European Journal of Clinical Pharmacy

Print ISSN: 2385-409X **Online ISSN**: Applied Website: https://farmclin.com/

Evaluation of Changes in Pharyngeal Airway Size and Hyoid Bone Position Following Expansion Therapy

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ABSTRACT

Introduction: Maxillary constriction has been associated with compromised pharyngeal airway dimensions and altered hyoid bone position, which may predispose individuals to airway obstruction. Rapid maxillary expansion (RME) is widely used to correct transverse maxillary deficiency and has been suggested to produce favorable changes in airway morphology.

Aim: To evaluate changes in pharyngeal airway dimensions and hyoid bone position following maxillary expansion.

Materials and Methods: This prospective cephalometric study included 24 subjects aged 8–14 years with transverse maxillary deficiency treated using a Hyrax rapid maxillary expander. Pre-expansion (T1) and post-expansion (T2) lateral cephalograms were obtained and manually traced. Upper pharyngeal airway dimensions (PNS–Ad1, U-MPW), lower pharyngeal airway (LPA), and hyoid bone position (C3–H) were measured. Statistical analysis was performed using paired t-tests after confirmation of normality.

Results: A statistically significant increase was observed in the upper pharyngeal airway dimensions following expansion. The PNS–Ad1 and U-MPW measurements showed highly significant improvement ($p < 0.001$). In contrast, changes in the lower pharyngeal airway and hyoid bone position were minimal and statistically non-significant ($p > 0.05$).

Conclusion: Maxillary expansion produces a significant improvement in upper pharyngeal airway dimensions; however, its effect on the lower pharyngeal airway and hyoid bone position is limited. These findings suggest that the airway benefits of expansion therapy are primarily localized to the upper airway region.

KEYWORDS: Rapid maxillary expansion, Pharyngeal airway, Hyoid bone position, Upper airway dimensions, Transverse maxillary deficiency, Lateral cephalogram.

How to Cite: Dr Rahul Paul, Dr Deepti Yadav, Dr Prakher Saini, Dr Rohit Tiwari, (2026) Evaluation of Changes in Pharyngeal Airway Size And Hyoid Bone Position Following Expansion Therapy, European Journal of Clinical Pharmacy, Vol.8, No.1, pp. 1527-1539

INTRODUCTION

The pharyngeal airway is a vital anatomical passage that ensures the unobstructed flow of air from the nasal cavity to the lungs, playing a crucial role in respiratory function. Maintaining airway patency is essential for normal breathing, particularly during sleep, where structural or functional obstructions can lead to disorders such as obstructive sleep apnea (OSA). The pharyngeal airway is divided into three regions: the nasopharynx, oropharynx, and laryngopharynx. Its patency relies on a delicate balance between soft tissue support, neuromuscular control, and skeletal structure. Disruptions in this balance—such as soft tissue collapse, mandibular retrusion, or abnormal hyoid bone positioning—can result in airway obstruction, especially during sleep when muscle tone diminishes. OSA, a common disorder, is characterized by repeated episodes of pharyngeal collapse due to reduced muscle tone, leading to hypoxia and fragmented sleep. Risk factors for OSA include craniofacial abnormalities, obesity, and altered hyoid bone position.

The relationship between craniofacial structure and respiratory function has been a subject of significant interest in orthodontic research for decades. The foundational work by Subtelny (1954)[1] first demonstrated that orthodontic appliances, including maxillary expanders, could significantly influence pharyngeal airway dimensions, establishing an early link between skeletal growth and respiratory function. This concept was further developed by Enlow (1960)[2], who emphasized the intrinsic link between skeletal growth patterns and soft tissue development, noting that transverse maxillary growth significantly influences adjacent soft tissues and overall airway patency.

Building on this theoretical framework, Hershey et al. (1976)[3] provided early empirical evidence, demonstrating that Rapid Maxillary Expansion (RME) significantly reduces nasal airway resistance by increasing the transverse width of the nasal cavity. The therapeutic potential of this approach was highlighted by Linder-Aronson (1979)[4], who reported notable improvements in airway patency among children with enlarged adenoids following RME, suggesting its role in airway-compromised individuals. McNamara (1981)[5] reinforced these findings, showing that RME effectively increases nasal cavity dimensions and contributes to a reduction in mouth-breathing behaviors, encouraging a shift to nasal respiration**.**

The hyoid bone, a unique U-shaped "floating" bone in the anterior neck, serves as a critical anchor for muscles involved in mastication, swallowing, and airway stability. Unlike other bones, it does not articulate directly with the skeleton but is suspended by muscles and ligaments. The suprahyoid muscles (digastric, stylohyoid, mylohyoid, and geniohyoid) assist in swallowing and jaw opening, while the infrahyoid muscles (sternohyoid, omohyoid, thyrohyoid, and sternothyroid) stabilize the hyoid and larynx during respiration and phonation. These muscles are essential for maintaining airway stability, preventing pharyngeal collapse during inspiration and swallowing. The position of the hyoid bone is influenced by craniofacial anatomy, posture, and muscle activity. A low-lying hyoid (inferiorly positioned) has been linked to an increased risk of OSA due to reduced pharyngeal space, as well as mandibular retrognathia, where a retruded mandible alters hyoid positioning and compromises airway dimensions. Conversely, an anteriorly positioned hyoid is associated with better airway patency, as observed in patients undergoing mandibular advancement surgery for OSA.

