was selected as the age range for this study.

The 30 individuals were divided equally into three groups of skeletal malocclusion based on the clinical and cephalometric evaluation and the following inclusion criteria.

Inclusion criteria

Group 1: skeletal class I normal occlusion comprised of 10 individuals with skeletal class I normal occlusion, having a class I molar relationship on both the sides, normal overjet and overbite, with spacing and crowding, if present less than 2 mm.

Group 2: skeletal class II div 1 malocclusion comprised of 10 individuals with a class II molar relationship on both the sides and an overjet of more than 5 mm.

Group 3: skeletal class II div 2 malocclusion included 10 individuals with a class II molar relationship on both the sides and overjet less than 2 mm and an overbite of more than 2 mm.

Exclusion criteria

Patients with any oral and parafunctional habits, any facial deformity or craniofacial syndrome, and those with any facial trauma, who had undergone any facial reconstructive or cosmetic surgery, were all excluded from the study. Patients having any crossbite or open bite were excluded from the study. Patients who had undergone orthodontic treatment in the past were also excluded from the study.

Method of data collection

The study involved the evaluation of tongue position at rest and occlusion on the lateral head cephalogram. The tongue is a soft tissue and hard to visualize radiographically. For better visualization of the tongue, its dorsum surface was coated with a radio-opaque solution of barium sulphate. The patients were asked to protrude their tongue, and a cotton swab was used to coat the barium sulphate from the middle to the lateral borders, covering the dorsal surface of the tongue. Standardized pre-treatment lateral cephalograms of the individuals were taken with the same X-ray machine (Rotograph Plus, Villa system medical, Italy) and the same positioning instructions at the rest position and in centric occlusion. While shooting the cephalogram, the patients' heads were stabilized in a natural head position, such that the Frankfort horizontal plane of the individual was parallel to the floor. Each patient was instructed to swallow and relax, to keep the lips in a

together position, and teeth in centric occlusion for the first lateral cephalogram. For the lateral cephalogram in the rest position, the patients were instructed to pronounce the words *ram* or *Mississippi* repeatedly, and hold the position immediately. The lateral cephalogram was shot while the patients' oral structures were in a relaxed position. The lateral cephalograms, as obtained, can be seen in Figures 1 and 2.

Evaluation of tongue position

The position of the tongue was evaluated based on the tongue analysis method using a template described by Rakosi[15] in 1982 and further by Graber *et al*.[16] in 1997. The landmarks selected and marked on the lateral cephalogram are described in Table 1 and can be seen in Figure 3.

The template on the lateral cephalogram was constructed by joining the tip of the lower incisors (ii) and cervical, distal-most point on the second erupted molar (Mc), extending posteriorly till the most caudal point of the soft palate or uvula or its projection on the reference line (U). Taking (O) as the mid-point of the reference plane ii-U, the tongue was equally divided into seven parts by constructing angles at 30°, 60°, 90°, 120°, and 150°. Apart from these seven parameters, labeled as Tg1–Tg7 and as described by Rakosi, the tongue height (Tgh), tongue length (Tgl)—based on reference lines given by Lowe *et al*[12]—and distance of the tongue from the pharyngeal wall (Pt – Pw), were also evaluated and compared. The 10 parameters assessed are described in Table 2 and marked in Figure 4.

Statistical analysis

The Statistical Package for the Social Sciences (SPSS) version 20.0 was used to calculate descriptive data. Paired *t*-test was performed to evaluate the change from rest to centric occlusion in all three groups of malocclusions.

The analysis of variance (ANOVA) with *post hoc* Tukey test was done to compare the obtained data in all three groups of skeletal malocclusions.

Results

Tongue position in two different groups of skeletal malocclusions was evaluated and compared, at rest position and in centric occlusion. While group 1 with skeletal class I normal occlusion was taken as the control group, groups 2 and 3 with skeletal class II div 1 and skeletal class II div 2 malocclusions were the study groups.

