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# Effect of Fixed versus Removable Appliances for Mandibular Advancement on Pharyngeal Airway of Growing Individuals

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## Abstract

**Aim**: Dental malocclusion and jaw misalignments are the foremost reasons for airway constriction. To facilitate anterior mandibular repositioning and the concomitant anterior positioning of the tongue can induce the expansion of the pharyngeal airway. The study aimed to compare comprehensive treatment outcomes of fixed and removable mandibular advancement appliances on the width of the pharyngeal airway space.
**Methods**: Twenty growing patients with skeletal Class II malocclusion were placed into two groups: Advansync2 and twin block. Patients were advised to use mandibular advancement appliances (MAA) for 9–12 months. Lateral cephalograms and the Epworth Sleepiness Scale (ESS) were evaluated to assess alterations in the pharyngeal airway space and quality of sleep at two intervals. Chi-squre test, one-way ANOVA and Duncan's post hoc test were used for statistical analysis. P-values<0.05 were considered as significant.
**Results**: Based on the results, only the change in PNS-V measurements indicated a significant difference between appliances. Advansync2 showed more change (0.70±2.45 mm) compared to twin block (-1.80±2.34 mm), indicating a statistically significant difference (p=0.032).
**Conclusion**: A significant reduction in the ESS score in both groups was observed without any significant differences between them.

**Keywords:** Advansync2; Twin Block, Epworth Sleepiness Scale (ESS); Mandibular Advancement Appliances (MAA)

## Background

Skeletal class II malocclusion is indicated by maxillary prognathism, mandibular retrognathism, or a combination of both (1). A retrognathic mandible, located rearward relative to the cranial base, can compromise facial aesthetics. This condition is often linked to low self-esteem, reduced self-perceived attractiveness and reduced oral health-related quality of life due to a retruded chin and its resulting soft tissue profile (2). Concurrently, the posterior positioning of the tongue and soft palate reduces upper airway dimensions, elevating the risk of respiratory challenges throughout the day, and nighttime complications like snoring or obstructive sleep apnea (OSA) (3,4).

To promote mandibular growth in developing patients with skeletal class II malocclusion, various fixed and removable functional appliances are employed. Similar oral appliances can enhance upper airway patency (UA) in adult OSA patients (5). While lifestyle modifications such as weight management, smoking cessation, moderate alcohol consumption, postural adjustment, and sleep hygiene are suggested for milder OSA symptoms, severe cases usually require interventions like continuous positive airway pressure (CPAP) or mandibular advancement devices (MADs) (6).

MADs have been found effective in preventing upper airway collapse and augmenting airway dimensions in adults with mild to moderate OSA (7). While invasive surgical methods like maxillomandibular advancement can improve airway dimensions and respiratory function (8), their adoption is limited due to surgical risks and post-operative repercussions. Functional appliances, including the activator, bionator,

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Frankel, or twin block, serve to anteriorly position the tongue, soft palate, hyoid bone, and retrognathic mandible. Advancing these structures aids in enlarging the pharyngeal airway dimensions. Nonetheless, the applicability of these devices is often restricted by the patient's age (9-12).

Given this background, the study's primary objective is to comparatively assess the therapeutic effects of fixed and removable mandibular advancement appliances on the width of the pharyngeal airway space.

**Methods**

The study was approved by the Scientific Review Board and the Institutional Ethics Committee of the Coorg Institute of Dental Science, Virajpet, Karnataka, India and the study was registered at the Clinical Trials Registry – India (CTRI) with the number: CTRI/2021/09/036547. Patients, or their parents, were thoroughly informed about the study's objectives and procedures, and informed consent was obtained.

In 2008, Terry Dischinger introduced the fixed tooth-borne functional appliance known as AdvanSync 2. This appliance streamlines functional therapy and fixed mechanotherapy, potentially reducing treatment duration and boosting patient adherence (13). Compared to similar fixed functional appliances, it is credited with achieving more pronounced skeletal changes. Specifically, the AdvanSync 2 (Ormco Corp., Glendora, CA, USA) is constructed with crowns fixed to the first permanent molars in both the mandibular and maxillary arches. This design facilitates concurrent treatment with preadjusted edgewise appliances and effectively rectifies the malocclusion.

For removable appliances, the twin block is a popular choice for treating class II dentoskeletal malocclusion. Based on the individual's growth pattern, construction bites are acquired approximately 2-3 mm further than the freeway space, and adjustments are made according to the severity of the sagittal discrepancy. Patients are advised to wear the appliance consistently and ensure their lips remain sealed when in use.

Sample size was estimated based on a study conducted by Hourfar et al. (14). Sample size was calculated based on P6: pP-aP on pC4-aC4 between two groups, utilizing the ensuing formula: $n=(Z\alpha/2+Z\beta)2 *2*\sigma2 / d2$, $Z\alpha/2=1.96\%$ at 95% confidence interval, $Z\beta=0.67$ at 75% power of the study, $\sigma2=2.463$, $d=1.84$, $n=10$ per group. A total of 20 patients with a mean age of $11.75\pm1.08$ years were opted for being a part of the study, out of which nine were males and 11 were females.

Clinical examination was done, and patients were chosen according to the inclusion criteria of the study (Fig. 1, 9). Inclusion criteria were subjects from 9 to 14 years old, with pubertal growth remaining, Angle's class II malocclusion, an overjet of at least 4 mm, willing for mandibular advancement appliance therapy (MAA), no clinical signs of periodontal diseases, and with no history of periodontal therapy. Subjects with a history of any orthodontic or orthopedic treatment, previous extraction of permanent teeth or planned extractions, any bone pathology, ankylosed teeth, drug intake that modifies normal bone physiology (i.e., bisphosphonates) on or before a period of three months, long-term antibiotics use, phenytoin, cyclosporine, anti-inflammatory drugs, systemic corticosteroids, and calcium channel blockers, and those with evidence of bone loss were excluded from the study.

After the recruitment of the samples, the subjects were placed into two groups randomly:

Group A comprised 10 patients who underwent treatment with fixed mandibular advancement appliance (AdvanSync 2 – Ormco®, USA). Group B consisted of 10 patients who underwent treatment with removable mandibular advancement appliance (twin block).

After dental and stomatognathic examination, dental impressions of the upper and lower arch were made using alginate impression material for the fabrication of mandibular advancement appliances (MAA). Bite registration was done using the George bite gauge with mandibular advancement of 60% of maximum mandibular protrusion.

The custom-made fixed mandibular advancement appliance, AdvanSync 2 (Fig. 4,5) and the removable mandibular advancement appliances, twin block (Fig. 12) were fabricated. At the end of the functional phase, intra and extra oral photographs were taken of the AdvanSync 2 (Fig. 6) and the twin block (Fig. 13), and lateral cephalograms were taken of the AdvanSync 2 (Fig. 7) and the twin block (Fig. 14). ESS for AdvanSync 2 (Fig. 8) and twin block (Fig. 15) were re-evaluated to study the alternations in the pharyngeal airway space and sleep and daytime discomforts.