Clinical studies highlight the significance of hyoid bone positioning in airway disorders. Cephalometric analyses reveal that OSA patients often exhibit a lower hyoid bone position (H-MP distance) compared to healthy individuals. Surgical interventions, such as hyoid suspension and maxillomandibular advancement (MMA), aim to reposition the hyoid to enhance airway patency. Additionally, pediatric studies suggest that abnormal hyoid positioning may contribute to adenotonsillar hypertrophy and pediatric OSA. Understanding the interplay between the hyoid bone, craniofacial morphology, and airway dynamics is crucial for diagnosing and managing respiratory obstructions, particularly in sleep-related breathing disorders.

The etiology of pharyngeal airway obstruction and obstructive sleep apnea (OSA) is multifactorial, involving anatomical, neuromuscular, and physiological factors that collectively influence airway patency during sleep. Craniofacial abnormalities play a significant role, with maxillary constriction reducing nasal cavity volume and nasopharyngeal space, thereby increasing airway resistance during inspiration. This often leads to chronic mouth breathing, further destabilizing the pharyngeal airway and contributing to long-term obstruction, particularly in children with adenoid facies. Mandibular retrognathia is another critical factor, as a retruded mandible displaces the tongue base posteriorly, diminishing oropharyngeal space and increasing airway collapsibility during sleep. This is especially pronounced in conditions like Pierre Robin sequence, where micrognathia significantly elevates OSA risk.

The hyoid bone's position is a key determinant of airway stability, as it anchors the suprahyoid and infrahyoid muscles that regulate pharyngeal patency. An inferior or posteriorly positioned hyoid increases mechanical load on the genioglossus and geniohyoid muscles, reducing their ability to maintain an open airway and leading to higher apnea-hypopnea index (AHI) values due to greater pharyngeal collapsibility. This malposition also weakens tongue protrusion force, exacerbating nocturnal airway collapse. However, surgical interventions such as hyoid advancement or myotomy can improve OSA severity in selected patients by optimizing hyoid positioning.

Soft tissue hypertrophy further contributes to obstruction, with adenotonsillar enlargement being a primary cause of pediatric OSA due to direct mechanical blockage of the oropharynx. Chronic inflammation from hypertrophic adenoids and tonsils worsens airway resistance by promoting edema. In adults, obesity-related fat deposition in the parapharyngeal and submental regions compresses the pharyngeal lumen, while central obesity reduces lung volumes, diminishing tracheal traction on the upper airway. Additionally, leptin resistance in obese individuals may impair ventilatory control, further aggravating OSA severity.

Finally, neuromuscular dysfunction plays a crucial role, particularly the loss of pharyngeal dilator muscle tone during sleep, which reduces the genioglossus's ability to maintain airway patency. This diminished reflex responsiveness to obstruction is exacerbated by aging and neuropathic conditions such as diabetes, which impair neuromuscular compensation and worsen upper airway stability. Together, these factors create a complex interplay that underlies pharyngeal obstruction and OSA, necessitating a multidisciplinary approach for effective diagnosis and management.

The biomechanical effects of expansion were found to extend beyond the nasal cavity. Zachrisson (1982)[6] highlighted its impact on improved tongue posture, positing that increased palatal width provides the tongue with a broader resting surface. Timms (1984)[7] further proposed that RME leads to an increase in pharyngeal airway space through anterior displacement of the maxillary segments and subsequent soft tissue remodeling. The clinical rationale for these interventions was strongly supported by Vargervik and Harvold (1987)[8], who identified a clear association between maxillary constriction and reduced airway dimensions, indicating that skeletal narrowing contributes to compromised respiratory function. Finally, Ozbek et al. (1998)[9] expanded the scope of inquiry by observing that patients with skeletal discrepancies often display abnormal positioning of the hyoid bone, introducing it as a potential anatomical marker for respiratory and skeletal harmony.

Rapid Maxillary Expansion (RME) exerts its therapeutic effects by mechanically separating the two halves of the maxilla at the midpalatal suture, triggering a series of physiological adaptations that enhance airway patency and respiratory function. One of the primary mechanisms is the increase in nasal cavity volume. Since the maxilla forms the floor of the nasal cavity, its expansion through RME widens the nasal floor, reducing airflow resistance. Imaging studies confirm a 15-25% increase in nasal cavity width post-RME, correlating with improved nasal breathing. Clinically, children with chronic mouth breathing due to nasal obstruction demonstrate significant respiratory improvement following RME, as evidenced by reduced nasal airway resistance in acoustic rhinometry studies.

Beyond nasal effects, RME also enhances oropharyngeal space. The downward and forward displacement of the hard palate increases the oropharyngeal dimension by 3-5 mm, as seen in cephalometric analyses. Additionally, a narrow maxilla often forces the tongue into a posterior position, contributing to airway collapse during sleep. RME alleviates this restriction by expanding intraoral volume, allowing the tongue to assume a more anterior posture and reducing pharyngeal obstruction.

A critical yet less discussed benefit of RME is its influence on hyoid bone positioning. The hyoid bone, which anchors pharyngeal muscles, plays a pivotal role in upper airway stability. RME modifies tension in the suprahyoid and infrahyoid musculature, leading to anterior and superior repositioning of the hyoid bone. Lateral cephalometric studies document a 1-2 mm upward displacement of the hyoid post-expansion, which enhances pharyngeal stability and reduces airway collapsibility during sleep. This mechanism is particularly relevant in obstructive sleep apnea (OSA), where RME has been shown to decrease apnea-hypopnea index (AHI) values by optimizing airway muscle tone and structural support.