The mean values and standard deviation of the 10 parameters studied in rest and centric occlusion in group 1 can be seen in Table 3. On analyzing the different positions of the tongue, at centric occlusion, the maximum value was observed with partial length of tongue in the

Table 1: Description of the landmarks marked on the lateral cephalograms

Landmark	Description
ANS	The apex of the anterior nasal spine
E	The most inferior and anterior point on the epiglottis
Ii	Incisal tip of most prominent mandibular incisors
Is	Incisor tip of the most prominent maxillary incisor
Mc	A point on the cervical, distal third of the last erupted permanent molar
mc	Distobuccal cusp tip off the maxillary first permanent molar
O	Middle of the linear distance U-ii on Mc-ii line
PT	The intersection point of the occlusal line and contour of the tongue
PW	The intersection point of the occlusal line (OL) and the pharyngeal wall
TT	Tip of the tongue
U	Tip of the uvula or its projection on Mc-ii line

Figure 1: Lateral cephalogram showing tongue in rest position after being coated with barium sulphate solution

Figure 2: Lateral cephalogram showing tongue in centric occlusion after being coated with barium sulphate solution

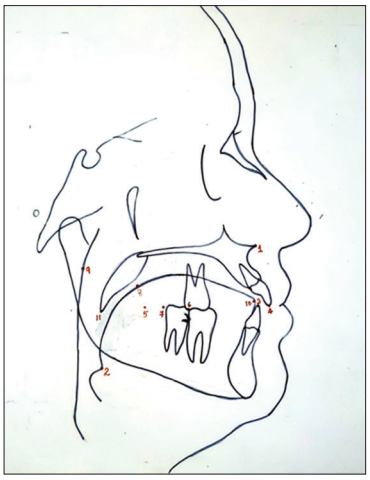

Figure 3: The landmarks marked on the lateral cephalogram as described in Table 1

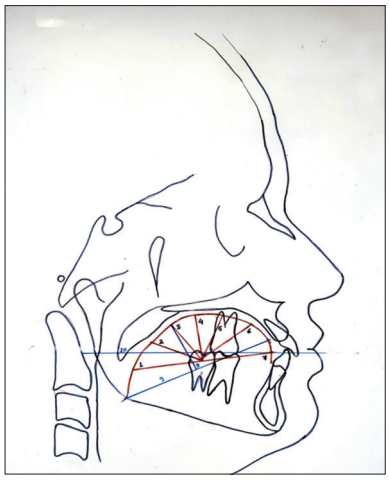

Figure 4: The cephalometric parameters used for the analysis of tongue posture as described in Table 2

tip region (Tg7) and the minimum value with partial length of tongue in the middle of the dorsum of tongue Tg4. At rest position, the maximum measurements were observed with partial length of tongue in the posterior region (Tg1) and the minimum measurements with Tg5. Statistically significant differences were found between the rest position and centric occlusion position of the tongue at levels of Tg3, Tg4, Tg5, Tg6, and Tg7.

The mean values and standard deviation of the 10 parameters in group 2 showed the highest value with Tg1 at centric occlusion and Tg7 at rest, while the lowest values were observed with Tg5 at centric occlusion and Tg4 at rest position. Statistically significant differences ($P < 0.05$) in the position of the tongue between rest and centric occlusion were only observed at Tg4, that is, the middle of the tongue [Table 4].

In group 3, the values measured for Tongue length showed highest value at the Tg1 level and the lowest values of the tongue at rest position at Tg5 level and also at centric occlusion at Tg4 level. Statistically significant differences between the rest and centric occlusion positions were seen at the middle-anterior part of the tongue, at Tg2, and in the measurement of the height of the tongue, Tgh [Table 5].

On comparison of the three groups, at centric occlusion, using ANOVA, statistically significant differences were found at levels of Tg5, Tg6, Tg7, and Tgl [Table 6].

On the other hand, intergroup comparison at rest position showed statistically significant findings only at Tg4 [Table 7].

