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Original Research Article

Comparative assessment of tongue posture in class II division 1 patients treated with functional appliance and camouflage orthodontic treatment: a retrospective cephalometric study

Ann Susan Joseph, Tejashri Pradhan*

Department of Orthodontics and Dentofacial Orthopedics, KLE Academy of Higher Education and Research, KLE VK Institute of Dental Sciences, Belagavi, Karnataka, India

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***Correspondence:**
Dr. Tejashri Pradhan,
E-mail: annsusjoseph@gmail.com

ABSTRACT

Background: Class II division 1 malocclusion is frequently associated with mandibular retrognathism, which may compromise tongue posture and airway, increasing the risk of respiratory issues. This study aimed to assess and compare the effects of functional appliance therapy and extraction-based camouflage orthodontic treatment on tongue posture in Class II division 1 patients. Limited literature exists on the impact of anterior retraction on tongue posture in skeletal Class II camouflage cases, warranting further investigation.
Methods: A retrospective cephalometric analysis was conducted on two groups: patients treated with functional appliances and those treated with premolar extractions. Pre- and post-treatment lateral cephalograms were analyzed using cephalometric parameters described by Rakosi and Lowe (tg1–tg7, tgH, tgL). Inter- and intra-group comparisons were made using the independent and dependent t-test respectively.
Results: Functional therapy showed significant improvement in total tongue length TgL intra and inter-group, suggesting enhanced oral cavity volume and forward tongue positioning. The anterior tongue dimension (Tg1) also showed significant inter-group difference. In contrast, camouflage treatment showed a significant intra-group reduction in TgL, indicating possible tongue space restriction. Other tongue posture parameters showed non-significant trends.
Conclusions: Functional appliance therapy benefits tongue posture and airway space, particularly in growing patients, by promoting mandibular and tongue advancement. In contrast, extraction-based camouflage may adversely affect tongue posture, especially in non-growing individuals. These findings emphasize the importance of airway-focused treatment planning and support the use of functional appliances when indicated.

Keywords: Class II malocclusion, Functional appliances, Camouflage therapy, Tongue posture, Cephalometrics, Orthodontic treatment planning

INTRODUCTION

Class II skeletal malocclusion represents a prevalent sagittal discrepancy in orthodontics, typically characterized by mandibular retrognathism, maxillary prognathism, or both, with mandibular retrusion being the most frequently encountered combination[1]. According to Proffit's equilibrium theory, the resting posture of orofacial muscles like the buccinator and particularly the tongue, plays a pivotal role in maintaining dental and skeletal harmony.[2] In a normal scenario, the tongue exerts a gentle, expansive pressure against the palate, aiding transverse maxillary development and maintaining arch width.[3,4] However, in Class II patients with low tongue posture, this balance is disturbed, allowing unchecked inward forces from the cheeks and lips to constrict the arch, resulting in a high, narrow palate and compromised arch length and width.[5] The growth of the mandible is restricted transversely, or the mandible is not able to catch up due to the constricted and V-shaped maxillary arch. Additionally, a lower tongue position affects pharyngeal airway dimensions, contributing to reduced oropharyngeal space and increasing the risk of functional sequelae such as compromised breathing, altered swallowing patterns and instability post-treatment.[6,7] The disruption in muscular equilibrium thus has far-reaching consequences not only on dental arch form but also on airway patency and long-term orthodontic stability.[8] The etiology is multifactorial, involving hereditary patterns, environmental factors and neuromuscular imbalances.[9,10]

The tongue, a muscular hydrostat, functions intricately in breathing, mastication, swallowing and speech.[11] In Class II malocclusion, mandibular retrusion and posterior tongue displacement can encroach upon this airway space, predisposing individuals to upper airway resistance syndrome (UARS) and obstructive sleep apnea (OSA), especially during sleep when muscle tone is reduced.[12,13] The compromised airway space not only affects respiratory efficiency but also exacerbates craniofacial growth disturbances, potentially perpetuating a cycle of dysfunction.[14] Studies have shown that Class II patients with narrow airways often present clinical symptoms such as snoring, mouth breathing and daytime somnolence, underlining the clinical relevance of assessing airway dimensions during orthodontic diagnosis.[15]

