Evaluation of Changes in the Pharyngeal Airway Dimensions in Skeletal Class II Patients Treated with Forsus Fatigue Resistant Device

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Abstract

Background: Orthodontic malocclusions can have a significant influence on patients' dental health, appearance, speech, and social interactions. Class II malocclusions, which include mandibular deficiency may contribute to upper airway disorders and oropharyngeal airway inadequacies. Skeletal Class II malocclusion caused by mandibular retrusion has been linked to upper and lower airway deficits. **Objectives:** The objective was to assess the effects of Forsus Fatigue Resistant Device on pharyngeal airway dimesions in skeletal class II patients before and after Forsus treatment and to evaluate the stability of Forsus Fatigue Resistant Device on pharyngeal airway dimensions atleast one year after completion of treatment. **Method:** The study was carried out on lateral cephalograms of head and neck region of 24 individuals who had undergone Forsus fatigue resistant device treatment. Lateral cephalograms were taken at three different time periods such as pre treatment (T1), at the time of achieving class I molar relationship (T2) and post treatment period of 3 years (T3) which were taken from the archives of Department of Orthodontics and Dentofacial Orthopedics, Yenepoya Dental College for the orthodontic treatment purpose and it is compared. **Result:** There was statistically significant changes in mean values from T1 to T2 in the PP projection (p = 0.003), SPS (p = <0.001), MPS (p = <0.001) and CV2 projection (p = 0.016) and CV3 projection (p=0.001). The post retention period demonstrated statistically highly significant changes at the level of CV3 projection (p < 0.001), increasing from pre-treatment (T1) to post 1 (T2) and post 2 (T3) assessments. Additionally, there were significant changes observed from pre-treatment (T1) to post 1 (T2), post 1 (T2) to post2 (T3) and statistically highly significant changes from pre (T1) to post 2 (T3) showing stability in the improvement of pharyngeal airway. There is improvement in the pharyngeal airway in the PP projection, SPS, MPS and CV2 projection levels from pre treatment to post 1 and post 2 after 3 years of treatment. But post retention period did not result in statistically significant changes in the PP projection, SPS, MPS and CV2 projection levels. **Conclusion:** Post retention period demonstrated statistically significant changes at the level of CV3 projection, increasing from pre-treatment (T1) to post 1 (T2) and pre-treatment (T1) to post 2 (T3) assessments. FFA appliances can improve pharyngeal airway dimensions in individuals with Class II malocclusion, particularly those with respiratory issues by providing anterior traction of the tongue far from the soft palate, minimizing pressure and improving the airway dimensions.

Keywords: Class II malocclusion, Forsus Fatigue Resistant Device, Pharyngeal airway, Fixed functional appliance

Introduction

Most common characteristic of Class II malocclusion is a backward posture of the lower jaw, not an abnormal protrusion of the upper jaw.[1]Class II malocclusions, which include mandibular deficiency, may contribute to upper and lower airway deficits. Backward position of the mandible causes the tongue to rest more posteriorly, reducing the distance between the cervical vertebrae and the mandibular corpus, reducing the overall available space for the tongue and pharyngeal airway, which may affect respiratory function.[2]

Narrow pharyngeal airway dimensions cause breathing difficulties and have been linked to obstructive sleep apnea (OSA) in elder population leading to apnoea and hypopnoea. Furthermore, an airway insufficiency can impair pulmonary ventilation, oxygenation, sleep quality, sweating, and nocturnal enuresis.

A functional appliance is defined as one that alters the posture of the mandible, causing the patient to hold it forward for Class II correction or back for Class III correction. [3]The fixed functional appliance performs a variety of functions, including treating skeletal problems in growing patients. In non-growing individuals, it allows for distalization of the maxilla to rectify Class II molar relation, anterior repositioning of the mandible for temporomandibular joint problem cases, presurgical muscle conditioning, and postsurgical occlusion stabilization. Patients who approach during the late pubertal development phases are frequently treated with fixed functional appliances. Fixed Class II appliances include the mandibular anterior repositioning appliance (MARA), Herbst, Jasper Jumper, and Forsus fatigue-resistant device (FRD), among others.[4]

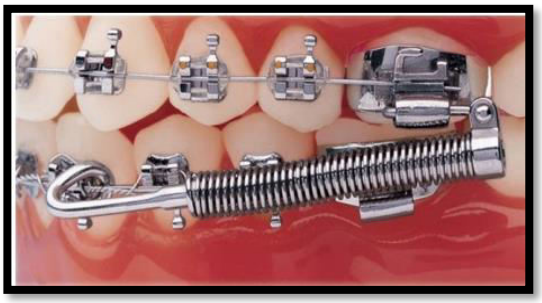


Fig. 1 - Forsus FRD L pin attachment

Fig. 2 - Forsus FRD EZ 2 Module

It is critical to assess the stability of treatment done with Forsus who have completed their growth phase and are being treated for correction by mandibular advancement and unilateral advancement. Previous research suggests that dentoalveolar alterations may modify airway dimensions; hence, alterations in airway diameter can also be predicted with FFA.[5]Only a certain number of research have examined the impact of FFA on pharyngeal airway into deeper extent.[6]

As a result, the goal of this study is to assess the stability of alterations in pharyngeal airway dimensions following Forsus Fatigue Resistant Device treatment in skeletal Class II patients, as stability is an essential component for effective orthodontic results.