On pairwise intergroup comparison of the three groups, with mandible at centric relation, statistically significant results were found between group 1 and group 2 at levels of Tg5 and Tg6, while statistically significant results between group 1 and group 3 were found at levels of Tg7 and Tgl [Table 8]. Statistically significant differences between the two groups of skeletal class II malocclusion were seen only at Tg4 [Table 9].

Table 2: Description of the cephalometric parameters used for the analysis of the tongue

Parameter	Description
Tg1	Tgl measures the length of the tongue in the posterior portion (root) of the tongue.
Tg2	Tg2 indicates the partial length of the tongue in the posterior region of the dorsum.
Tg3	Tg3 indicates the partial length of the middle part of the dorsum of the tongue.
Tg4	Tg4 indicates the partial length of the tongue in the middle of the dorsum of the tongue.
Tg5	Tg5 indicates the partial length of the tongue in the middle of the dorsum of the tongue.
Tg6	Tg6 indicates the partial length of the tongue in the anterior region of the tongue.
Tg7	Tg7 indicates the partial length of the tongue in the tip region.
Tgh	It measures the height of the tongue during the rest and centric occlusion.
Tgl	Total tongue length
Pt-Pw	Distance of tongue from pharyngeal wall. This measures the distance of the root part and posterior part of the dorsum of the tongue from the pharyngeal wall.

Discussion

The tongue, being an agile and versatile appendage of the oral cavity, has long been considered to have a direct impact on dentoskeletal structures. Any abnormality in the function and position of the tongue is seen to have a direct influence on the jaw bases, especially the mandible. While various studies in the past have reported a direct correlation between a lowered tongue posture and class III malocclusion,[11] and between a retracted tongue

Table 3: The mean and standard deviation for various parameters at rest and at centric occlusion for skeletal class I normal occlusion (group 1). Occ: Tongue position at occlusion, Rest: Tongue position at rest. *- (P<0.05) significant statistical difference

Pair	Mean	Std. Deviation	P*
Pair 1			
Tg1 occ	33.60	3.502	0.693
Tg1 rest	34.00	3.018	
Pair 2			
Tg2 occ	26.00	3.232	0.692
Tg2 rest	25.50	3.866	
Pair 3			
Tg3 occ	22.30	3.561	0.020*
Tg3 rest	18.90	4.886	
Pair 4			
Tg4 occ	21.30	3.860	0.000*
Tg4 rest	15.80	4.566	
Pair 5			
Tg5 occ	22.40	4.274	0.000*
Tg5 rest	15.40	4.719	
Pair 6			
Tg6 occ	27.80	3.910	0.000*
Tg6 rest	18.50	5.523	
Pair 7			
Tg7 occ	33.30	3.199	0.036*
Tg7 rest	27.70	6.111	
Pair 8			
Tgh occ	36.20	7.927	0.118
Tgh rest	31.30	3.917	
Pair 9			
Tgl occ	80.40	4.526	0.039*
Tgl rest	74.80	6.494	
Pair 10			
Pt-Pw occ	17.50	4.327	0.782
Pt-Pw rest	17.80	3.084	

Table 4: The mean and standard deviation for various parameters at rest and at centric occlusion for skeletal class II division 1 malocclusion (group 2). Occ: Tongue position at occlusion, Rest: Tongue position at rest. *- (P<0.05) statistically significant difference

Pair	Mean	Std. Deviation	P*
Pair 1			
Tg1 occ	34.00	4.899	0.299
Tg1 rest	32.50	3.171	
Pair 2			
Tg2 occ	24.70	5.658	0.462
Tg2 rest	23.50	4.170	
Pair 3			
Tg3 occ	19.60	2.591	0.155
Tg3 rest	17.70	4.572	
Pair 4			
Tg4 occ	18.10	4.332	0.038*
Tg4 rest	14.50	4.143	
Pair 5			
Tg5 occ	16.40	2.797	0.193
Tg5 rest	14.60	4.326	
Pair 6			
Tg6 occ	20.00	3.887	0.195
Tg6 rest	17.90	4.818	
Pair 7			
Tg7 occ	28.70	5.078	0.494
Tg7 rest	26.90	7.415	
Pair 8			
Tgh occ	34.30	4.057	0.429
Tgh rest	33.20	5.245	
Pair 9			
Tgl occ	73.30	9.866	0.449
Tgl rest	71.20	9.830	
Pair 10			
Pt-Pw occ	18.90	1.853	0.200
Pt-Pw rest	20.30	3.713	

posture and class II div 1 malocclusion,[2] little is known about the tongue position in class II div 2 malocclusions.