Skeletal class II division 1 patients typically exhibit features such as convex facial profile, increased overjet, maxillary protrusion, mandibular retrusion and a retrognathic chin.[16] Dental manifestations include proclined maxillary incisors and retroclined mandibular incisors, while soft tissue features often present as lip incompetence and an acute nasolabial angle.[17] These skeletal and soft tissue patterns influence tongue posture and airway configuration, further complicating the clinical picture.[18]

Treatment strategies for class II malocclusion include functional appliance therapy, camouflage treatment involving extractions, or orthognathic surgery.[19] Functional appliances like the twin block are most effective in growing patients, leveraging residual mandibular growth to posture the mandible forward, enhancing skeletal correction.[20,21] Conversely, camouflage treatment, typically used in non-growing individuals, relies on dental compensations such as premolar extractions to manage protrusion without altering the skeletal base.[22] In severe skeletal cases or post-growth phases, orthognathic surgery becomes necessary for comprehensive correction.[23] Treatment decisions are guided by the patient's age, growth potential, severity of malocclusion and airway considerations.[24] Tongue volume and posture exhibit age-related changes, peaking during adolescence and stabilizing in adulthood, although variations persist due to anatomical and functional factors.[8] Several imaging modalities aid in evaluating tongue posture. These include CBCT and MRI, with lateral cephalometry remaining the most accessible and widely used in orthodontics.[25] Despite being two-dimensional, cephalometry provides reliable data on sagittal airway space, tongue posture and related craniofacial structures.[26] Parameters such as PAS (posterior airway space), distance from the dorsum of the tongue to the palate and the position of the hyoid bone have been validated as key indicators of functional changes following orthodontic intervention.[27]

Given the intricate relationship between mandibular position, tongue posture, understanding the impact of different treatment modalities is crucial. While functional appliances aim to improve both skeletal and tongue dimensions, camouflage approaches may not address these concerns effectively.[28] Therefore, this retrospective cephalometric study, aims to provide a comparative evaluation of these parameters, offering insights to refine treatment planning and enhance both esthetic and functional outcomes.[29] Very few studies have been conducted on the effect of anterior retraction on tongue posture in class II skeletal malocclusion camouflage cases and its comparison to treatment by functional appliances and therefore this study has been undertaken.

METHODS

Study design

It was a retrospective cephalometric study.

Source of data/laboratory details

40 pre and post-treatment functional and camouflage treated lateral cephalograms obtained from the record data base of patients who underwent orthodontic treatment in Department of Orthodontics and Dentofacial Orthopedics, at a Dental hospital in India. The study was conducted between the period of September 2023 to March 2025.

Inclusion criteria

The study included cephalometric records of male and female patients, with skeletal malocclusion with mandibular retrognathism, having ANB greater than or equal to 4 degree and AO-BO greater than 2 mm, in the age group of 10-15 years in functional treatment group and 16-40 years in the camouflage treatment group. Only cephalometrics of good quality were taken.

Exclusion criteria

Cephalometric records of patients having respiratory disorders and who had past medical history of trauma to jaw, enlarged adenoids or any surgery of tonsils or a history of nasal stenosis, cleft lip and palate, or any other systemic condition that interferes with normal growth were excluded from the study.

Class II div 1 malocclusion identified cases

Group 1
Functional Orthodontic Treatment Group

Group 2
Camouflage Orthodontic Treatment Group

Pre and post treatment Lateral cephalograms of patients taken in natural head position was collected

Acetate sheet was placed on the top the radiographs and the landmarks were traced

Tongue posture parameters pre- and post-treatment, were measured in each group

Descriptive Statistical Analysis was conducted for the measured parameters pre- and post-treatment

The pre and the post treatment values were compared within the Group 1 and Group 2.

Difference between pre and the post treatment values were measured in each group and compared between Group 1 and Group 2

Figure 1: Materials and methodology.

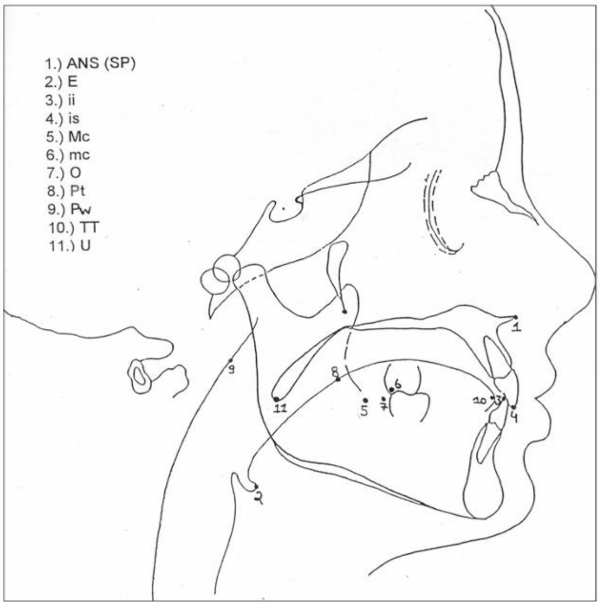

Figure 2: Landmarks.[16,30]