Materials and Methods

The study commenced following approval from the Institutional Ethics Committee on August 04, 2023.Lateral Cephalograms were taken for orthodontic purpose at the age group of 18-25 years. Eligibility criteria included skeletal Class II malocclusion with retrognathic mandible, patients who have already undergone Forsus fatigue resistant device treatment, patients within the age group of 18-25 years. Exclusion criteria encompassed significant asymmetries, congenital anomalies, any history of orthognathic surgery, any history of cleft lip and palate, medical history about a respiratory problem or an upper airway surgery, enlarged tonsils and adenoids.

The study was carried out on lateral cephalograms of head and neck region of 24 individuals who had undergone Forsus fatigue resistant device were taken at three different time periods such as pre treatment (T1), at the time of achieving class I molar relationship(T2) and post treatment period of 3 years (T3) which were taken from the archives of Department of Orthodontics and Dentofacial Orthopedics, Yenepoya Dental college for the orthodontic treatment purpose and it is compared.The lateral cephalograms were taken for each subject in natural head position and patient's teeth occluding in maximum intercuspation. All the lateral cephalograms were traced by a single examiner and the linear measurements were taken.

The sample size for the study was estimated for paired sample t test using G+ Power. The anticipated effect size is 0.8 which indicates that the difference in before and after Forsus Fatigue Resistant device is 80% of pooled standard deviation. In order to detect the anticipated difference with 80% power, 10%level of significance 24 subjects have been included in the study.

Parameters used in the study:

Cephalometric landmarks are:

1) PP projection (the distance between PNS and the posterior pharynx wall through palatal plane).

2) SPS (the distance of the midpoint of the line from PNS to tip of soft palate to the horizontal counterpart on the posterior pharyngeal wall along the parallel line to Frankfurt horizontal plane).

3) MPS (the distance of the tip of the soft palate to the horizontal counterpart on the posterior pharyngeal wall along the parallel line to Frankfurt horizontal plane).

4) Cv2 projection (the distance between the meeting points on anterior and posterior pharyngeal wall through Cv2(cervical vertebrae 2) along the parallel line to Frankfurt horizontal plane).

5) Cv3 projection (the distance between the meeting on anterior and posterior pharyngeal wall through Cv3(cervical vertebrae) along the parallel line to Frankfurt horizontal plane).