Thus, the study aimed to evaluate and compare the tongue position at rest and centric occlusion in subjects with skeletal class II div 1 malocclusion, skeletal class II div 2 malocclusion, and skeletal class I normal occlusion. As various authors have emphasized the importance of resting tongue posture as a critical feature in dentoskeletal growth and development, both the tongue position at rest and in centric occlusion were investigated and compared in the study.

Subjects in the age range of 18–25 years were selected for the study as previous reports have suggested that the dorsal tongue height in children is higher than that in adults and the tongue growth in females is essentially completed by 18 years of age.[14] Clinical examination was used to segregate the patients into the three groups of malocclusions based on the inclusion and exclusion criteria. As lateral cephalograms are a routine diagnostic aid required by the patients undergoing orthodontic treatment at institutions, are economical, easy to use, and provide definitive and quantitative information about the soft tissues, they were the preferred choice of method for this study.[15,16] With only a limited number of methods for tongue analysis on the radiograph, the analysis given by Graber *et al.*[15] was used to assess the tongue posture in this study. Guay *et al.*[17] suggested that to better visualize the soft tissue structures on the radiographs, they must be coated with a radio-opaque solution that is adhesive and retains its integrity for at least two swallows. Thus, in this study, the tongue of each subject was coated with barium sulphate solution before shooting the lateral cephalograms. Barium sulphate solution was chosen as it was easy to use, a light medium, palatable, and did not interfere with the movements of the tongue.[18]

Table 5: The mean and standard deviation for various parameters at rest and at centric occlusion for skeletal class II division 2 malocclusion (group 3). Occ: Tongue position at occlusion, Rest: Tongue position at rest. *- (*P*<0.05) statistically significant difference

Pair	Mean	Std. Deviation	Mean Difference	*t*	*P**
Pair 1					
Tg1 occ	31.40	3.565	−1.700	−1.596	0.145
Tg1 rest	33.10	2.685			
Pair 2					
Tg2 occ	22.50	2.953	−2.900	−2.824	0.020*
Tg2 rest	25.40	2.119			
Pair 3					
Tg3 occ	18.70	3.529	−1.700	−2.047	0.071
Tg3 rest	20.40	2.221			
Pair 4					
Tg4 occ	17.90	3.784	−2.100	−1.783	0.108
Tg4 rest	20.00	3.742			
Pair 5					
Tg5 occ	19.00	5.774	0.200	0.141	0.891
Tg5 rest	18.80	3.393			
Pair 6					
Tg6 occ	21.90	6.951	0.100	0.055	0.958
Tg6 rest	21.80	4.686			
Pair 7					
Tg7 occ	25.90	5.971	0.400	0.246	0.811
Tg7 rest	25.50	5.930			
Pair 8					
Tgh occ	31.10	2.331	−2.300	−2.769	0.022*
Tgh rest	33.40	3.307			
Pair 9					
Tgl occ	68.70	7.875	3.600	1.804	0.105
Tgl rest	65.10	9.562			
Pair 10					
Pt-Pw occ	17.10	4.508	−.100	−.091	0.930
Pt-Pw rest	17.20	3.011			

Table 6: Intergroup comparison of different parameters of tongue position between the three groups at centric occlusions. *- (*P*<0.05) statistically significant difference

Comparison	Parameter	Sum of Squares	Mean Square	*P*
Group 1 vs.	Tg1	40.217	20.108	0.314
Group 2 vs.	Tg2	62.917	31.458	0.176
Group 3	Tg3	66.650	33.325	0.059
	Tg4	72.800	36.400	0.120
	Tg5	184.217	92.108	0.018*
	Tg6	323.117	161.558	0.006*
	Tg7	279.200	139.600	0.008*
	Tgh	127.817	63.908	0.125
	Tgl	694.867	347.433	0.008*
	Pt-Pw	17.736	8.868	0.543