All the subjects were evaluated with a subjective sleep study questionnaire (Epworth Sleepiness Scale; Table 1, Fig. 3, 11) along with lateral cephalograms (Fig. 2, 10) at the first appointment. Hard and soft tissue radiographic landmarks were located, and tracings were made. The subjective sleep study questionnaire (ESS) and pharyngeal airway space were evaluated at two intervals: T0 - pre-treatment and T1 - post functional.



**Figure 1.** Pre-treatment photographs



**Figure 2.** Pre-treatment lateral cephalogram with tracing

SLEEP STUDY PRE-SCREENING QUESTIONNAIRE
& EPWORTH SLEEPINESS SCALE

Pre-treatment

| | | |
|---|---|---|
| FIRST NAME: RYAN. | DATE: 11-02-2021. | HEIGHT: 175cm. |
| MIDDLE INT: | GENDER: ☑M ☐F | WEIGHT: 71 Kg. |
| LAST NAME: | DOB: 13-05-2004. | NECK SIZE: |

HAVE YOU BEEN DIAGNOSED OR TREATED FOR ANY OF THE FOLLOWING CONDITIONS?

| | | | |
|---|---|---|---|
| High Blood Pressure | ☐YES ☑NO | Heart Disease | ☐YES ☑NO |
| Diabetes | ☐YES ☑NO | Lung Disease | ☐YES ☑NO |
| Insomnia | ☐YES ☑NO | Narcolepsy | ☐YES ☑NO |
| Morning Headaches | ☐YES ☑NO | Stroke | ☐YES ☑NO |
| Depression | ☐YES ☑NO | Sleep Apnea | ☑YES ☐NO |
| Nasal Oxygen Use | ☐YES ☑NO | Restless Leg Syndrome | ☐YES ☑NO |
| Sleeping Medication | ☐YES ☑NO | Pain Medication (e.g., Vicodin, Oxycontin) | ☐YES ☑NO |

SLEEP QUESTIONS:

| | |
|---|---|
| Do you snore? | ☑YES ☐NO |
| Is your snoring interrupted by pauses or choking? | ☐YES ☑NO |
| Has anyone ever said that you stop breathing or have pauses in your breathing during your sleep? | ☑YES ☐NO |
| Do you wear a CPAP? | ☐YES ☑NO |
| How many hours of sleep do you usually attain per night? | ☐2-4 ☐5 ☐6 ☐7 ☑8 ☐9 |
| Do you know the recommended amount of sleep per night is 7-9 hours? | ☑YES ☐NO |
| Do you feel fatigued, exhausted or tired? | ☑YES ☐NO |
| Do you feel that in some way your sleep is not refreshing or restful? | ☑YES ☐NO |
| Do you have periods of the day when you have trouble paying attention, remembering things or staying awake? | ☐YES ☑NO |

EPWORTH SLEEPINESS SCALE (ESS):

| Chance of dozing: | | | | |
|---|---|---|---|---|
| 0 = NONE | 1 = SLIGHT | 2 = MODERATE | 3 = STRONG | |
| While sitting or reading? | ☐0 | ☐1 | ☑2 | ☐3 |
| Watching TV? | ☐0 | ☐1 | ☑2 | ☐3 |
| Sitting inactive in a public place (theater or meeting)? | ☐0 | ☑1 | ☐2 | ☐3 |
| As a passenger in a car for an hour without a break? | ☐0 | ☐1 | ☑2 | ☐3 |
| Lying down to rest in the afternoon when possible? | ☐0 | ☐1 | ☑2 | ☐3 |
| Sitting and talking to someone? | ☐0 | ☑1 | ☐2 | ☐3 |
| Sitting quietly after a lunch without alcohol? | ☐0 | ☐1 | ☐2 | ☑3 |
| In a car while stopped for a few minutes at a traffic light? | ☐0 | ☑1 | ☐2 | ☐3 |
| | | TOTAL ESS SCORE: 14 | | |

**Figure 3.** Pre-treatment Epworth sleepiness scale questionnaire



**Figure 4.** Advansync 2 appliance



**Figure 5.** Post appliance insertion photographs



**Figure 6.** Post-functional photographs

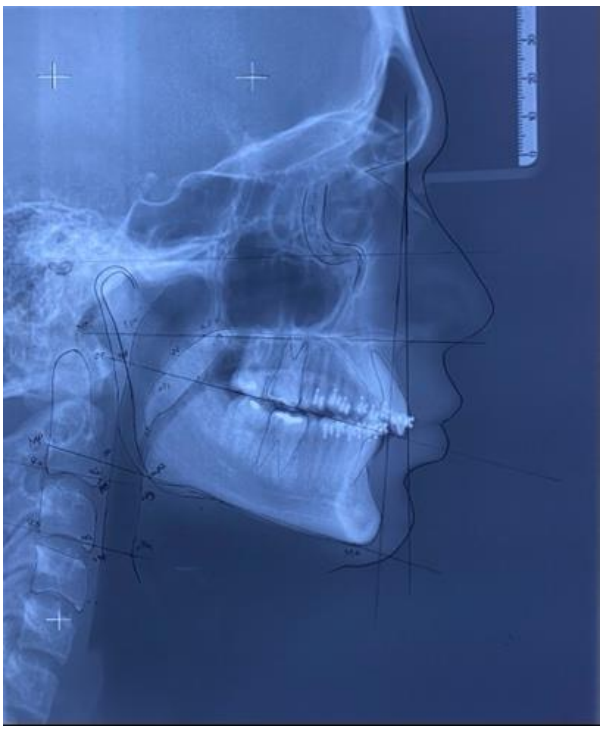


**Figure 7.** Post-functional lateral cephalogram with tracing

SLEEP STUDY PRE-SCREENING QUESTIONNAIRE
& EPWORTH SLEEPINESS SCALE

Post - TREATMENT.

| | | |
|---|---|---|
| FIRST NAME: RYVAN. | DATE: 26-08-2022 | HEIGHT: 174 cm. |
| MIDDLE INT: | GENDER: ☑M ☐F | WEIGHT: 74 kg. |
| LAST NAME: | DOB: 13-05-2004. | NECK SIZE: |

**HAVE YOU BEEN DIAGNOSED OR TREATED FOR ANY OF THE FOLLOWING CONDITIONS?**

| | | | |
|---|---|---|---|
| High Blood Pressure | ☐YES ☑NO | Heart Disease | ☐YES ☑NO |
| Diabetes | ☐YES ☑NO | Lung Disease | ☐YES ☑NO |
| Insomnia | ☐YES ☑NO | Narcolepsy | ☐YES ☑NO |
| Morning Headaches | ☐YES ☑NO | Stroke | ☐YES ☑NO |
| Depression | ☐YES ☑NO | Sleep Apnea | ☐YES ☑NO |
| Nasal Oxygen Use | ☐YES ☑NO | Restless Leg Syndrome | ☐YES ☑NO |
| Sleeping Medication | ☐YES ☑NO | Pain Medication (e.g., Vicodin, Oxycontin) | ☐YES ☑NO |