Figure 3: Cephalometric Landmarks

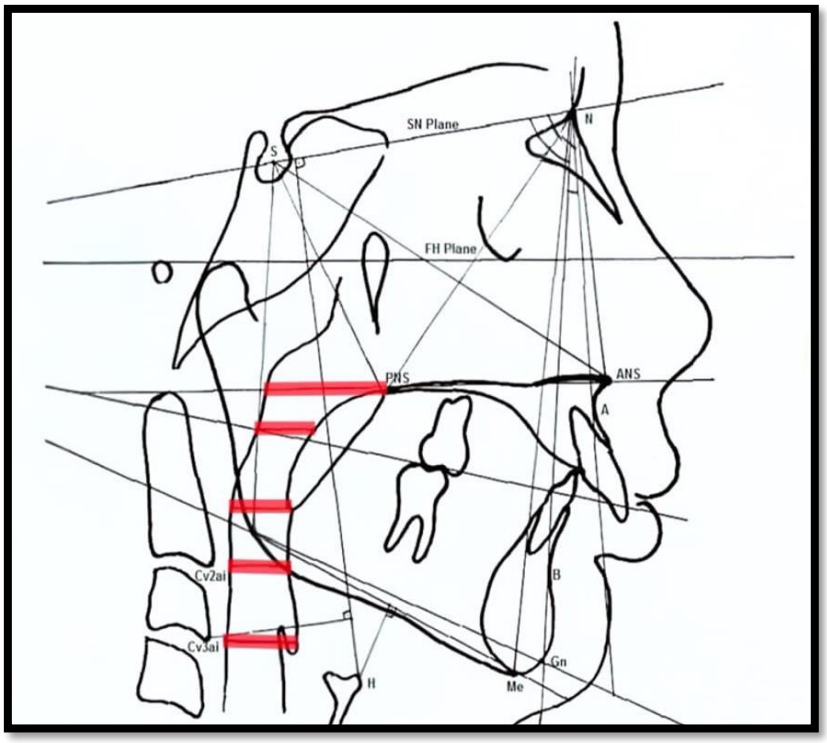


Figure 4: Pre treatment lateral cephalogram

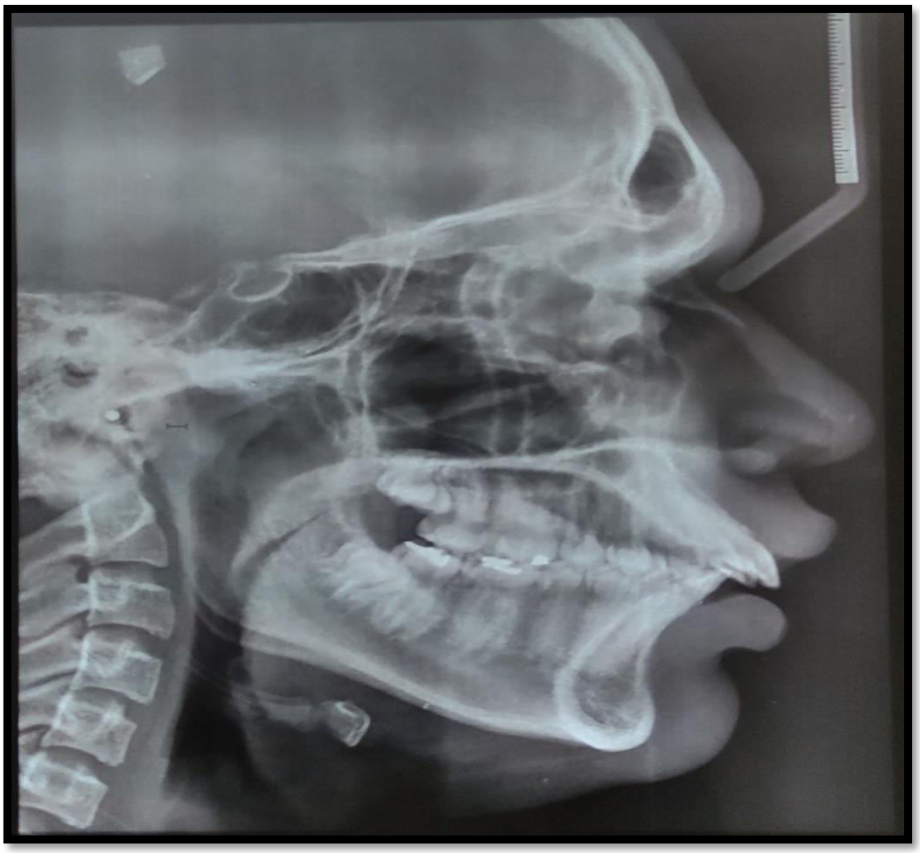


Figure 5: Post forsus treatment cephalogram

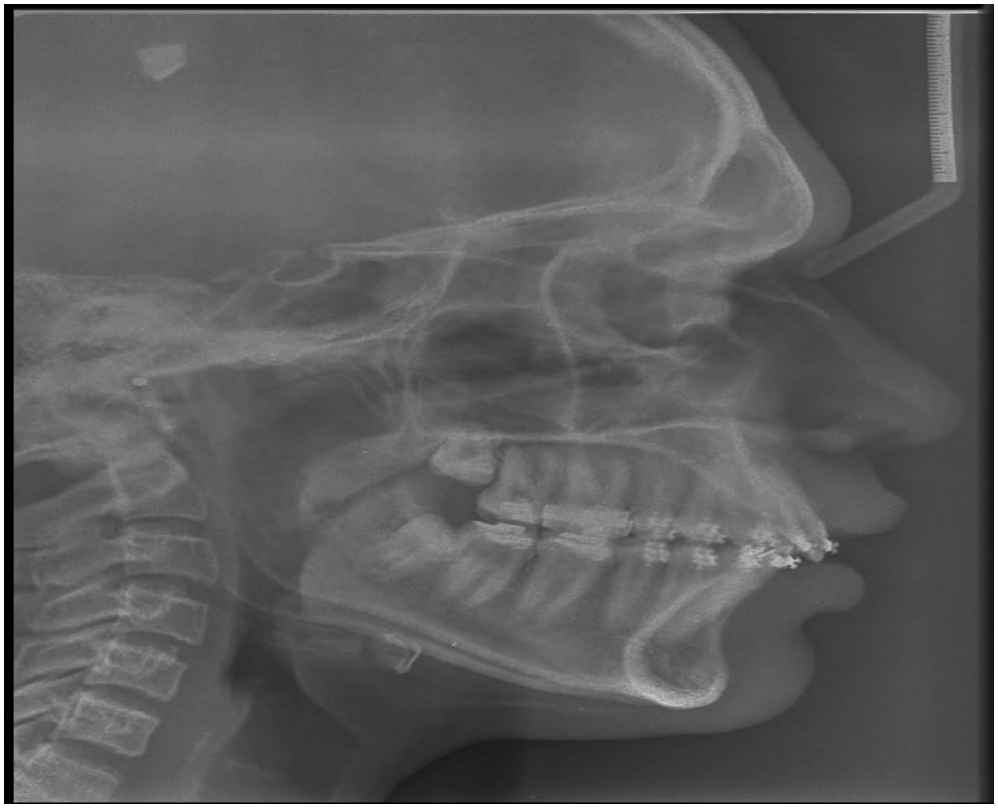
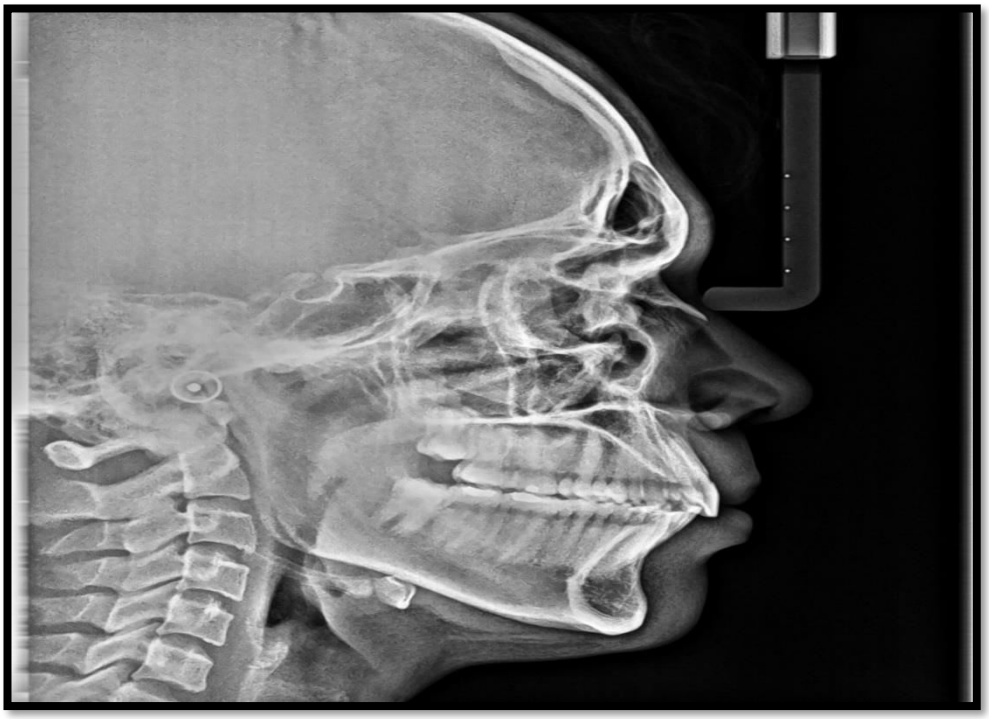


Figure 6: Post three year follow up lateral cephalogram



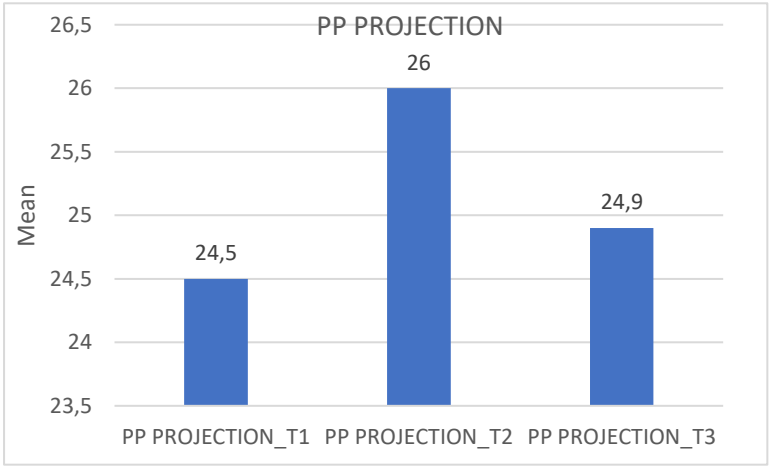
Results

This study evaluated the potential of Forsus Fatigue Resistant Device to cause changes in airway dimensions and stability of changes in pharyngeal airway using lateral cephalograms taken before treatment, after advancement with the Forsus Appliance, and after a post-treatment period of at least three years as stability is the fundamental key to successful outcome of orthodontic treatment. The study was carried out on lateral cephalograms of head and neck region of 24 individuals who had undergone Forsus fatigue resistant device**.** These lateral cephalograms were analyzed using Dolphin Imaging Software with selected parameters. The amount of pharyngeal airway space changes was evaluated on lateral cephalograms and statistically analyzed.