This study will utilize pre- and post-treatment lateral cephalograms to assess RME's effects on pharyngeal airway dimensions and hyoid bone position. Radiographic analysis will measure changes in airway size from the nasopharynx to the laryngopharynx, with particular focus on the posterior tongue space at multiple levels. The hyoid bone's positional changes will be tracked relative to mandibular and cervical landmarks to determine its relationship with airway expansion. Findings will clarify how orthopedic maxillary expansion—whether via rapid

palatal expansion (RPE) improves breathing capacity by influencing both skeletal and muscular components of the upper airway. Given the established link between maxillary constriction and OSA, this research underscores RME's potential as a non-invasive treatment for airway obstruction, particularly in growing patients.

AIM OF THE STUDY

The aim of this study is to evaluate the changes in pharyngeal airway size and hyoid bone position following maxillary expansion. This investigation seeks to determine the impact of maxillary expansion on respiratory function and related anatomical structures.

OBJECTIVE OF THE STUDY

- To measures the changes in pharyngeal airway dimensions following maxillary expansion
- To measure the position of the hyoid bone following maxillary expansion.
- To Evaluate the relationship between the changes in airway size and hyoid bone position to understand their combined effect on airway patency.

NULL HYPOTHESIS

- There are no significant changes in the dimensions of the pharyngeal airway or the position of the hyoid bone as a result of the maxillary expansion procedure.

MATERIALS & METHOD

The present study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics, Inderprastha Dental College and Hospital, Sahibabad, Ghaziabad, in association with the Research Department. A total of 24 subjects aged between 8 and 14 years, all diagnosed with transverse maxillary deficiency requiring maxillary expansion, were included in the study. The materials and tools used in the study were:

Armamentarium:

1. Cephalostat CS 8000C (Carestream Health, Inc, France)

Figure 1: Cs 8000c (Carestream Health, Inc, France)

2. Tracing paper measuring 8X10-inch and 0.003-inch in thickness.

Figure 2: Tracing Paper

3. Tracing essentials (lead pencil, 0.5mm lead, , magic tape, divider, protractor, compass, ruler).

Figure 3: Tracing Essentials

4. Hyrax Device

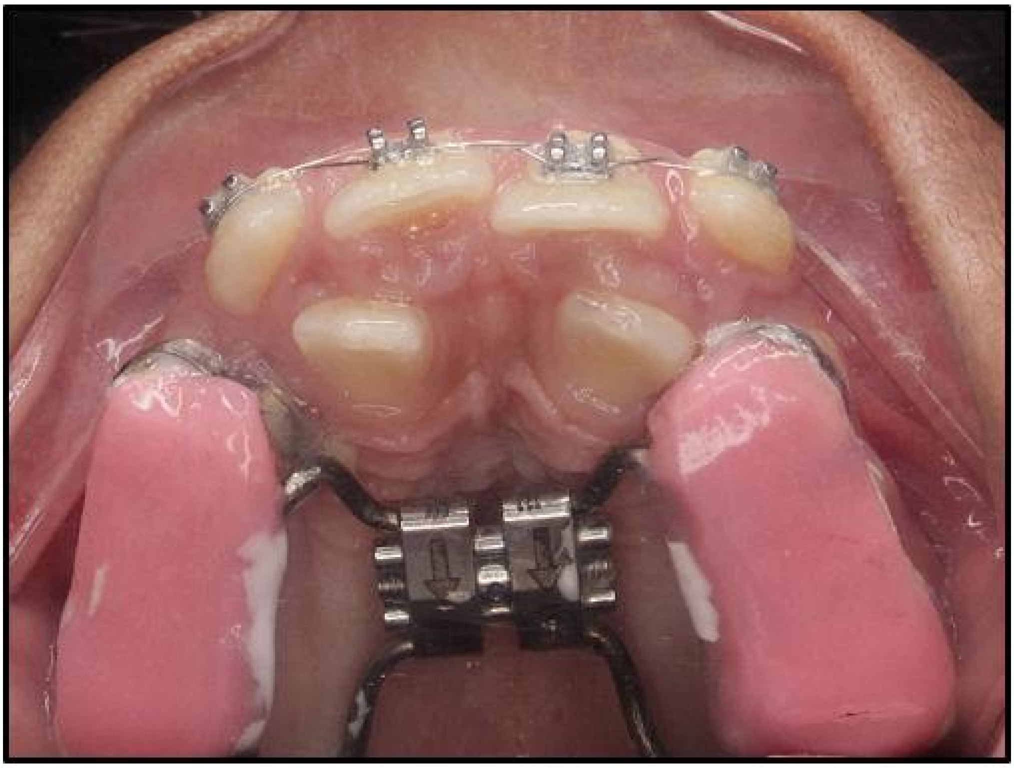


Figure 4: Hyrax (Rapid maxillary expander)

Inclusion Criteria

Subjects were selected based on the following criteria:

1. Age Range: 8–14 years.
2. Presence of Maxillary Constriction who require R.M.E
3. Good General Health
4. Healthy Periodontium

Exclusion Criteria

Subjects were excluded if they met any of the following conditions:

1. Previous Orthodontic Treatment
2. Craniofacial Syndromes
3. Chronic Respiratory Illness
4. Systemic Illness
5. Craniofacial anomalies

METHOD

The present study was conducted on a sample of 24 patients lateral cephalograms of aged between 8–14 years who underwent fixed orthodontic treatment with Rapid maxillary expansion. The pre- and post-expansion cephalograms were evaluated to assess changes in pharyngeal airway dimensions and hyoid bone position.