**SLEEP QUESTIONS:**

| | |
|---|---|
| Do you snore? | ☐YES ☑NO |
| Is your snoring interrupted by pauses or choking? | ☐YES ☑NO |
| Has anyone ever said that you stop breathing or have pauses in your breathing during your sleep? | ☐YES ☑NO |
| Do you wear a CPAP? | ☐YES ☑NO |
| How many hours of sleep do you usually attain per night? | ☐2-4 ☐5 ☐6 ☐7 ☑8 ☐9 |
| Do you know the recommended amount of sleep per night is 7-9 hours? | ☑YES ☐NO |
| Do you feel fatigued, exhausted or tired? | ☐YES ☑NO |
| Do you feel that in some way your sleep is not refreshing or restful? | ☐YES ☑NO |
| Do you have periods of the day when you have trouble paying attention, remembering things or staying awake? | ☐YES ☑NO |

**EPWORTH SLEEPINESS SCALE (ESS):**

| Chance of dozing: | | | |
|---|---|---|---|
| 0 = NONE | 1 = SLIGHT | 2 = MODERATE | 3 = STRONG |
| While sitting or reading? | ☐0 | ☑1 | ☐2 ☐3 |
| Watching TV? | ☑0 | ☐1 | ☐2 ☐3 |
| Sitting inactive in a public place (theater or meeting)? | ☑0 | ☐1 | ☐2 ☐3 |
| As a passenger in a car for an hour without a break? | ☐0 | ☑1 | ☐2 ☐3 |
| Lying down to rest in the afternoon when possible? | ☐0 | ☑1 | ☐2 ☐3 |
| Sitting and talking to someone? | ☑0 | ☐1 | ☐2 ☐3 |
| Sitting quietly after a lunch without alcohol? | ☐0 | ☑1 | ☐2 ☐3 |
| In a car while stopped for a few minutes at a traffic light? | ☑0 | ☐1 | ☐2 ☐3 |

TOTAL ESS SCORE: 4

**Figure 8.** Post-functional Epworth sleepiness scale questionnaire



**Figure 9.** Pre-treatment intra oral photographs



**Figure 10.** Pre-treatment lateral cephalogram with tracing



SLEEP STUDY PRE-SCREENING QUESTIONNAIRE
& EPWORTH SLEEPINESS SCALE

PRE-TREATMENT

| | | |
|---|---|---|
| FIRST NAME: PONNIAPPA .P.P. | DATE: 04-06-21. | HEIGHT: 145cm. |
| MIDDLE INT: | GENDER: ☑M ☐F | WEIGHT: 42.5kg. |
| LAST NAME: | DOB: 03-04-2012. | NECK SIZE: |

HAVE YOU BEEN DIAGNOSED OR TREATED FOR ANY OF THE FOLLOWING CONDITIONS?

| | | | |
|---|---|---|---|
| High Blood Pressure | ☐YES ☑NO | Heart Disease | ☐YES ☑NO |
| Diabetes | ☐YES ☑NO | Lung Disease | ☐YES ☑NO |
| Insomnia | ☐YES ☑NO | Narcolepsy | ☐YES ☑NO |
| Morning Headaches | ☐YES ☑NO | Stroke | ☐YES ☑NO |
| Depression | ☐YES ☑NO | Sleep Apnea | ☐YES ☑NO |
| Nasal Oxygen Use | ☐YES ☑NO | Restless Leg Syndrome | ☐YES ☐NO |
| Sleeping Medication | ☐YES ☑NO | Pain Medication (e.g., Vicodin, Oxycodone) | ☐YES ☑NO |

SLEEP QUESTIONS:

| | |
|---|---|
| Do you snore? | ☑YES ☐NO |
| Is your snoring interrupted by pauses or choking? | ☐YES ☑NO |
| Has anyone ever said that you stop breathing or have pauses in your breathing during your sleep? | ☑YES ☐NO |
| Do you wear a CPAP? | ☐YES ☑NO |
| How many hours of sleep do you usually attain per night? | ☐2-4 ☐5 ☐6 ☐7 ☐8 ☑9 |
| Do you know the recommended amount of sleep per night is 7-9 hours? | ☑YES ☐NO |
| Do you feel fatigued, exhausted or tired? | ☑YES ☐NO |
| Do you feel that in some way your sleep is not refreshing or restful? | ☑YES ☐NO |
| Do you have periods of the day when you have trouble paying attention, remembering things or staying awake? | ☐YES ☑NO |

EPWORTH SLEEPINESS SCALE (ESS):

| Chance of dozing: | | | | |
|---|---|---|---|---|
| 0 = NONE | 1 = SLIGHT | 2 = MODERATE | 3 = STRONG | |
| While sitting or reading? | ☐0 | ☐1 | ☑2 | ☐3 |
| Watching TV? | ☐0 | ☑1 | ☐2 | ☐3 |
| Sitting inactive in a public place (theater or meeting)? | ☐0 | ☐1 | ☑2 | ☐3 |
| As a passenger in a car for an hour without a break? | ☐0 | ☑1 | ☐2 | ☐3 |
| Lying down to rest in the afternoon when possible? | ☐0 | ☑1 | ☐2 | ☐3 |
| Sitting and talking to someone? | ☐0 | ☐1 | ☑2 | ☐3 |
| Sitting quietly after a lunch without alcohol? | ☐0 | ☐1 | ☐2 | ☑3 |
| In a car while stopped for a few minutes at a traffic light? | ☐0 | ☑1 | ☐2 | ☐3 |

TOTAL ESS SCORE: 13.