Table 1: Comparison of variables at Pretreatment (T1), Post Forsus treatment (T2) and Post 2 after three years of treatment period (T3)

	T1 (pre)		T2(post1)		T3 (post2 after 3yrs)			P value		
PARAMETER	MEAN	SD	MEAN	SD	MEAN	SD	p value	T1-T2	T2-T3	T1-T3
PP PROJECTION	24.5	4.16	26.0	3.7	24.9	3.18	0.001	0.003	0.004	1.000
SPS	14.5	3.89	16.1	3.47	15.3	3.56	<0.001	<.001	0.001	0.181
MPS	12.2	4.21	13.7	4.43	12.8	4.40	<0.001	<.001	0.010	0.336
Cv2 projection	12.0	4.18	13.2	3.41	12.5	3.64	0.001	0.016	0.045	0.215
Cv3 projection	12.8	3.72	14.7	3.43	13.7	3.64	<0.001	0.001	0.037	<0.001

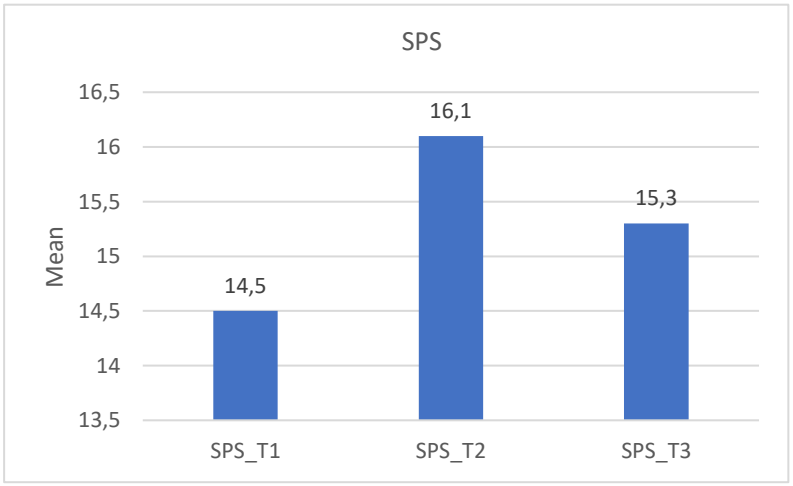
GRAPH 1: PP PROJECTION



Interpretation

- **PP Projection**: There was a statistically significant change in mean values from T1 to T2 (p = 0.003) and from T2 to T3 (p = 0.004). However, the change from T1 to T3 was not statistically significant.

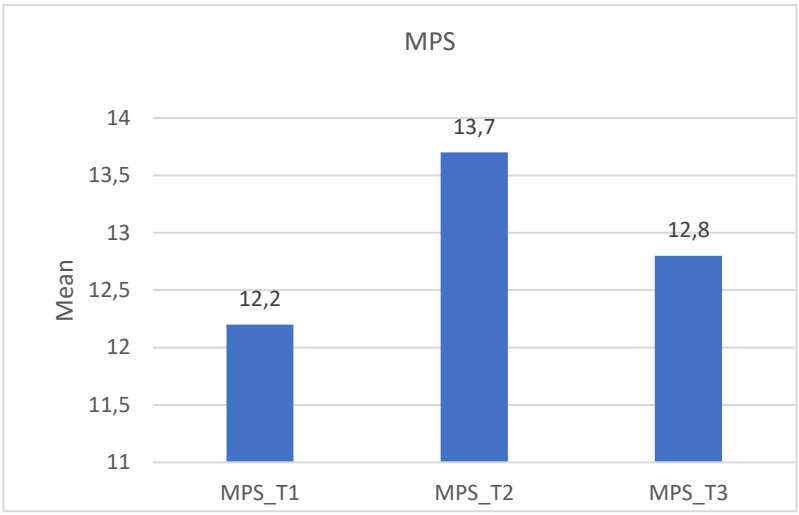
GRAPH 2: SPS



Interpretation

- **SPS:** There was a statistically significant change in mean values from T1 to T2 (p = <0.001) and from T2 to T3 (p = 0.001). However, the change from T1 to T3 was not statistically significant.