Table 7: Intergroup comparison of different parameters of tongue position between the three groups at rest position. *- (*P*<0.05) statistically significant difference

Comparison	Parameter	Sum of Squares	Mean Square	*P*
Group 1 vs.	Tg1	12.817	6.408	0.495
Group 2 vs.	Tg2	26.717	13.358	0.349
Group 3	Tg3	37.917	18.958	0.329
	Tg4	166.250	83.125	0.018*
	Tg5	101.150	50.575	0.071
	Tg6	90.617	45.308	0.186
	Tg7	25.017	12.508	0.746
	Tgh	25.800	12.900	0.493
	Tgl	480.867	240.433	0.060
	Pt-Pw	52.850	26.425	0.105

Table 8: Pairwise multiple intergroup comparison of the significant parameters between three groups at centric occlusion. *- (*P*<0.05) statistically significant difference

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I–J)	*P*
Tg5	Group 1	Group 2	6.05000*	0.014*
		Group 3	3.45000	0.210
	Group 2	Group 1	−6.05000*	0.014*
		Group 3	−2.60000	0.403
	Group 3	Group 1	−3.45000	0.210
		Group 2	2.60000	0.403
Tg6	Group 1	Group 2	7.70000*	0.006*
		Group 3	5.85000*	0.042
	Group 2	Group 1	−7.70000*	0.006*
		Group 3	−1.85000	0.701
	Group 3	Group 1	−5.85000*	0.042*
		Group 2	1.85000	0.701
Tg7	Group 1	Group 2	4.60000	0.110
		Group 3	7.40000*	0.006*
	Group 2	Group 1	−4.60000	0.110
		Group 3	2.80000	0.421
	Group 3	Group 1	−7.40000*	0.006*
		Group 2	−2.80000	0.421
Tgl	Group 1	Group 2	7.10000	0.120
		Group 3	11.70000*	0.006
	Group 2	Group 1	−7.10000	0.120
		Group 3	4.60000	0.392
	Group 3	Group 1	−11.70000*	0.006
		Group 2	−4.60000	0.392

The outcomes of the study showed that in group 1, the maximum thickness of the tongue at rest position was seen in the anterior tip region of the tongue (Tg7) while the minimum thickness was observed in the middle region of the dorsum (Tg5). However, in centric occlusion, the maximum thickness of the tongue was observed in the root portion (Tg7) while the minimum thickness was observed in the middle portion of the dorsum (Tg4). When the tongue moved from rest to centric occlusion, it showed statistically significant increases at levels of Tg3, Tg4, Tg5, Tg6, Tg7, and Tgl. This suggests that the tongue moved antero-superiorly

Table 9: Pairwise multiple intergroup comparison of the significant parameters between three groups at rest position. *- (*P*<0.05) statistically significant difference

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	*P*
Tg4	Group 1	Group 2	1.25000	0.786
		Group 3	−4.25000	0.080
	Group 2	Group 1	−1.25000	0.786
		Group 3	−5.50000*	0.018*
	Group 3	Group 1	4.25000	0.080
		Group 2	5.50000*	0.018*

in the posterior and root end regions and superiorly in the middle region of the dorsum by a significant amount. These results coincide with the explanation given by Peat *et al*.[19] that in normal occlusion, there are two positions of the tongue: the first is the contact of the dorsum with the soft palate to maintain the posterior oral seal, and the second is the contact of the tip of the tongue to maintain the anterior oral seal. Both are produced at the expense of contact with the hard palate.