**Figure 11.** Pre-treatment Epworth sleepiness scale questionnaire



**Figure 12.** Post appliance insertion photographs



**Figure 13.** Post-functional photographs



**Figure 14.** Post-functional lateral cephalogram with tracing



SLEEP STUDY PRE-SCREENING QUESTIONNAIRE
& EPWORTH SLEEPINESS SCALE

post TREATMENT

| | | | |
|---|---|---|---|
| FIRST NAME: [illegible] PP. | DATE: 20-09-22. | HEIGHT: | 151cm. |
| MIDDLE INT: | GENDER: ☑M ☐F | WEIGHT: | 46kg. |
| LAST NAME: | DOB: 02-04-2012. | NECK SIZE: | |

HAVE YOU BEEN DIAGNOSED OR TREATED FOR ANY OF THE FOLLOWING CONDITIONS?

| | | | |
|---|---|---|---|
| High Blood Pressure | ☐YES ☑NO | Heart Disease | ☐YES ☑NO |
| Diabetes | ☐YES ☑NO | Lung Disease | ☐YES ☑NO |
| Insomnia | ☐YES ☑NO | Narcolepsy | ☐YES ☑NO |
| Morning Headaches | ☐YES ☑NO | Stroke | ☐YES ☑NO |
| Depression | ☐YES ☑NO | Sleep Apnea | ☐YES ☑NO |
| Nasal Oxygen Use | ☐YES ☑NO | Restless Leg Syndrome | ☐YES ☐NO |
| Sleeping Medication | ☐YES ☑NO | Pain Medication (e.g., Vicodin, Oxycontin) | ☐YES ☑NO |

SLEEP QUESTIONS:

| | |
|---|---|
| Do you snore? | ☐YES ☑NO |
| Is your snoring interrupted by pauses or choking? | ☐YES ☑NO |
| Has anyone ever said that you stop breathing or have pauses in your breathing during your sleep? | ☐YES ☑NO |
| Do you wear a CPAP? | ☐YES ☑NO |
| How many hours of sleep do you usually attain per night? | ☐2-4 ☐5 ☐6 ☐7 ☐8 ☑9 |
| Do you know the recommended amount of sleep per night is 7-9 hours? | ☑YES ☐NO |
| Do you feel fatigued, exhausted or tired? | ☐YES ☑NO |
| Do you feel that in some way your sleep is not refreshing or restful? | ☐YES ☑NO |
| Do you have periods of the day when you have trouble paying attention, remembering things or staying awake? | ☐YES ☑NO |

EPWORTH SLEEPINESS SCALE (ESS):

| Chance of dozing: | 0 = NONE | 1 = SLIGHT | 2 = MODERATE | 3 = STRONG |
|---|---|---|---|---|
| While sitting or reading? | ☐0 | ☑1 | ☐2 | ☐3 |
| Watching TV? | ☑0 | ☐1 | ☐2 | ☐3 |
| Sitting inactive in a public place (theater or meeting)? | ☑0 | ☐1 | ☐2 | ☐3 |
| As a passenger in a car for an hour without a break? | ☐0 | ☑1 | ☐2 | ☐3 |
| Lying down to rest in the afternoon when possible? | ☐0 | ☑1 | ☐2 | ☐3 |
| Sitting and talking to someone? | ☑0 | ☐1 | ☐2 | ☐3 |
| Sitting quietly after a lunch without alcohol? | ☐0 | ☑1 | ☐2 | ☐3 |
| In a car while stopped for a few minutes at a traffic light? | ☑0 | ☐1 | ☐2 | ☐3 |
| TOTAL ESS SCORE: 4 | | | | |

**Figure 15.** Post-functional Epworth sleepiness scale questionnaire

**Table1**. Epworth sleeping scale

| | | | | | |
|---|---|---|---|---|---|
| **First Name:** | | | **DOB:** | | |
| **Last Name:** | | | **WEIGHT** | | |
| Have you been diagnosed or treated for any of the following conditions? | | | | | |
| High Blood Pressure | ☐Yes | ☐No | Heart Disease (CHF) | ☐Yes | ☐No |
| Diabetes | ☐Yes | ☐No | Lung Disease (COPD) | ☐Yes | ☐No |
| Insomnia | ☐Yes | ☐No | Narcolepsy | ☐Yes | ☐No |
| Morning Headaches | ☐Yes | ☐No | Stroke | ☐Yes | ☐No |
| Depression | ☐Yes | ☐No | Sleep Apnea | ☐Yes | ☐No |
| Nasal Oxygen Use | ☐Yes | ☐No | Restless Leg Syndrome | ☐Yes | ☐No |
| Sleeping Medication | ☐Yes | ☐No | Pain Meds | ☐Yes | ☐No |
| Sleep Questions: | | | | | |
| Do you snore? | | | | ☐Yes | ☐No |
| Is your snoring interrupted by pauses or choking? | | | | ☐Yes | ☐No |
| Has anyone ever said that you stop breathing during your sleep? (witnessed apnea) | | | | ☐Yes | ☐No |
| Do you have problems keeping your legs still at night or need to move them to feel comfortable? | | | | ☐Yes | ☐No |
| How many hours of sleep do you usually get per night? | | | ☐2-4 ☐5 ☐6 ☐7 | ☐8 ☐9+ | |
| Do you experience excessive daytime sleepiness, fatigued, exhausted or tired? | | | | ☐Yes | ☐No |
| Do you feel that in some way your sleep is not refreshing or restful? | | | | ☐Yes | ☐No |
| Do you have periods of the day when you have trouble paying attention, remembering things or staying awake? | | | | ☐Yes | ☐No |
| Epworth Sleepiness Scale (ESS): | | | | | |
| Sitting and Reading? | | | ☐0 ☐1 | ☐2 | ☐3 |
| Watching TV? | | | ☐0 ☐1 | ☐2 | ☐3 |
| Sitting inactive in a public place (theater or meeting)? | | | ☐0 ☐1 | ☐2 | ☐3 |
| As a passenger in a car for an hour without a break? | | | ☐0 ☐1 | ☐2 | ☐3 |
| Lying down to rest in the afternoon when possible? | | | ☐0 ☐1 | ☐2 | ☐3 |
| Sitting and talking to someone? | | | ☐0 ☐1 | ☐2 | ☐3 |
| Sitting quietly after a lunch without alcohol? | | | ☐0 ☐1 | ☐2 | ☐3 |
| In a car, while stopped for a few minutes at a traffic light? | | | ☐0 ☐1 | ☐2 | ☐3 |
| TOTAL ESS SCORE ☐0-7 Normal, ☐8-9 Mild, ☐10-14 Moderate, ☐>15 High | | | | | |

The treatment period was 9-12 months for both the fixed and removable mandibular advancement appliance. Lateral cephalograms were recorded with the patient in an erect position, the teeth in intercuspation and the subject's head sustained by a cephalostat and positioned based on the Frankfort horizontal plane. Then cephalometric landmarks were labeled, tracings were produced, and data was statistically evaluated (Table 2).