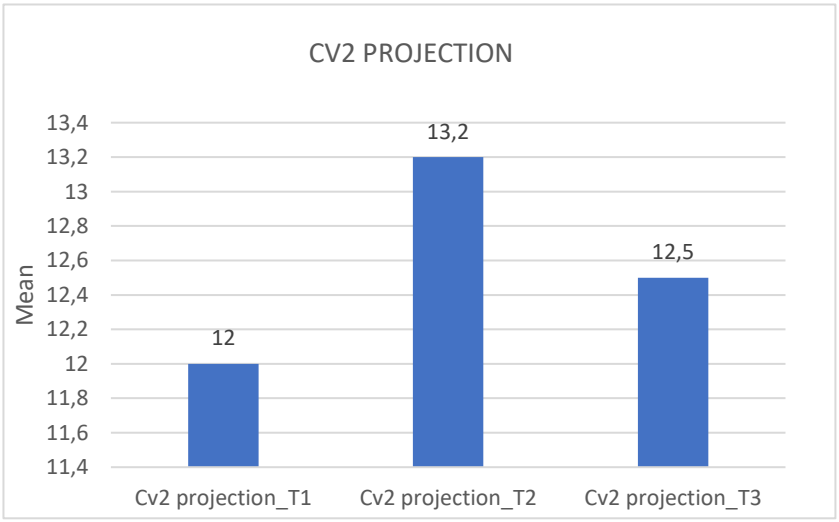
GRAPH 3: MPS



Interpretation

- **MPS:** There was a statistically significant change in mean values from T1 to T2 (p = <0.001) and from T2 to T3 (p = 0.010). However, the change from T1 to T3 was not statistically significant.

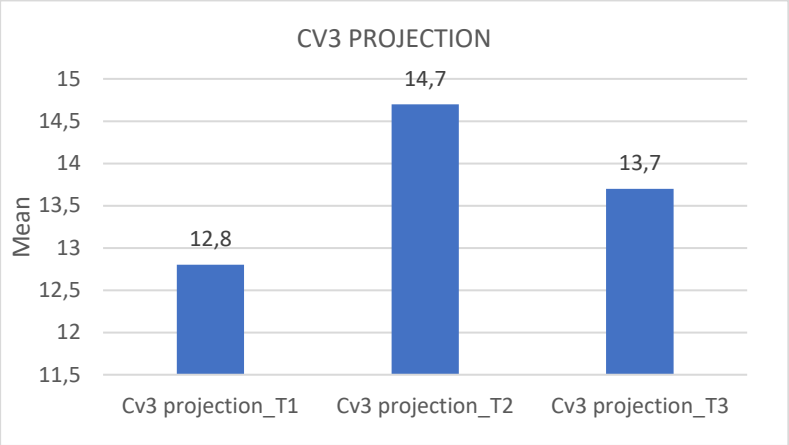
GRAPH 4: CV2 PROJECTION



Interpretation

- **CV2 PROJECTION:** There was a statistically significant change in mean values from T1 to T2 (p = 0.016) and from T2 to T3 (p = 0.045). However, the change from T1 to T3 was not statistically significant.

GRAPH 5: CV3 PROJECTION



Interpretation

- **CV3 PROJECTION:** There was a statistically significant change in mean values from T1 to T2 (p = 0.001) from T2 to T3 (p = 0.037) and statistically highly from T1 to T3 (p = <0.001).

The data showed statistically significant changes in mean values from T1 to T2 in the PP projection (p = 0.003), SPS (p = <0.001), MPS (p = <0.001) and CV2 projection (p = 0.016) and CV3 projection (p = 0.001).
The post retention period demonstrated statistically significant changes at the level of CV3 projection (p < 0.001), increasing from pre-treatment (T1) to post 1 (T2) and post 2 (T3) assessments. Additionally, there were significant changes observed from pre-treatment (T1) to post 1 (T2), post 1 (T2) to post 2 (T3) and statistically highly significant changes from pre (T1) to post 2 (T3) showing stability in the improvement of pharyngeal airway.
There is improvement in the pharyngeal airway in the PP projection, SPS, MPS and CV2 projection levels from pre treatment to post 1 and post 2 after 3 years of treatment. But post retention period did not result in statistically significant changes in the PP projection, SPS, MPS and CV2 projection levels.

Discussion

Orthodontists encounters constant challenge while treating Class II malocclusions as it's distinguished by mandibular inadequacy, may be one of the underlying causes of upper airway diseases and oropharyngeal airway inadequacies. Functional appliances serve as the primary methods of treatment in patients with retrognathic mandible during their developmental stage, since they are supposed to improve growth via forward placement of the mandible. The seappliances improve the skeletal pattern and increase oropharyngeal dimensions by moving the mandible, hyoid bone, tongue, and soft palate forward. [7,8] Although, the necessity of patient compliance limits the use of these removable devices. [9]Compliance problems motivated doctors to design intraoral appliances such as fixed functional appliances (FFA), which provide dependable

mechanics without requiring patient compliance.[9]Research findings indicate that Class II malocclusion can be corrected with FFA mostly through dentoalveolar modifications, with minor skeletal effects according to the appliance, age, and residual latent growth of the individual.

They also adjust the mandibular condyle within the glenoid fossa, allowing the lower jaw to auto-rotate naturally. These functional appliances are available in two varieties: removable and fixed. As a hybrid appliance, Forsus device (FFRD) is fracture-resistant, provides consistent force, and is simple to position at the chairside. Long-term follow-up studies play an essential role in observing the impacts of a treatment modality and potential relapse or changes over time despite the absence of any intervening factors. The research aimed to assess the stability of alterations in pharyngeal airway dimensions after completion of treatment with the Forsus Fatigue Resistant Device in skeletal Class II patients.