Pre-Expansion Assessment (T1)

Written informed consent was obtained from parents or guardians. Basic demographic and Case histories were recorded. Each subject underwent a detailed dental and orthodontic clinical examination.

The Intraoral Impression was taken from the patient. Impression poured in Orthokal to obtain a working cast with bands embedded.

The **Hyrax screw** was positioned along the mid-palatal suture line of the cast. Wire arms are extended from the screw and soldered to the palatal surfaces of the bands.The soldered appliance is polished, finished, and made ready for cementation.

Baseline radiographs included a Pre Expansion lateral cephalogram (T1). Lateral cephalograms were taken using a cephalostat with the Frankfort Horizontal Plane aligned parallel to the floor.

Cephalometric Analysis (Manual Tracings on Lateral Cephalograms)

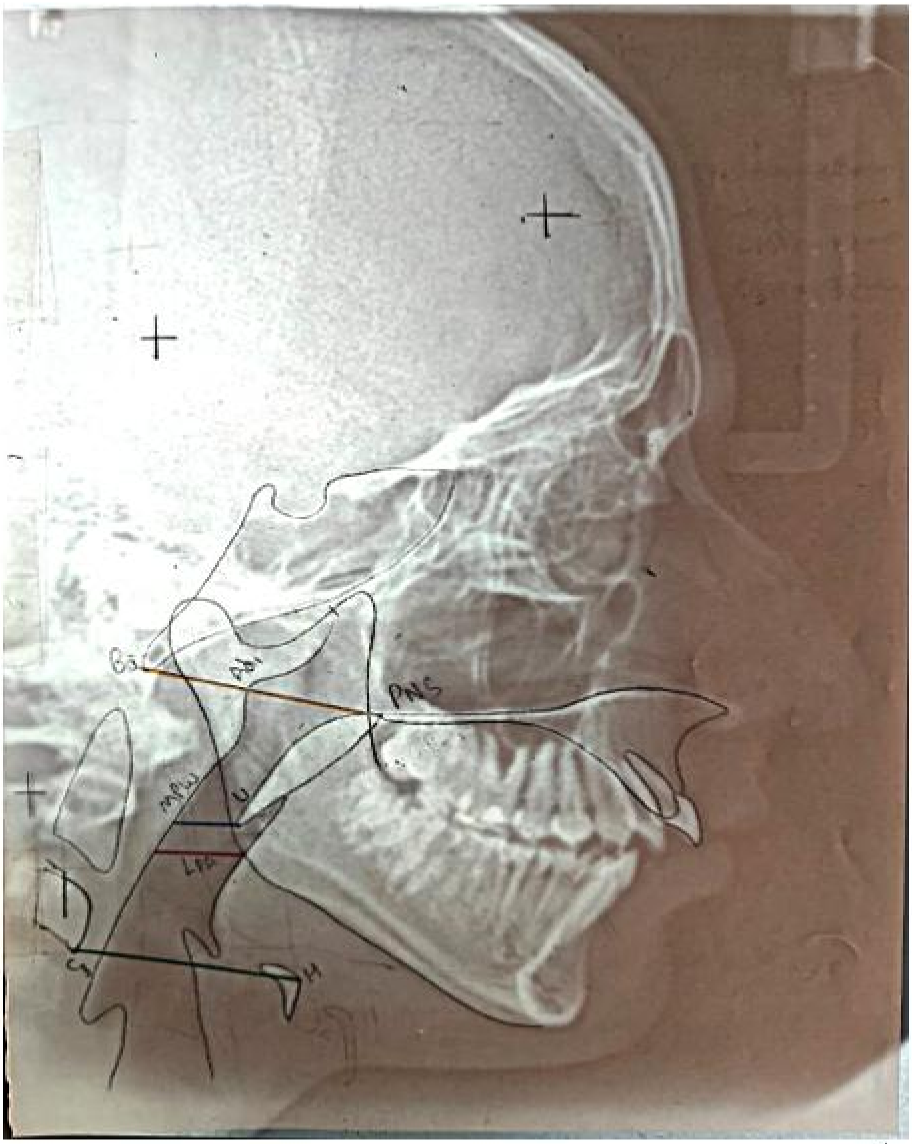


Figure 5: Pre Expansion Lateral Cephalogram

Upper Airway Measurements

1. **PNS–Ad1 Distance**
   - Distance between Posterior Nasal Spine (PNS) and Ad1 (the intersection point of the line drawn from PNS to Basion with the posterior pharyngeal wall).

2. **U–MPW Distance**
   - Distance between the tip of the uvula (U) and the closest point on the posterior pharyngeal wall (MPW).

Lower Airway Measurement

3. **Lower Pharyngeal Airway (LPA)**

- Shortest distance between the point where the posterior tongue contour crosses the mandible and the nearest point on the posterior pharyngeal wall.