Materials

Pre and post treatment lateral cephalograms of subjects, 0.35 mm mechanical lead pencil for tracing of radiographs, illuminated view box for tracing of radiographs, acetate matte sheets, scale, setsquares, protractor were used.

Tongue analysis

The tongue analysis was done according to the landmarks (Table 1 and Figure 2) and measurement parameters (Table 2 and Figure 3) as given by Rakosi et al and Lowe et al.[16,30]

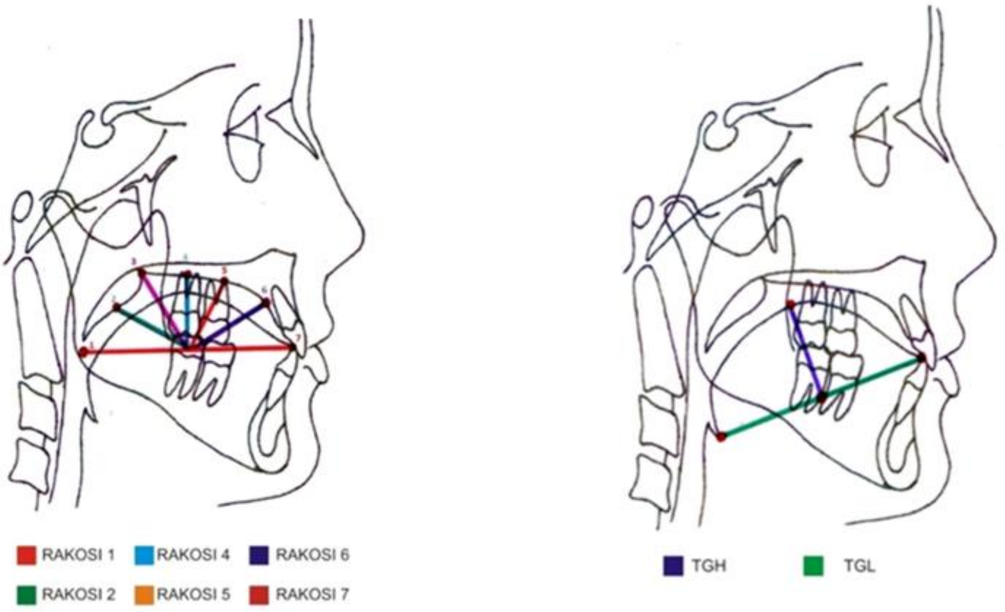

Figure 3: Parameters.[16,30]

Table 1: Description of landmarks.[16,30]

Landmark	Description
A.N.S.	The anterior nasal spine's apex
E	The epiglottis's most anterior and inferior points
Ii	Most prominent mandibular incisors' incisal tip
Is	The tip of the most noticeable maxillary incisor
Mc	A location on the cervical distal third of the final permanent molar to erupt
mc	Distobuccal cusp tip of the first permanent molar in the maxilla
O	The midpoint of the linear distance U-ii on the Mc-ii line
TT	Tongue tip
U	Uvula projection on the Mc-ii line or its tip

Table 2: Description of parameters.[16,30]

Parameters	Description
tg1	The tongue's length at its posterior region, or root. Line constructed through the O and ii.
tg2	The tongue's partial length in the dorsum's posterior area. Line constructed on O at 30° Mc-ii line.
tg3	The tongue’s partial length of the dorsum's middle length. Line constructed on O at 60° Mc-ii line.
tg4	The partial length of the tongue in the center of the its dorsum. Line constructed on O at 90° Mc-ii line.
tg5	The partial length of the tongue in the center of its dorsum. Line constructed on O at 120° Mc-ii line.
tg6	The partial length of the tongue in the anterior area. Line constructed on O at 150° Mc-ii line.
tg7	The partial length of the tongue in the tip area. Line constructed on O at 180° Mc-ii line.
TgH	The tongue's height during centric occlusion and rest.
TgL	Whole length of the tongue.