Study was done on 24 lateral cephalograms of patients who have undergone fixed functional therapy in department of Orthodontics and Dentofacial Orthopedics, Yenepoya Dental College, Mangalore. Pre treatment (To), at the time of achieving class I molar relationship(T2) and post treatment period of 3 years (T3) radiographs were taken from the archives of Department of Orthodontics and Dentofacial Orthopedics, Yenepoya Dental college for the orthodontic treatment purpose and it's compared. The lateral cephalograms were taken for each subject in natural head position and patient's teeth occluding in maximum intercuspation. All the lateral cephalograms were traced by a single examiner. The linear measurements were taken.

Cephalometric landmarks used in the study are PP projection (the distance between PNS and the posterior pharynx wall through palatal plane, SPS (the distance of the midpoint of the line from PNS to tip of soft palate to the horizontal counterpart on the posterior pharyngeal wall along the parallel line to Frankfurt horizontal plane, MPS (the distance of the tip of the soft palate to the horizontal counterpart on the posterior pharyngeal wall along the parallel line to Frankfurt horizontal plane, Cv2 projection (the distance between the points on anterior and posterior pharyngeal wall through Cv2(cervical vertebrae 2) along the parallel line to Frankfurt horizontal plane,Cv3 projection (the distance between the meeting points on anterior and posterior pharyngeal wall through Cv3(cervical vertebrae) along the parallel line to Frankfurt horizontal plane).

PP Projection

When comparing parameters between T1-T2, T2-T3, and T1-T3 exhibited statistically significant mean value changes from T1 to T2 and T2 to T3. T1-T3 mean values were statistically not significant .PP projection mean value in pre cephalogram tracing(T1) is 24.5±4.16 and post fixed functional appliance cephalometric tracing (T2) mean value is 26.0±3.7 shows statistically significant changes with P value as 0.003. Post 2 after 3 years cephalometric tracing (T3) showed a mean value of 24.9±3.18 with P value as 1.000 showed statistically insignificant changes from T1.

SPS

When comparing parameters between T1-T2, T2-T3, and T1-T3 exhibited statistically significant mean value changes from T1 to T2 and T2 to T3. T1-T3 mean values were statistically not significant. SPS mean value in pre cephalogram tracing (T1) is 14.5±3.89 and post fixed functional appliance cephalometric tracing (T2) mean value is 16.1±3.47 shows statistically significant changes with P value as <0.001. Post 2 after 3 years cephalometric tracing (T3) showed a mean value of 15.3±3.56 with P value as 0.181 showed statistically insignificant changes from T1.

MPS

When comparing parameters between T1-T2, T2-T3, and T1-T3 exhibited statistically significant mean value changes from T1 to T2 and T2 to T3. T1-T3 mean values were statistically not significant. MPS mean value in pre cephalogram (T1) tracing is 12.2±4.21 and post fixed functional appliance cephalometric tracing (T2) mean value is 13.7±4.43 shows statistically significant changes with P value as <0.001. Post 2 after 3 years cephalometric tracing (T3) showed a mean value of 12.8±4.40 with P value as 0.336 showed statistically insignificant changes from T1.

CV2 Projection

When comparing parameters between T1-T2, T2-T3, and T1-T3 exhibited statistically significant mean value changes from T1 to T2 and T2 to T3. T1-T3 mean values were statistically not significant. CV2 projection mean value in pre cephalogram (T1) tracing is 24.5±4.16 and post fixed functional appliance cephalometric tracing (T2) mean value is 12.0±4.18 shows statistically significant changes with P value as 0.001. Post 2 after 3 years cephalometric tracing (T3) showed a mean value of 12.5±3.64 with P value as 0.215 showed statistically insignificant changes from T1.

CV3 Projection

When comparing parameters between T1-T2, T2-T3, and T1-T3 exhibited statistically significant mean value changes from T1 to T2, T2 to T3 and T1 to T3 . CV3 projection mean value in pre cephalogram(T1) tracing is 12.8±3.72 and post fixed functional appliance cephalometric tracing (T2) mean value is 14.7±3.43 shows statistically significant changes with P value as 0.001. Post 2(T3) after 3 years cephalometric tracing (T3) showed a mean value of 13.7±3.64 with P value as <0.001 showed statistically highly significant changes from T1.