**Table2.** Cephalometric landmark

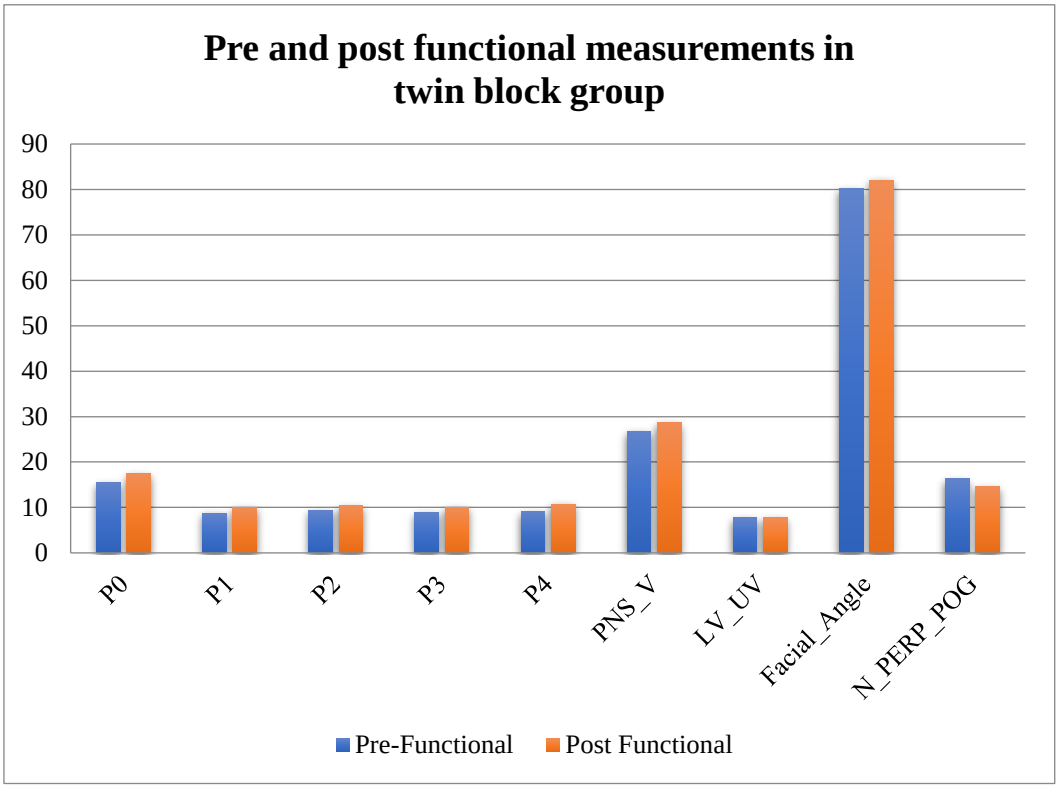
| | |
|---|---|
| aC2 | Most anteroinferior point on corpus of C2 |
| aC3 | Most anteroinferior point on corpus of C3 |
| pC2 | Most posteroinferior point on corpus of C2 |
| pC3 | Most posteroinferior point on corpus of C3 |
| aP0 | Intersection point between posterior surface of soft palate and NF |
| aP1 | Intersection point between posterior surface of soft palate and OP |
| aP2 | Intersection point between anterior pharyngeal wall and MP |
| aP3 | Intersection point between anterior pharyngeal wall and line connecting pC2 and aC2 |
| aP4 | Intersection point between anterior pharyngeal wall and line connecting pC3 and aC3 |
| pP0 | Intersection point between posterior pharyngeal wall and NF |
| pP1 | Intersection point between posterior pharyngeal wall and OP |
| pP2 | Intersection point between posterior pharyngeal wall and MP |
| pP3 | Intersection point between posterior pharyngeal wall and line connecting pC2 and aC2 |
| pP4 | Intersection point between posterior pharyngeal wall and line connecting pC3 and aC3 |
| Hy | Most superior and anterior point on body of hyoid bone |
| LV | Intersection point between line on maximal diameter of velum in oronasal direction and oral surface of velum |
| UV | Intersection point between line of maximal diameter of velum in oronasal direction and nasal surface of velum |
| V | Point corresponding to tip of velum (soft palate) |
| Pharyngeal dimensions: | |
| P0 | Linear distance between posterior pharyngeal wall and posterior soft palate along NF (pP0-aP0) (mm) |
| P1 | Linear distance between posterior pharyngeal wall and posterior soft palate along OP (pP1 - aP1) (mm) |
| P2 | Linear distance between posterior and anterior pharyngeal walls along MP (pP2 - aP2) (mm) |
| P3 | Linear distance between posterior and anterior pharyngeal walls along base of C2 (pP3 - aP3) (mm) |
| P4 | Linear distance between posterior and anterior pharyngeal walls along base of C3 (pP4 – aP4) (mm) |
| Velum dimensions: | |
| PNS | V Length of velum; distance between PNS and V (mm) |
| LV- UV | Thickness of velum; distance between LV and UV (mm) |
| MANDIBULAR POSITION | |
| Angular measurement | |
| Facial angle | Angle formed by FH- NPog |
| Linear measurement | |
| N ⊥ Pog | Horizontal distance between perpendicular line from nasion to Pog |

The software SPSS (version 22.0; IBM Corp., Armonk, NY, USA) was used to statistically analysis the coded data. The descriptive analysis was used to present mean and standard deviation. The inferential statistics included the paired t-test and one-way ANOVA followed by the post hoc Tukey's test for comparison. The level of significance was set at 0.05 at a 95% confidence interval.