Hyoid Bone Position Measurement

4. **C3–H Distance**

- Distance between the **hyoid bone (H)** and the **inferior part of third cervical vertebra (C3)**

Maxillary Expansion Protocol

Activation Schedule According to Timms has followed plan

- **For patients aged ≤ 15 years (Figure 6)**

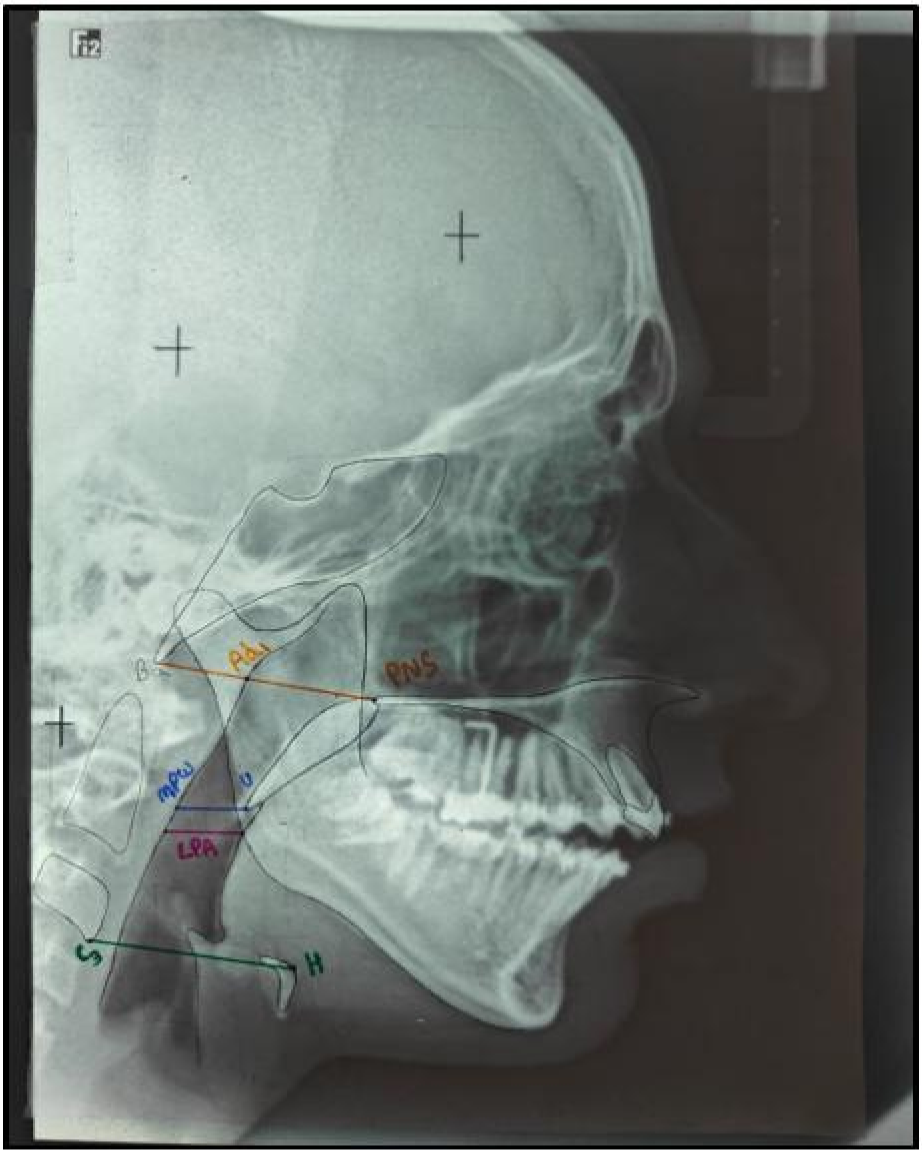


Figure 6: Post Expansion Lateral Cephalogram

Activation was performed by rotating the screw 90 degrees twice daily—once in the morning and once in the evening till the desired expansion is achieved.

Post-Expansion Assessment (T2)

At the end of the retention period after Expansion, Post Expansion lateral cephalograms (T2) were taken. Manual cephalometric analysis was repeated using the same landmarks as in T1. **Figure 6: Post Expansion Lateral Cephalogram**

Table 1: Landmarks of Post Expansion Lateral Cephalogram:

Category	Landmarks	Description
Upper Airway	PNS-Ad1 Distance U-MPW Distance	Distance between the Posterior Nasal Spine (PNS) and Ad1 (intersection point of the line from PNS to Basion with the posterior pharyngeal wall) Distance between the tip of the uvula (U) and the closest point on the posterior pharyngeal wall (MPW)
Lower Airway	Lower pharyngeal airway(LPA) Shortest Distance	Minimum distance between the point where the posterior tongue contour crosses the mandible and the nearest point on the posterior pharyngeal wall
Hyoid Bone Position	C3–H Distance	Distance between the hyoid bone (H) and the third cervical vertebra (C3)

Data Collection

Pre-Expansion and Post- Expansion Lateral Cephalogram from Department of Orthodontics & Dentofacial Orthopaedics of Inderprastha Dental College & Hospital for participants who underwent the Rapid Maxillary Expansion.

Statistical Analysis

The pre-Expansion and post-Expansion measurements were compared using paired t-tests (for normally distributed data) after ascertaining normality by the Shapiro- Wilk test. Changes in pharyngeal airway space and hyoid bone position were statistically evaluated to determine the effect of expansion therapy.