RESULTS

Comparison of pre-treatment and post-treatment values (in mm) of tongue related parameters in functional and camouflage treatment groups by dependent t test.

Table 3 depicts changes within functional and camouflage group. In the functional group, tgL showed statistically significant difference (61.95±4.73 mm (Pre) and 65.15±5.75 mm (Post); p=0.0091), suggesting an improvement in overall tongue posture and space. While tg1 and tg7 showed improvement, they did not reach statistical significance.

In the extraction group, tgL showed statistically significant difference (66.65±6.22 mm (Pre) and 65.50±6.12 mm (Post); p=0.0278), indicating a potential reduction in tongue space following extraction and retraction. All other parameters across both groups remained statistically non-significant, suggesting limited change in mid and posterior tongue posture from treatment alone.

Comparison between Functional appliance treatment group and Camouflage treatment group of tongue related parameters in mm by independent t test.

Table 4 compares tongue posture measurements between the functional and extraction groups. Statistically significant differences were observed in tg1 and tgL. Post-treatment tg1 increased in the functional group (30.95±4.26 mm) but decreased in the extraction group (28.20±3.96 mm), resulting in a significant difference. This suggests forward positioning of the tongue in functional cases. Similarly, tgL, which represents total tongue length, increased in the functional group (from 61.95±4.73 mm to 65.15±5.75 mm) and decreased in the extraction group (from 66.65±6.22 mm to 65.50±6.12 mm), with a statistically significant difference, indicating that extraction therapy restricts tongue length due to reduced oral volume. Other parameters such as tg2–tg7 and tgH did not show statistically significant inter-group differences (p>0.05), indicating stability in those regions regardless of treatment modality.

Table 3: Comparison of pre-treatment and post-treatment values (in mm) of tongue related parameters in functional and camouflage treatment groups by dependent t test.

Group	Parameters	Pre-test		Post-test		Mean Diff.	% of change	t value	P value
		Mean	SD	Mean	SD				
Functional	tg1	29.55	2.44	30.95	4.26	-1.4	-4.74	-1.6286	0.1199
	tg2	21.75	3.39	22.4	3.56	-0.65	-2.99	-0.8345	0.4144
	tg3	17.8	3.33	18	3.32	-0.2	-1.12	-0.2564	0.8004
	tg4	15.8	2.91	16.2	3.69	-0.4	-2.53	-0.4573	0.6527
	tg5	16.15	3.25	17.1	3.7	-0.95	-5.88	-1.1784	0.2532
	tg6	19.1	3.54	20.3	3.31	-1.2	-6.28	-1.633	0.1189
	tg7	26	3.67	27.7	3.71	-1.7	-6.54	-1.7608	0.0944
	tgH	29.2	3.02	29.7	3.81	-0.5	-1.71	-0.488	0.6312
	tgL	61.95	4.73	65.15	5.75	-3.2	-5.17	-2.9047	0.0091*
Extraction	tg1	29.5	4.29	28.2	3.96	1.3	4.41	1.3316	0.1988
	tg2	20.55	4.31	19.35	4.04	1.2	5.84	1.0799	0.2937
	tg3	15.75	3.65	15.8	3.76	-0.05	-0.32	-0.056	0.9559
	tg4	14	3.48	14.45	4.31	-0.45	-3.21	-0.5057	0.6189
	tg5	14.75	3.24	15.7	4.35	-0.95	-6.44	-1.0468	0.3083
	tg6	18.6	4.01	19.35	4.04	-0.75	-4.03	-0.8679	0.3963
	tg7	28.3	4.18	28.15	2.96	0.15	0.53	0.1784	0.8603
	tgH	29.3	2.79	28.8	4.32	0.5	1.71	0.461	0.65
	tgL	66.65	6.22	65.5	6.12	1.15	1.73	2.3823	0.0278*

*p<0.05W

Table 4: Comparison between functional appliance treatment group and camouflage treatment group of tongue related parameters in mm by independent t test.

Parameters	Time points	Functional group		Extraction group		Effect size	t-value	P value
		Mean	SD	Mean	SD			
tg1	Pretest	29.55	2.44	29.50	4.29	0.02	0.0453	0.9641
	Posttest	30.95	4.26	28.20	3.96	1.39	2.1155	0.0410*
	Difference	-1.40	3.84	1.30	4.37	-1.24	-2.0756	0.0447*
tg2	Pretest	21.75	3.39	20.55	4.31	0.56	0.9792	0.3337
	Posttest	22.40	3.56	19.35	4.04	1.51	2.5321	0.0156
	Difference	-0.65	3.48	1.20	4.97	-0.74	-1.3633	0.1808

Continued.