The study of Yassaei et al were also in accordance with our results. The study found that functional appliance therapy has the ability to improve pharyngeal airway widths throughout treatment, and the improvement in pharyngeal airway widths appears to be stable over time. These improvements in pharyngeal airway after treating with functional appliance helps in treating Obstructive Sleep Apnea (OSA) and the results were maintained for up to two years.[10] Similarly results of present study revealed that

the post retention period demonstrated statistically significant changes at the level of CV3 projection ($p < 0.001$), increasing from pre-treatment (T1) to post1(T2) and pre-treatment(T1) to post2(T3) assessments.[10]

In a retrospective study conducted by Bavbek et al. in 2016 to investigate the effects of Forsus fatigue resistant device on width of airway in the pharyngeal region and position of hyoid bone in individuals with Class II malocclusion and its juxtaposed with Class II malocclusion batch who had not undergone any treatment. The study revealed that fixed functional treatment resulted in improved oropharyngeal airway dimensions and enhanced hyoid bone displacement to a more forward position. These datas indicate the appliance's early impacts and they concluded that further research is needed to determine the long-term consequences of fixed functional appliances on pharyngeal airway morphology.[11]

In a retrospective study conducted by Varun Govindraj et al in 2021 to assess airway dimensions in upper pharyngeal region in skeletal Class II teenage patients treated with theForsus Fatigue Resistant Device (FRD). In addition to soft tissue examination on the lateral cephalogram, Acoustic Pharyngometry (AP) was used to document airway alterations before and after Forsus FRD. [12] This research suggested that Forsus FRD can successfully treat skeletal Class II malocclusion in teenage patients, resulting in a favourable and better facial profile, as well as the volume and width of hypopharyngeal and oropharyngeal dimensions improved extensively, leading to enhanced upper airway functionality.[7] In contrast to previous studies the present study mainly focused on potential of Forsus Fatigue Resistant Device to cause changes in airway dimensions and stability of changes in pharyngeal airway after using the Forsus Fatigue Resistant Device as stability is the fundamental key to successful outcome of orthodontic treatment.[12]

Celikoglu et al stated that the herbst and skeletal anchored Forsus FRD EZ appliance groups showed an increase in upper and lower pharyngeal airway dimensions, with the skeletal anchored group showing a statistically significant increase in lower pharyngeal dimensions ($P < 0.05$). Measurements of oropharyngeal region increased considerably in both teams. A comparison of the groups revealed that both sets noticed identical modifications with no variations that were statistically significant($P > 0.05$).[13] These findings are consistent with the findings of the current investigation, which show an improvement in the pharyngeal airway in the PP projection, SPS, MPS, CV2 and CV3 projection levels from pre-treatment (T1) to post-treatment (T2).

In agreement with our findings, Bavbek et al reported that the resulting effects of employing the FFRD appliance were anterior positioning of the hyoid bone, and improvement in airway widths. In clinical practice, favorable effects of these appliances on pharyngeal airway dimensions should be examined in Class II patients, particularly those who have respiratory issues. However, because these findings represent the appliance's early effects, they recommended that further research be conducted to assess the long-term effects of fixed functional appliances on pharyngeal airway morphology.[11]So present study focused on long-term effects of fixed functional

appliances on pharyngeal airway and results revealed that the post retention period demonstrated statistically significant changes at the level of CV3 projection ($p < 0.001$), increasing from pre-treatment (T1) to post 1 (T2) and pre-treatment (T1) to post 2 (T3) assessments. Additionally, there were significant changes observed from pre-treatment to post 1 ($p=0.001$), post 1 to post 2 ($p = 0.037$) and from pre to post 2 ($p = <0.001$).

There is improvement in the pharyngeal airway in the PP projection, SPS, MPS and CV2 projection levels from pre treatment to post 1 and post 2 after 3 years of treatment, but post retention period did not result in statistically significant airway at the level of PP projection, SPS, MPS and CV2 projection.

Conclusion

Subsequent interpretations were formed based on the results of this investigation:

- PP PROJECTION: The data showed statistically significant change in mean values from T1 to T2 and from T2 to T3. However, the change from T1 to T3 was not statistically significant.
- SPS: There was a statistically significant change in mean values from T1 to T2 and from T2 to T3. However, the change from T1 to T3 was not statistically significant.
- MPS: There was a statistically significant change in mean values from T1 to T2 and from T2 to T3. However, the change from T1 to T3 was not statistically significant.
- CV2 PROJECTION: There was a statistically significant change in mean values from T1 to T2 and from T2 to T3. However, the change from T1 to T3 was not statistically significant.
- CV3 PROJECTION: There was a statistically significant change in mean values from T1 to T2, T2 to T3 and from T1 to T3.

Post retention period demonstrated statistically significant changes at the level of CV3 projection, increasing from pre-treatment (T1) to post 1 (T2) and statistically highly significant changes from pre-treatment (T1) to post 2 (T3) assessments showing stability in the improvement of pharyngeal airway.

There is improvement in the pharyngeal airway in the PP projection, SPS, MPS and CV2 projection levels from pre treatment (T1) to post 1(T2) and post 2 after 3 years (T3) of treatment, but post retention period did not result in statistically significant changes at the level of PP projection, SPS, MPS and CV2 projection. Positive influence of these appliances on improving width of pharyngeal airway should be considered in Class II patients, particularly those with respiratory disorders, because the FFA appliance delivers forward positioning of the tongue far from the soft palate, minimizing pressure and improves the pharyngeal airway dimensions.

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