RESULT

The present study was carried out to evaluate the changes in upper and lower pharyngeal airway dimensions and the hyoid bone position in patients treated with a maxillary palatal expander. Pre- and post-treatment lateral cephalograms were analyzed, and the results were tabulated and statistically evaluated.

Table 2 & Graph 1 demonstrates the **pre- and post-treatment mean values** for the selected variables. The mean value of **PNS–Ad1** increased from **23.8 mm to 24.6 mm**, while **U-MPW** increased from **9.37 mm to 9.72 mm** after expansion therapy. The **lower pharyngeal airway** showed a slight reduction in mean values, from **9.62 mm to 9.56 mm**, whereas the mean value of **C3–H** decreased marginally from **30 mm to 29.8 mm**.

Table 2: Evaluation of changes in pharyngeal airway size and hyoid bone position following maxillary expansion

VARIABLES		Mean(mm)	Std. Deviation
PNS-Ad1	**Pre**	23.8	3.575
	Post	24.6	3.394
U-MPW	**Pre**	9.37	2.202
	Post	9.72	2.066
Lower Pharyngeal Airway	**Pre**	9.62	3.499
	Post	9.56	3.528
C3H	**Pre**	30	4.649
	Post	29.8	4.590

Graph 1: Graphical Representation of changes in pharyngeal airway size and hyoid bone position following maxillary expansion.

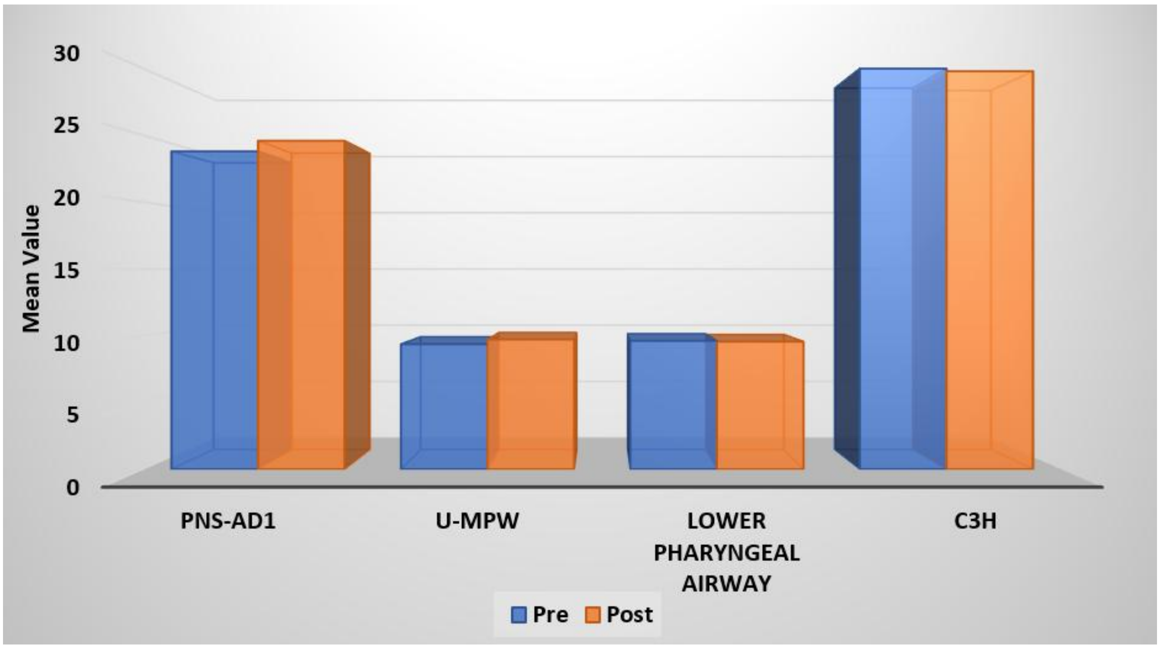


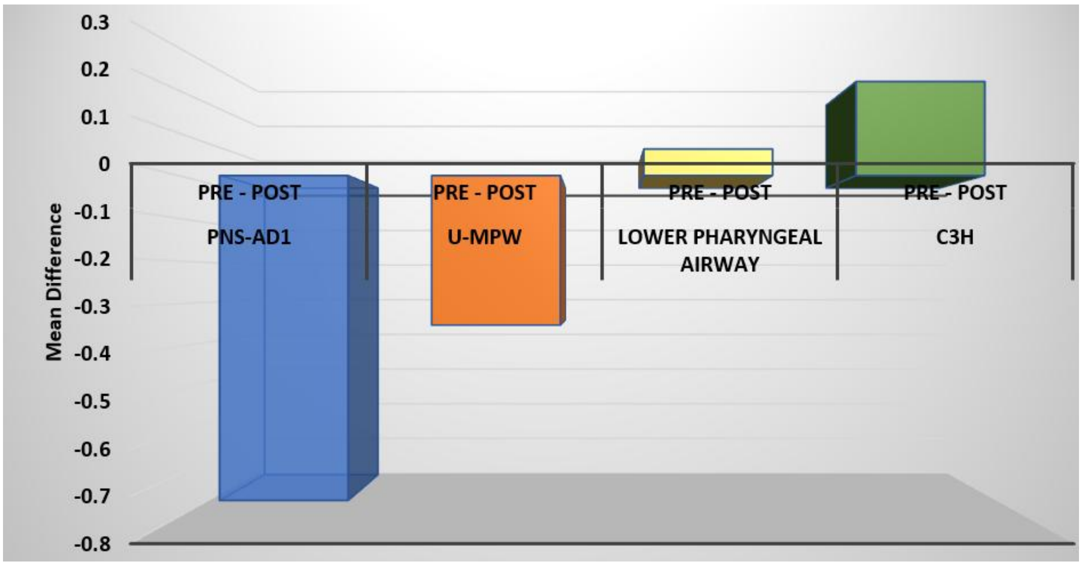
Table 3 & graph 2 depicts the **mean differences between pre- and post-treatment values**. The upper pharyngeal airway measurements showed statistically significant differences. **PNS–Ad1** exhibited a mean difference of –0.760 mm (SD = 0.219), and **U-MPW** recorded a mean difference of –0.350 mm (SD = 0.158). Both results were found to be **highly significant ($p < 0.001$)**.