Parameters	Time points	Functional group		Extraction group		Effect size	t-value	P value
		Mean	SD	Mean	SD			
tg3	Pretest	17.80	3.33	15.75	3.65	1.12	1.8533	0.0716
	Posttest	18.00	3.32	15.80	3.76	1.17	1.9591	0.0575
	Difference	-0.20	3.49	-0.05	3.99	-0.08	-0.1265	0.9000
tg4	Pretest	15.80	2.91	14.00	3.48	1.03	1.7740	0.0841
	Posttest	16.20	3.69	14.45	4.31	0.81	1.3788	0.1760
	Difference	-0.40	3.91	-0.45	3.98	0.03	0.0401	0.9682
tg5	Pretest	16.15	3.25	14.75	3.24	0.86	1.3640	0.1806
	Posttest	17.10	3.70	15.70	4.35	0.64	1.0960	0.2800
	Difference	-0.95	3.61	-0.95	4.06	0.00	0.0000	1.0000
tg6	Pretest	19.10	3.54	18.60	4.01	0.25	0.4184	0.6780
	Posttest	20.30	3.31	19.35	4.04	0.47	0.8131	0.4212
	Difference	-1.20	3.29	-0.75	3.86	-0.23	-0.3967	0.6938
tg7	Pretest	26.00	3.67	28.30	4.18	-1.10	-1.8487	0.0723
	Posttest	27.70	3.71	28.15	2.96	-0.30	-0.4236	0.6742
	Difference	-1.70	4.32	0.15	3.76	-0.98	-1.4451	0.1566
tgH	Pretest	29.20	3.02	29.30	2.79	-0.07	-0.1087	0.9140
	Posttest	29.70	3.81	28.80	4.32	0.42	0.6982	0.4893
	Difference	-0.50	4.58	0.50	4.85	-0.41	-0.6702	0.5068
tgL	Pretest	61.95	4.73	66.65	6.22	-1.51	-2.6906	0.0105*
	Posttest	65.15	5.75	65.50	6.12	-0.11	-0.1864	0.8531
	Difference	-3.20	4.93	1.15	2.16	-4.03	-3.6166	0.0009*

*$p<0.05$

DISCUSSION

The tongue is an agile muscular organ essential for articulation, deglutition, mastication and airway maintenance, with its morphology characterized by intricate musculature and extensive sensory innervation.[31] Its positioning significantly influences craniofacial development and occlusal relationships.[16] In skeletal Class II malocclusions, the posteriorly positioned tongue, as documented by Shinde et al and Chhabra et al, restricts the pharyngeal airway dimensions, predisposing to obstructive sleep apnea (OSA).[5,6]

Battagel et al, demonstrated that this posterior tongue position reduces upper airway patency during sleep, while Jain et al noted that mandibular retrognathism further exacerbates this airway constriction.[11,32] According to Verma et al, the altered tongue posture in Class II patients creates a self-perpetuating cycle affecting both respiration and craniofacial development.[17] Proper tongue positioning against the palate plays a vital role in ensuring adequate transverse maxillary arch development and stability of dental arches, with significant variations across age and gender as documented by Rakosi et al and Baker et al.[6,7,16,31]

Obstructive sleep apnea (OSA) is a common yet significant sleep disorder, clinically defined by repetitive episodes of partial or complete obstruction of the upper airway during sleep, resulting in compromised respiratory airflow. Such episodes commonly manifest as snoring, frequent awakenings, fragmented sleep patterns and intermittent hypoxia, adversely affecting the quality of life and systemic health of affected individuals.[13,15] Patients typically present with daytime fatigue, impaired cognitive function and various behavioral disturbances, including irritability, mood swings and symptoms resembling attention deficit hyperactivity disorder (ADHD). The complex pathophysiology of OSA is multifactorial, involving anatomical, neurological and physiological dimensions, often interlinked with underlying craniofacial structural discrepancies and neuromuscular dysfunction.[13]