In group 2, while the rest position showed a maximum thickness at the tip of the tongue (Tg7), the centric occlusion showed maximum thickness at the posterior root level (Tg1). This suggests that the tongue moved superior-posteriorly while the mandible moved from rest to centric occlusion. These results are similar to those of Rakosi *et al*.[16] who pointed out that as the tip of the tongue in class II malocclusion is retracted, the position of the tip of the tongue does not change much from rest to centric occlusion. However, he also concluded that the posterior portion of the tongue moved anteriorly from rest to centric occlusion. The least values at the rest and centric occlusion were obtained in the middle portion of the dorsum of the tongue (Tg4, Tg5). A statistically significant increase ($P < 0.05$) was observed in the middle portion of the dorsum of the tongue (Tg4) as it moved from rest to centric occlusion. These results coincide with those of Verma *et al*.[7] wherein the tongue in class II div 1 malocclusion was observed to significantly move posterior-superiorly in the posterior-medial region of the tongue.

In group 3, the highest values were observed at the tip of the tongue for both rest and centric occlusion positions, while the lowest values were observed at the middle portion of the dorsum of the tongue (Tg4, Tg5). A statistically significant increase was noted in the medial-posterior region of the tongue (Tg2), suggesting that the tongue moved posterior-superiorly from rest to centric occlusion.

On comparison of the three groups at the centric position, statistically significant differences ($P < 0.05$) were noted at the anterior regions of the tongue and the tongue tip (Tg7, Tg6, Tg5) along with the total length of the tongue (Tgl). On pairwise comparison of the three groups, significant differences were seen between group 1 and 2 at the middle portion of the tongue (Tg5) and anterior body of the tongue (Tg6), suggesting that the anterior part of the tongue was more superiorly and posteriorly placed in skeletal class II div 1 malocclusion. Significant differences were observed between groups 2 and 3 at the tip of the tongue and the total tongue length, suggesting that the total length of the tongue was shorter in class II div 2 malocclusion compared to class I. Also, the tip of the tongue was retracted and more posteriorly placed in class I compared to class II div 2 malocclusion. Significant differences between groups 2 and 3 were only found at rest position, at the middle portion of the dorsum of the tongue. This suggests that the tongue in skeletal class II div 2 malocclusion is more highly placed and closer to the palate compared to the position of the tongue in class II div 1 malocclusion. This is seen to have a clinical implication, as a class II div 2 malocclusion is characterized by a broader arch form, while a class II divis 1 malocclusion is normally found with constricted arches.

On comparison of the change in tongue position from rest to centric occlusion, between the three groups, statistically significant differences were observed in the middle and anterior regions of the tongue, namely, Tg3, Tg4, Tg5, Tg6, and Tgh, suggesting that the tongue in all three groups significantly moved in the posterior and superior direction. The maximum amount of change in posture from rest to centric occlusion was observed in class I, and the least with class II div 2 malocclusion. No statistically significant change was noted in the tongue position from rest to centric occlusion between class II div 1 and div 2. However, highly significant differences were noted between class I normal occlusion and class II div 2 malocclusions. These differences were mainly observed in the middle portion of the dorsum of the tongue and at the tongue height, which suggests that change in tongue posture from rest to centric occlusion is significantly much lesser in class II div 2 malocclusion compared to class I normal occlusion, particularly in the middle portion of the tongue.

Conclusions

Within the limitations of this study, the following conclusions can be drawn:

The tongue posture in class II division 2 malocclusion is more retracted compared to that in class I normal occlusion. The length of the tongue is also significantly smaller compared to class I normal occlusion. In comparison to class II division 1 malocclusion, the middle

portion of the dorsum of the tongue in class II division 2 is more highly placed when at rest position.

The tongue position in class I is more anteriorly and superiorly placed in centric occlusion, when compared to class II division 1 malocclusion, which was seen to have a more retracted tongue posture. On moving from rest to centric occlusion, the tongue in all three groups moved in a posterior and superior direction. The posture of the tongue varied significantly in the two groups of class II malocclusion. The dorsum of the tongue was higher at the back and lower in the front in class II division 1 group compared to class I normal occlusion group. Tongue height and tongue length were significantly reduced in class II division 1 and class II division 2 malocclusion groups when compared to class I control group.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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