Table 3: Mean differences of pre Expansion and post Expansion changes in pharyngeal airway size and hyoid bone position following maxillary expansion.

Variables		Mean Difference	SD	Lower	Upper	t-value	p-value,S/NS
PNS-Ad1	Pre - Post	-0.760	0.219	-0.853	-0.667	-16.967	**<0.001,HS**
U-MPW	Pre - Post	-0.350	0.158	-0.417	-0.282	-10.798	**<0.001,HS**
Lower Pharyngeal Airway	Pre - Post	0.062	0.199	-0.021	0.146	1.534	0.135,NS
C3H	Pre - Post	0.220	0.629	-0.045	0.486	1.718	0.090,NS

p ≤ 0.05 – Significant, CI = 95 %

Graph 2: Graphical Representation of Mean differences of pre and post changes in pharyngeal airway size and hyoid bone position following maxillary expansion



On the other hand, the lower pharyngeal airway showed a mean difference of 0.062 mm (SD = 0.199), which was statistically **non-significant (p = 0.135)**. Similarly, the **C3–H measurement** reflected a mean change of 0.220 mm (SD = 0.629), which also did not reach statistical significance (p = 0.090).

Thus, the findings indicate that maxillary expansion produces a **highly significant effect on the upper pharyngeal airway dimensions**, whereas its effect on the **lower pharyngeal airway and hyoid bone position** is minimal and statistically non-significant.

The pre- and post-treatment measurements of pharyngeal airway dimensions and hyoid position are presented in Tables 1 and 2. For the PNS-Ad1 distance, the mean pre-expansion value was 23.8 ± 3.575 mm, which increased to 24.6 ± 3.394 mm post-expansion. The mean difference (pre minus post) was –0.760 ± 0.219 mm (95% confidence interval –0.853 to –0.667), yielding a t-value of –16.967. This change was highly significant (p < 0.001, HS). Similarly, the upper airway minimum pharyngeal width (U-MPW) increased from a pre-treatment mean of 9.37 ± 2.202 mm to a post-treatment mean of 9.72 ± 2.066 mm. The mean difference was –0.350 ± 0.158 mm (95% CI –0.417 to –0.282) with a t-value of –10.798, which was also highly significant (p < 0.001, HS). In contrast, the lower pharyngeal airway (LPA) showed only a negligible change, with a pre-expansion mean of 9.62 ± 3.499 mm and a post-expansion mean of 9.56 ± 3.528 mm. The mean difference was 0.062 ± 0.199 mm (95% CI –0.021 to 0.146), t = 1.534, and this change was not statistically significant (p = 0.135, NS). Likewise, the C3–H (hyoid) distance changed slightly from 30.0 ± 4.649 mm pre-treatment to 29.8 ± 4.590 mm post-treatment, with a mean difference of 0.220 ± 0.629 mm (95% CI –0.045 to 0.486) and t = 1.718. This difference was also not significant (p = 0.090, NS). In summary, after maxillary expansion the PNS-Ad1 and U-MPW dimensions showed statistically significant increases (both p < 0.001), whereas the changes in lower pharyngeal airway and C3–H were minimal and did not reach statistical significance (p > 0.05).

DISCUSSION

The present study evaluated the effects of maxillary expansion on pharyngeal airway dimensions and hyoid bone position using pre- and post-treatment lateral cephalograms. The findings demonstrated a statistically significant increase in the upper pharyngeal airway dimensions, like PNS–Ad1 and U-MPW, while changes in the lower pharyngeal airway and hyoid bone

position (C3–H) were minimal and statistically non-significant.
The significant increase in upper pharyngeal airway dimensions is consistent with previous investigations that have reported favorable airway changes following rapid maxillary expansion (RME). Zhao et al. (2010) documented a significant increase in oropharyngeal airway dimensions after RME, attributing the improvement to skeletal widening and subsequent nasal airway remodeling18. Similarly, Ribeiro et al. (2012) observed that maxillary expansion leads to increased retropalatal airway volume, correlating with enhanced breathing efficiency in growing children21. In another study, Baratieri et al. (2011) confirmed that maxillary expansion produces a notable enlargement of the nasopharyngeal airway space, suggesting its therapeutic value in managing airway-related concerns20. These findings support the results of the present study, particularly with regard to upper airway enhancement.