Orthodontics emerged as a critical discipline in airway management by the latter half of the 20th century, recognizing that craniofacial abnormalities such as mandibular retrognathism, maxillary constriction and altered tongue positioning substantially contribute to airway obstruction in OSA patients.[20] The introduction of orthodontic functional appliances was a transformative advancement in treating skeletal malocclusions, particularly Class II discrepancies, which are frequently associated with compromised airway space.[33] Functional appliances were initially created by Robin (monobloc), followed by influential modifications such as Andresen's activator, Balters' bionator and notably Clark's Twin Block appliance, each specifically designed to enhance mandibular growth and reposition mandibular posture anteriorly.[20]

These appliances have shown substantial efficacy in improving airway patency, predominantly through favorable skeletal modifications, enhanced soft tissue positioning and improved neuromuscular function.[12,28] In this present study, the Twin Block appliance was predominantly utilized due to its documented effectiveness, patient comfort, compliance benefits and predictable clinical outcomes, followed closely by the activator and bionator appliances.

Despite their considerable clinical success, functional orthodontic appliances are not universally applicable across all patient populations. Alternative treatment modalities, notably extraction-based camouflage orthodontics and orthognathic surgery, remain clinically relevant due to varying patient demographics, growth potential, severity of malocclusion and psychosocial or economic constraints.[22,24] Adolescents and younger patients often respond optimally to functional appliances due to their residual growth potential, which allows effective mandibular repositioning and skeletal remodeling. Conversely, post-adolescent patients with reduced or negligible growth potential commonly require alternative interventions. Orthodontic camouflage, which involves premolar extractions and significant anterior tooth retraction, is frequently preferred by patients reluctant to undergo invasive surgical procedures.[22]

Nonetheless, camouflage treatment has its limitations, often leading to posterior displacement of oral structures and subsequent airway narrowing.[34] Orthognathic surgical interventions, notably mandibular advancement procedures, offer substantial and predictable improvements in skeletal outcomes, representing the gold standard in treating severe skeletal discrepancies among adults.[11,24] Despite clear advantages, patient acceptance of surgery remains limited due to psychological apprehension, cost factors and potential morbidity.

Tongue posture was assessed through a series of linear dimensional parameters, as given by Rakosi et al and Lowe et al, evaluating aspects such as tongue length, position and height in relation to surrounding anatomical structures.[16,30] This comprehensive evaluation framework allowed for a detailed understanding of how each treatment modality influences tongue posture, contributing valuable insights to clinical orthodontic practice.

Tongue posture (measured as tg1-7, tgH, tgL) shows distinctive patterns across malocclusions, with Shinde et al, noting posteroinferior positioning in Class II division 1 compared to division 2, while Chhabra et al and Kalgotra and Mushtaq reported significant differences between Class II and III presentations.[5,6,35] Verma et al identified considerable variations between rest position and centric occlusion, with increase in tg3-7 and tgl from rest to co tg7 showed maximum value at rest and in centric occlusion and minimum value was shown by TG5 at rest and tg4 at centric occlusion, corroborated by Peat et al and Fishman et al.[17,36,37]

According to Cohen et al, tongue dimensions adapt with craniofacial growth patterns, with Guay et al documenting anterior posturing in Class III patients.[8,38] Following orthognathic surgeries, Jain et al and Battagel et al, observed significant adaptations in tongue posture.[11,38] In cases of incisor retraction and extraction spaces, Madhavan and Nagmode et al, noted posterior tongue displacement affecting pharyngeal dimensions.[39,40] Macroglossia frequently presents with buccal openbite, while tongue thrust manifests as anterior openbite with characteristic lisping.[12] Yu et al demonstrated how altered tongue pressure distribution during rest and function contributes to various malocclusions.[41] Afzal et al documented significant tongue adaptations following functional appliance therapy such as lowered position of tongue, expansion of dentoalveolar segments and thereby increasing the tongue area and intermaxillary space, supported by Yassaei et al, Ozebek et al, Ozdemir et al.[12,42-45]

Iwasaki et al, in his study has noted that there is a superior positioning of tongue followed by rapid maxillary expansion.[46] With regard to body posture in Pae's CBCT study, when there is a change from upright to supine position, the cross sectional area of tongue and the soft palate thickness increases and thereby the posterior tongue pressure and oropharyngeal airway decreases.[47] The effect of extraction and tongue space was noted by Germec-Caken et al.[48]

In minimum anchorage cases, posterior tongue space has increased after mesial molar movement and in cases of maximum anchorage, with retraction of upper and lower incisors, there was an adaptational narrowing of the tongue, which had its effect on pharyngeal airway by an increase and decrease respectively, which was contrary to the study by Valiathan et al.[49] According to Fishman the tip of the tongue contacted the lingual surfaces of the lower incisors in both rest and occlusion.[37] Dorsum of the tongue was superior to the occlusal plane but do not contact the hard palate. The posterior area of the dorsum contacted the soft palate. From rest to occlusion, the length and height decreased.