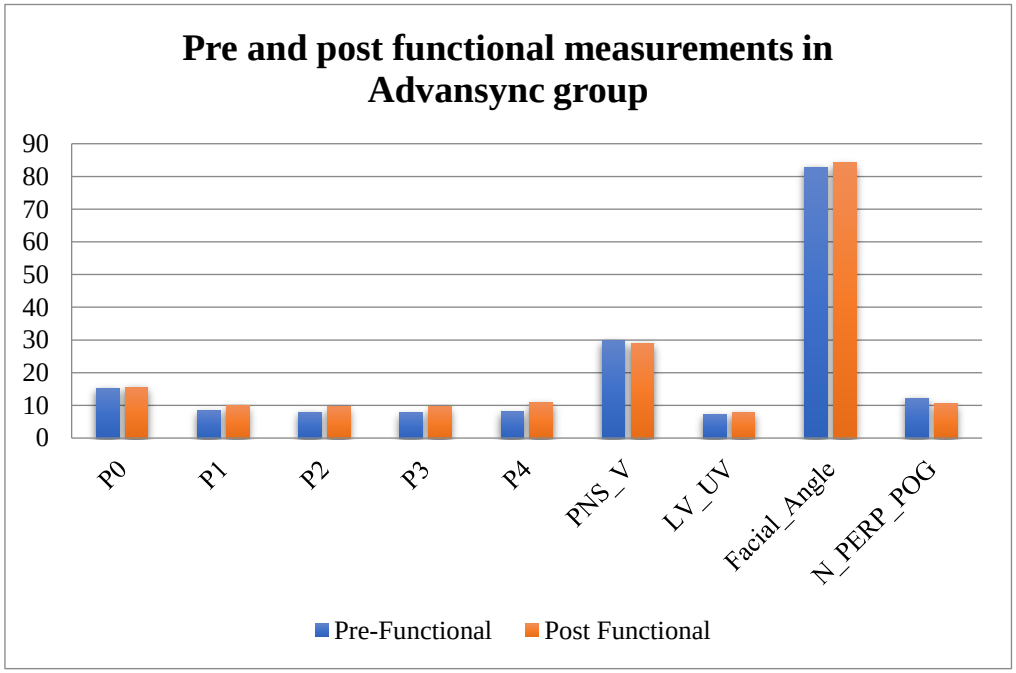
**Results**

In the twin block group (Table 3, Graph 1, 2) the pharyngeal dimension along the nasal floor (P0) increased from a pre-functional mean of 15.50 mm to a post-functional mean of 17.40 mm. The pharyngeal dimension along the occlusal plane (P1) increased from a pre-functional mean of 8.70 mm to a post-functional mean of 10.10 mm. The pharyngeal dimension along the mandibular plane (P2) increased from a pre-functional mean of 9.40 mm to a post-functional mean of 10.40 mm. The pharyngeal dimension along the base of C2 (P3) increased from a pre-functional mean of 9.00 mm to a post-functional mean of 10.10 mm. The pharyngeal dimension along the base of C3 (P4) increased from a pre-functional mean of 9.10 mm to a post-functional mean of 10.70 mm. The length of the velum increased from a pre-functional mean of 26.80 mm to a post-functional mean of 28.60

mm. The thickness of the velum remained constant from a pre-functional mean to a post-functional mean at 7.70 mm. The facial angle increased from a pre-functional mean of 80.10° to a post-functional mean of 82°. N PERP to POG decreased from a pre-functional mean of 16.30 mm to a post-functional mean of 14.60 mm. This shows that there is an increase in pharyngeal space at all levels with a thickness of velum being maintained.




**Graph 1.** Pre-functional and post-functional measurements in Twin Block group




**Graph 2.** Pre-functional and post-functional measurements in Advansync group

**Table 3.** The Mean ± SD of the two groups (pre-functional and post-functional)

| Measurements | Variable | N | TWIN BLOCK | | Advansync 2 | |
|---|---|---|---|---|---|---|
| | | | Mean | Std. Deviation | Mean | Std. Deviation |
| Pre-Functional | P0 | 10 | 15.50 | 6.803 | 15.30 | 4.900 |
| | P1 | 10 | 8.70 | 1.703 | 8.40 | 1.776 |
| | P2 | 10 | 9.40 | 2.271 | 7.90 | 1.729 |
| | P3 | 10 | 9.00 | 1.886 | 7.70 | 1.418 |
| | P4 | 10 | 9.10 | 2.234 | 8.00 | 1.826 |
| | PNS -V | 10 | 26.80 | 3.994 | 29.70 | 4.347 |
| | LV-UV | 10 | 7.70 | 0.675 | 7.20 | 0.919 |
| | Facial Angle | 10 | 80.10 | 3.107 | 82.80 | 4.158 |
| | N PERP POG | 10 | 16.30 | 6.273 | 12.20 | 5.051 |
| Post-Functional | P0 | 10 | 17.40 | 5.358 | 15.50 | 5.039 |
| | P1 | 10 | 10.10 | 2.923 | 9.90 | 2.807 |
| | P2 | 10 | 10.40 | 1.897 | 9.50 | 3.171 |
| | P3 | 10 | 10.10 | 2.234 | 9.50 | 2.799 |
| | P4 | 10 | 10.70 | 3.164 | 10.80 | 3.938 |
| | PNS-V | 10 | 28.60 | 4.624 | 29.00 | 2.867 |
| | LV-UV | 10 | 7.70 | 0.823 | 7.80 | 0.632 |
| | Facial Angle | 10 | 82.00 | 3.682 | 84.20 | 4.826 |
| | N PERP POG | 10 | 14.60 | 6.670 | 10.50 | 5.401 |

In the Advansync 2 group (Table 3, Graphs 1, 2) the pharyngeal dimension along the nasal floor (P0) increased from a pre-functional mean of 15.30 mm to post-functional mean of 15.50 mm. The pharyngeal dimension along the occlusal plane (P1) increased from a pre-functional mean of 8.40 mm to a post-functional mean of 9.90 mm.

The pharyngeal dimension along the mandibular plane (P2) increased from a pre-functional mean of 7.90 mm to a post-functional mean of 9.50 mm. The pharyngeal dimension along the base of C2 (P3) increased from a pre-functional mean of 7.70 mm to a post-functional mean of 9.50 mm. The pharyngeal dimension along the base of C3 (P4) increased from a pre-functional mean of 8.00 mm to a post-functional mean of 10.80 mm. The length of the velum decreased from a pre-functional mean of 29.70 mm to a post-functional mean of 29.00 mm.

The thickness of the velum increased from a pre-functional mean of 7.20 mm to a post-functional mean of 7.80 mm. The facial angle increased from a pre-functional mean of 82.80° to a post-functional mean of 84.20°. N PERP to POG decreased from a pre-functional mean of 12.20 mm to a post-functional mean of 10.50 mm. This shows that there is an increase in pharyngeal space at all levels along with an increase in length and thickness of velum. Statistically significant changes were seen between pre-functional and post-functional mean in both the twin block and AdvanSync 2 groups; however, when pre-treatment and post-treatment values of the ESS scores were compared with each other, the results were statistically non-significant (Table 4).

## Discussion

In the twin block group (Table 5) on intragroup comparison between pre-functional and post-functional mean, there was an increase in pharyngeal dimension along the nasal floor (P0), occlusal plane (P1), along the mandibular plane (P2), and along the base of C3 (P4) but it was statistically non-significant. However, there was a statistically significant increase in the pharyngeal dimension along the base of C2 (P3), length of the velum, facial angle and N PERP POG on intragroup comparison between pre-functional and post-functional mean. The thickness of the velum remained constant from pre-functional to post-functional mean.

**Table 4.** Comparison of pre – treatment and post – treatment Epworth sleepiness Scale among groups

| Variables | | | Mean | Standard Deviation | t | Significance |
|---|---|---|---|---|---|---|
| ESS Score | Pre | Twin Block | 12.700 | 1.567 | 1.812 | 0.087 |
| | | Advansync | 14.200 | 2.097 | | |
| | Post | Twin Block | 5.700 | 1.251 | 1.070 | 0.299 |
| | | Advansync | 6.400 | 1.646 | | |