In addition, studies employing advanced imaging modalities have reinforced similar conclusions. Iwasaki et al. (2013) utilized cone-beam computed tomography (CBCT) to evaluate airway changes after expansion and reported significant increases in the nasopharyngeal and retropalatal regions27. Gungor et al. (2016) also demonstrated through CBCT that RME resulted in volumetric enlargement of the upper airway, specifically in the nasal and oropharyngeal compartments35. These studies validate the present findings, emphasizing that skeletal expansion has a measurable and clinically beneficial effect on upper airway dimensions.

However, the non-significant findings related to the lower pharyngeal airway and hyoid bone position align with prior evidence indicating that the effect of maxillary expansion is localized. Wang et al. (2014) reported that while RME widens the nasal and retropalatal regions, its effect on the hypopharyngeal airway remains negligible50. Similarly, Buccheri et al. (2019) found no substantial post-expansion changes in the vertical or anteroposterior positioning of the hyoid bone, suggesting that the adaptive muscular and functional balance around the hyoid minimizes skeletal displacement51. Smith et al. (2016) also indicated that although RME enhances upper airway volume, its influence on the lower airway is inconsistent and often clinically insignificant52. Consistent with these outcomes, Kannan et al. (2017) demonstrated that expansion therapy primarily improves the nasopharyngeal and retropalatal regions but shows negligible impact on the hypopharyngeal airway and hyoid bone position37.

Further, Iwasaki et al. (2014) emphasized through CBCT evaluation that while upper airway spaces significantly increase after expansion, the hyoid bone maintains positional stability due to compensatory neuromuscular adaptations27. These findings highlight the possibility that hyoid bone displacement is under strong muscular regulation, which resists positional changes despite skeletal alterations.

Several studies support the present findings of significant improvement in the upper pharyngeal airway following expansion therapy. Ceylan and Oktay (1995) demonstrated that maxillary expansion improved nasopharyngeal airway dimensions in growing patients9. Similarly, Cross et al. (2010) found that RME increased nasal airway volume and reduced airway resistance, thereby improving nasal breathing19. De Felippe et al. (2008) also reported significant increases in nasopharyngeal airway space, noting that these changes were stable over time15. Collectively, these findings reinforce the conclusion that RME contributes positively to airway development, particularly in the upper regions.

Moreover, studies have highlighted the clinical relevance of these airway changes. Fastuca et al. (2015) reported that patients with maxillary constriction and sleep-disordered breathing demonstrated improvement in respiratory function following expansion32. Camacho et al. (2017), in a systematic review and meta-analysis, confirmed that expansion increases airway dimensions and can be considered as an adjunctive therapeutic intervention for pediatric obstructive sleep apnea36. These outcomes further validate the beneficial role of maxillary expansion in improving upper airway dimensions.

In contrast, several studies have presented conflicting findings, particularly concerning the lower pharyngeal airway and hyoid bone position. Souki et al. (2012) investigated the effects of RME on airway volume and reported improvements in the nasopharyngeal space but negligible changes in the hypopharynx25. Chang et al. (2013) found that while upper airway volume increased significantly, lower airway dimensions showed no significant alteration26. Similarly, Yassaei et al. (2016) concluded that hyoid bone position remains largely unchanged after RME, emphasizing the role of muscular adaptation in maintaining stability34.

Interestingly, some studies even question the long-term stability of upper airway changes. Vidya et al. (2018) reported that while immediate post-expansion airway enlargement was significant, follow-up records revealed partial relapse, particularly in the oropharyngeal regions41. These findings suggest that while short-term improvements are evident, long-term effects require further investigation with longitudinal follow-up.

Thus, the results of the current study are in agreement with prior research supporting significant improvements in upper airway dimensions following expansion therapy, but they also highlight the limited impact on the lower pharyngeal airway and hyoid bone position. This discrepancy suggests that the therapeutic benefits of expansion therapy are localized more to the naso- and oropharyngeal regions rather than extending to the hypopharyngeal airway. The consistency of findings across multiple studies emphasizes the selective nature of skeletal expansion on airway compartments.

Future studies with larger samples, 3D volumetric imaging, and long-term follow-up are warranted to better understand the stability of airway changes and the complex adaptive behavior of the hyoid bone. It is also recommended that future research stratify patients by age, skeletal pattern, and presence of airway-related disorders such as obstructive sleep apnea. This will help clarify which subgroups of patients are most likely to benefit from maxillary expansion in terms of airway improvement.

CONCLUSION

- The present study evaluated the effects of maxillary expansion on pharyngeal airway size and hyoid bone position. The results demonstrated a significant increase in the upper pharyngeal airway dimensions, particularly in PNS–Ad1 and U-MPW, confirming that maxillary expansion has a favorable influence on improving upper airway space.
- In contrast, changes observed in the lower pharyngeal airway and hyoid bone position (C3–H) were minimal and statistically non-significant. This suggests that the skeletal effects of expansion are more localized to the upper airway, while the lower airway and hyoid bone remain relatively unaffected due to adaptive soft tissue balance.
- Within the limitations of this study, it can be concluded that maxillary expansion is effective in enlarging the upper pharyngeal airway but has little impact on the lower airway and hyoid bone position. Further studies with larger samples and advanced imaging are recommended to validate and expand upon these findings.

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