The current study demonstrated significant improvements in tongue space, with a statistically significant increase in total tongue length (tgL) 61.95±4.73 to 65.15±5.75 mm, p=0.0091 and a noticeable anterior repositioning of the tongue (tg1) following functional appliance therapy, aligning with findings reported by Afzal et al and Dedhiya et al.[12,29] These outcomes underscore the biomechanical effectiveness of functional appliances in enhancing tongue posture and oral cavity volume, thereby contributing to functional stability.

In contrast, extraction therapy led to statistically significant reductions in tongue space (tgl) 66.65±6.22 to 65.50±6.12, p=0.0278, indicative of posterior displacement of the tongue due to incisor retraction. This finding is consistent with the observations of Bhatia et al, who noted that significant incisor retraction markedly reduced the available tongue space.[34] Although Sharma et al, reported relatively limited effects of extraction therapy on tongue positioning, such variability in outcomes underscores methodological differences, individual anatomical variability and variations in treatment protocols across studies.[50] Comparative analyses within this research clearly favored functional appliances by exhibiting a statistically significant difference in tongue length tgL ($p=0.0009$), emphasizing their advantage in maintaining or enhancing optimal tongue posture relative to extraction therapies.[7,33]

Diagnostic methodologies employed in evaluating craniofacial structures, tongue posture and its dimensions primarily rely on lateral cephalometry, a well-established, cost-effective, reproducible diagnostic modality widely utilized in orthodontic clinical practice.[27] Despite its widespread acceptance, lateral cephalometry inherently provides only two-dimensional representations, lacking the volumetric accuracy afforded by advanced imaging technologies such as cone beam computed tomography (CBCT) and magnetic resonance imaging.[25,27] Nevertheless, lateral cephalometry remains a valuable, routinely utilized diagnostic modality due to its accessibility, cost-effectiveness and minimal radiation exposure, providing reliable data on sagittal airway space and related anatomical structures critical for treatment planning and monitoring.[27]

Early orthodontic diagnosis and timely therapeutic intervention during adolescence represent pivotal factors for optimizing treatment outcomes, capitalizing on residual growth potentials and achieving maximal skeletal and airway benefits.[24] It is crucial to foster interdisciplinary collaboration and raise awareness among pediatricians, ENT specialists and general healthcare providers regarding the significance of early orthodontic evaluations in managing airway-related malocclusions.[13]

Orthodontists play an essential role not merely in addressing esthetic and dental alignment concerns but significantly contribute to improving systemic health and overall patient quality of life. For patients who surpass their optimal growth period without orthodontic intervention, contemporary treatment modalities such as maxillary and surgically assisted rapid palatal Expansion (MARPE and SARPE) provide minimally invasive or non-surgical options, effectively addressing maxillary transverse deficiencies and tongue posture.[23]

Future research should follow a prospective design to assess dynamic changes across growth phases and post-retention effects. Integrating orthodontics into interdisciplinary sleep medicine teams can help manage paediatric OSA, using growth-modification appliances as non-invasive airway intervention. Coordination with ENT specialists, sleep physicians, speech pathologists and radiologists can enable holistic patient evaluation and management.

The study has some limitations like variability in cephalometric magnification, which may affect linear accuracy; however, this was addressed through normalization techniques. Influence of head posture, body alignment and mandibular position during imaging; despite using natural head position, minor variations could still affect measurement consistency. Lack of control of tongue position on breathing, deglutition while the X-ray is being taken. Obesity and submental fat can contribute to varied posture of tongue. Relatively small sample size (n=40), which may limit generalizability of results to broader populations or different ethnic groups.

CONCLUSION

In conclusion, orthodontics, particularly through functional appliance therapy, holds substantial promise in the integrated management of OSA by tongue posture improvement, significantly improving patient health and quality of life. Continued multidisciplinary collaboration and advancement in diagnostic and treatment methodologies will undoubtedly enhance clinical outcomes and optimize patient care for individuals experiencing tongue-influenced malocclusions.

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