**Table 5.** Paired t-test for intragroup comparison (Pre-functional and Post-functional) in Twin block group

| Treatment Group | | Mean | Std. Deviation | 95% Confidence Interval | | p value | Significance |
|---|---|---|---|---|---|---|---|
| | | | | Lower | Upper | | |
| Twin Block | Pre – Post P0 | -1.900 | 3.142 | -4.148 | 0.348 | 0.088 | NS |
| | Pre – Post P1 | -1.400 | 2.590 | -3.253 | 0.453 | 0.122 | NS |
| | Pre - Post P2 | -1.000 | 1.490 | -2.066 | 0.066 | 0.063 | NS |
| | Pre – Post P3 | -1.100 | 1.370 | -2.080 | -0.119 | 0.032 | Significant |
| | Pre – Post P4 | -1.600 | 2.836 | -3.628 | 0.428 | 0.108 | NS |
| | Pre – Post PNS-V | -1.800 | 2.347 | -3.479 | -0.120 | 0.038 | Significant |
| | Pre – Post LV-UV | 0.000 | 1.054 | -0.754 | 0.754 | 1.000 | NS |
| | Pre–Post Facial Angle | -1.900 | 2.558 | -3.730 | -0.069 | 0.043 | Significant |
| | Pre-Post N PERP POG | 1.700 | 1.059 | 0.942 | 2.457 | 0.001 | Significant |

In the AdvanSync 2 group (Table 6) on intragroup comparison between pre-functional and post-functional mean, there was an increase in the pharyngeal dimension along the occlusal plane (P1), along the mandibular plane (P2), along the base of C2 (P3), along the base of C3 (P4), thickness of the velum, and N PERP POG, which was statistically significant. However, there was statistically non-significant change in the pharyngeal dimension along the nasal floor (P0) and thickness of the velum on intragroup comparison between pre-functional and post-functional mean.

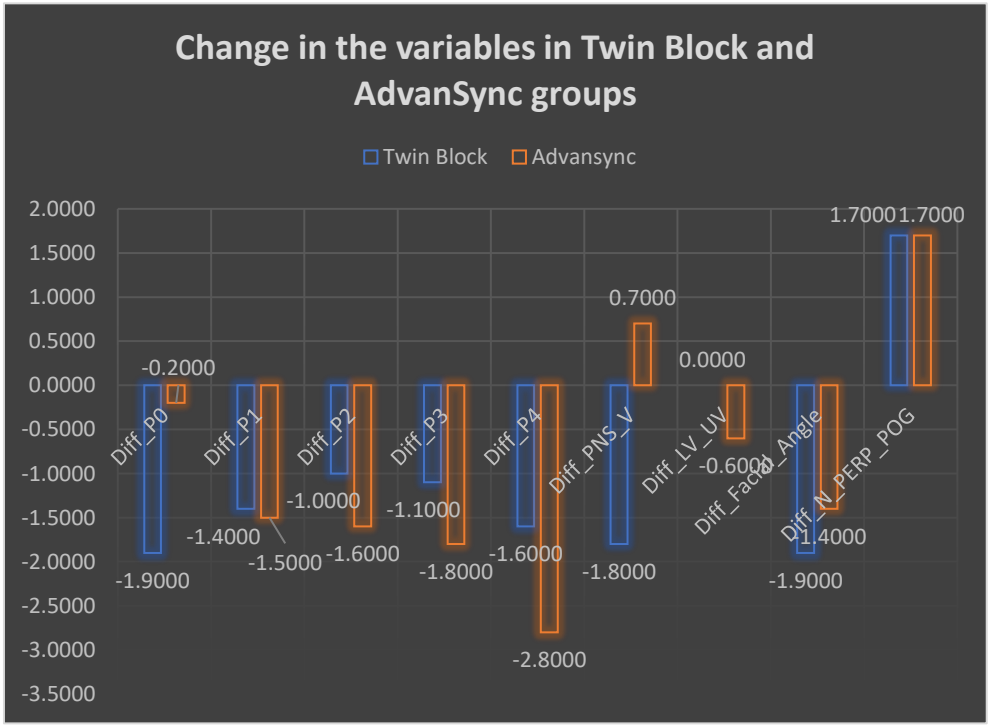
On comparison of change in variable between the twin block group and AdvanSync 2 group, (Table 7 and Graph 4), statistically significant differences were seen only concerning the length of the velum with AdvanSync 2, showing more change compared to the twin block. On comparison of change in variable between the twin block group and AdvanSync 2 group, differences were observed in the pharyngeal dimension along the nasal floor (P0), occlusal plane (P1), along the mandibular plane (P2), along the base of C2 (P3), along the base of C3 (P4), thickness of the velum, facial angle, and N PERP POG although the degree of changes observed were statistically non-significant. This agreed with a study conducted by Xiang to assess the changes in airway dimensions following functional appliances in growing patients with skeletal class II malocclusion (15).

**Table 6.** Paired t-test for intragroup comparison (pre-functional and post-functional) in Advansync 2 group

| Treatment Group | | Mean | Std. Deviation | 95% Confidence Interval | | p value | Significance |
|---|---|---|---|---|---|---|---|
| | | | | Lower | Upper | | |
| Advansync | Pre - Post P0 | -0.200 | 2.440 | -1.945 | 1.545 | 0.801 | NS |
| | Pre - Post P1 | -1.500 | 1.509 | -2.579 | -0.420 | 0.012 | Significant |
| | Pre - Post P2 | -1.600 | 2.065 | -3.077 | -0.122 | 0.037 | Significant |
| | Pre – Post P3 | -1.800 | 1.751 | -3.052 | -0.547 | 0.010 | Significant |
| | Pre – Post P4 | -2.800 | 3.084 | -5.006 | -0.593 | 0.018 | Significant |
| | Pre – Post PNS-V | 0.700 | 2.451 | -1.053 | 2.453 | 0.390 | NS |
| | Pre – Post LV-UV | -0.600 | 0.699 | -1.100 | -0.099 | 0.024 | Significant |
| | Pre-Post Facial Angle | -1.400 | 2.221 | -2.988 | 0.188 | 0.077 | NS |
| | Pre -Post N PERP POG | 1.700 | 1.251 | 0.804 | 2.595 | 0.002 | Significant |

**Table 7.** Comparison of change in variable between Twin block group and Advansync 2 group using Independent Sample test.

| | Treatment | Mean | Std. Deviation | Confidence Interval | | p value | Significance |
|---|---|---|---|---|---|---|---|
| | | | | Lower | Upper | | |
| Diff P0 | Twin Block | -1.900 | 3.142 | -4.343 | 0.9436 | 0.193 | NS |
| | Advansync | -0.200 | 2.440 | -4.355 | 0.9552 | | |
| Diff P1 | Twin Block | -1.400 | 2.590 | -1.891 | 2.091 | 0.917 | NS |
| | Advansync | -1.500 | 1.509 | -1.927 | 2.127 | | |
| Diff P2 | Twin Block | -1.000 | 1.490 | -1.092 | 2.292 | 0.466 | NS |
| | Advansync | -1.600 | 2.065 | -1.104 | 2.304 | | |
| Diff P3 | Twin Block | -1.100 | 1.370 | -0.777 | 2.177 | 0.333 | NS |
| | Advansync | -1.800 | 1.751 | -0.783 | 2.183 | | |
| Diff P4 | Twin Block | -1.600 | 2.836 | -1.583 | 3.983 | 0.377 | NS |
| | Advansync | -2.800 | 3.084 | -1.585 | 3.985 | | |
| Diff PNS-V | Twin Block | -1.800 | 2.347 | -4.755 | -0.244 | 0.032 | Significant |
| | Advansync | .700 | 2.451 | -4.755 | -.244 | | |
| Diff LV-UV | Twin Block | 0.000 | 1.054 | -0.2403 | 1.440 | 0.151 | NS |
| | Advansync | -0.600 | 0.699 | -0.2495 | 1.449 | | |
| Diff Facial Angle | Twin Block | -1.900 | 2.558 | -2.750 | 1.750 | 0.646 | NS |
| | Advansync | -1.400 | 2.221 | -2.753 | 1.753 | | |
| Diff N PERP POG | Twin Block | 1.700 | 1.059 | -1.089 | 1.089 | 1.000 | NS |
| | Advansync | 1.700 | 1.251 | -1.091 | 1.091 | | |




**Graph 4.** Comparison of change in variable between Advansync 2 group and Twin block group

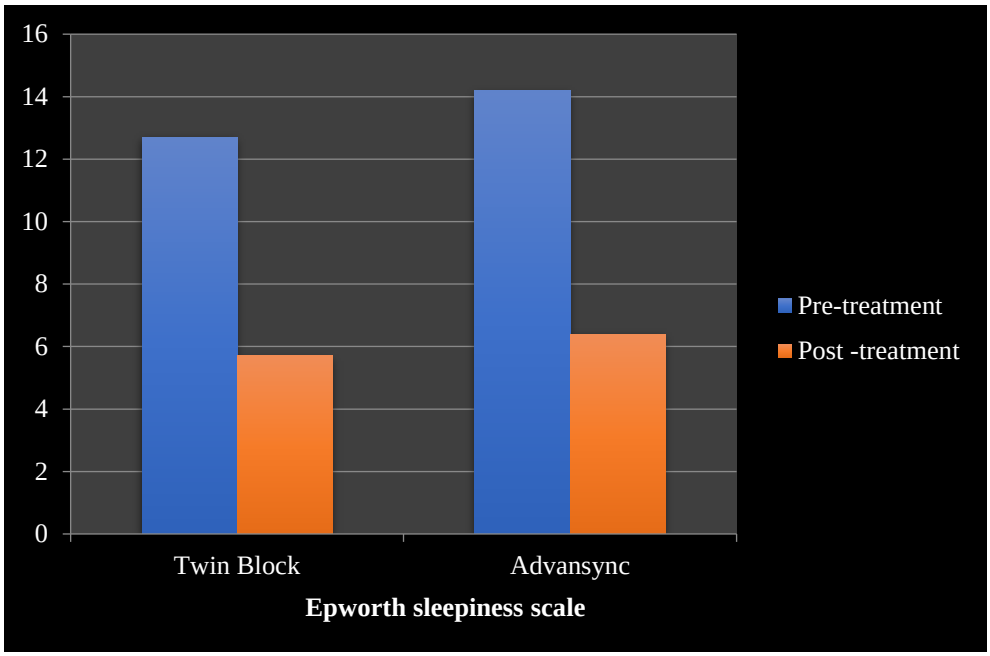
In the twin block group, upon comparison between the pre-functional and post-functional mean of the Epworth sleepiness scale, the ESS score was reduced from a mean of 12.700 pre-functional to a mean of 5.700 post-functional, which is statistically highly significant (Table 8 and Graph 5). This was in accordance with the results obtained from a study by Jena undertaken to study the efficiency of twin block and mandibular protraction appliance-IV to improve pharyngeal airway passage size in class II malocclusion patients with a retrognathic mandible. It showed improvements in the adaptations of the soft palate following treatment of class II malocclusion by functional appliances. The twin block and MPA-IV were useful to improve the depth of oropharynx in those with retrognathic mandibles although this was significantly more with use of the twin block appliance. Twin block treatment was effective to improve the hypopharyngeal airway passage dimension (16).

In the AdvanSync 2 group, upon comparison

between the pre-functional and post-functional mean of the Epworth sleepiness scale, the ESS score was reduced from a mean of 14.200 pre-functional to a mean of 6.400 post-functional, which is statistically highly significant (Table 8 and Graph 5). This was in line with research done by Shahi et al. in 2022, which demonstrated that the two appliances produced suitable results in the correction of class

**Table 8.** Comparison of pre – functional and post – functional Epworth sleepiness Scale between Advansync 2 and Twin block group

| Variables | | Mean | Standard Deviation | t | Significance |
|---|---|---|---|---|---|
| Twin block | Pre | 12.700 | 1.567 | 11.037 | 0.000 |
| | Post | 5.700 | 1.251 | | |
| Advansync | Pre | 14.200 | 2.097 | 9.250 | 0.000 |
| | Post | 6.400 | 1.646 | | |




**Graph 5.** Comparison of pre-functional and post-functional Epworth sleepiness Scale between Advansync 2 and Twin block group

II malocclusion. AdvanSync 2 produced more changes in SNB and effective mandibular length when compared to the twin block. Overjet and molar relations improved prominently with both appliances and produced similar skeletal, dentoalveolar, and soft tissue changes (17). The results obtained from the study are also concurrent with other systematic studies by Serra-Torres et al. (2015) and Yanyan et al. (2019), which showed mandibular advancement appliances, which increase the pharyngeal airway, can be effective for mild to severe patients before the end of the pubertal peak. The results of these studies indicate that AHI decreases, oxygen saturation increases, and the main symptoms of OSAHS improve when AdvanSync 2 is applied (7,8,16,18).

The study results were not akin to the study conducted by Ghaffar et al. that demonstrated both the appliances are helpful to correct skeletal class II malocclusion. Both appliances gave comparable effects in the sagittal plane nonetheless to achieve superior vertical control, the twin block is preferable. However, the AdvanSync 2 appliance is desirable over the twin block appliance when dentoalveolar and slight retrusive effect on the maxilla is wanted, mainly for those in the post-pubertal growth spurt (19).

## Conclusion

A statistically significant increase in the pharyngeal airway space was observed in both AdvanSync 2 and twin block, and both were beneficial for the treatment of OSA. Both AdvanSync 2 and twin block can be effective in the correction of retrognathic mandible by mandibular advancement in growing patients.

However, when both groups were compared, it was found that the only change was in PNS-V

measurements, which showed a significant difference with AdvanSync 2 (0.7000±2.45176 mm) showing more change compared to twin block (-1.8000±2.34758 mm) with (p=0.0320)

The Epworth sleepiness scale showed a statistically highly significant reduction in the score when compared from T0 (pre-functional) to T1 (post-functional) in both AdvanSync 2 and twin block.

**Conflicts of interest:** None to declare.

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