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Original Research Article

Assessment of sagittal skeletal change with Beta angle in patients treated with Frankel II appliance using Dolphin imaging software

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Abstract

Objective: To assess the sagittal skeletal changes with Beta angle in patients treated with Frankel II appliance using Dolphin Imaging Software.
Materials and Methods: Pretreatment (T0) and post-functional therapy (T1) lateral cephalograms of 30 patients (23 females and 7 males, Age range of 8 to 12 years) treated with Frankel II appliance in digital form were uploaded in Dolphin Imaging Software (Version 11.95). The position of each landmark was located digitally in the software and recorded. Pre- and post-treatment Beta angle for each patient was calculated by the software. The mean difference between T0 -T1 was compared to assess the effects of the Frankel II appliance and analyzed. Paired t-test was used to compare the statistical differences between the parameters.
Results: Intra-group comparison of the Beta angle measurements revealed that there existed a significant difference between the groups ($p<0.001$). Beta angle was increased significantly indicating that the skeletal malocclusion was improved.
Conclusion: Beta angle increased significantly following Frankel II therapy suggesting considerable improvement in skeletal discrepancy. The Frankel II appliance can be utilized in young children with class II malocclusion to treat maxillomandibular sagittal problems. Beta angle can also be used with other parameters to analyze sagittal skeletal malocclusions.

Keywords: Frankel II appliance, Beta angle, Dolphin Imaging Software.

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1. Introduction

About one-third of all the patients in the orthodontic practice have Class II malocclusion.[1] Although a variety of causes contribute to this malocclusion, mandibular skeletal retrusion is prevalent diagnostic feature in class II malocclusion.[2] Choice of treatment options includes functional or fixed appliances, depending on the age of the patient.

Among contemporary functional appliances, Functional Regulator II is one of the most popular and well-known.[3] Rolf Frankel designed this appliance as an orthopedic tool aimed at retraining the neuromuscular system of the orofacial region.[1] Despite the numerous studies on Functional Regulator II treatment that have been conducted to date, there are still some controversies, particularly about the skeletal effects given by this appliance.[2]

Linear as well as angular computations are used in several cephalometric investigations for aiding clinicians in diagnosing anteroposterior discrepancies and determining the best treatment plan. Angle ANB and Wits evaluation are the most widely used parameters among the several proposed by different researchers for measuring sagittal discrepancy.[4,5]

Although they are widely used, numerous authors in the literature have questioned their validity and have proposed several distorting factors against them like Nasion position and functional occlusal plane inclination.[4,5]

Therefore, in assessing the jaw-base relationship, a measurement independent of variable factors would be useful. Beta(β) angle is one such measurement. It was introduced by Chong Yol Baik.[6] It calculates angle which demonstrates extent as well as skeletal dysplasia type in the sagittal plane, utilizing three skeletal reference points: point

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A, point B, as well as Condyle's apparent axis (**Figure 1**). Beta-angle ranging from 27°-35°signifies Class I skeletal pattern, an angle below27° suggests a Class II skeletal pattern, along with a β-angle exceeding 34° shows a Class III skeletal pattern. This angle has been independent of any dental occlusion/cranial landmarks, making it particularly useful when other cephalometric computations, including Wits appraisal as well as ANB angle, are unable to be employed reliably due to their reliance on variable factors.[6]

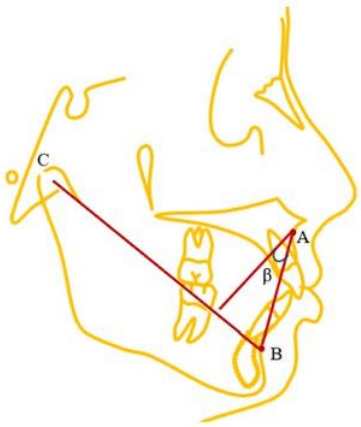

Figure 1: Beta angle

With the advances in technology, conventional cephalometric tracing has been largely replaced by computer-based cephalometry. Today, many different software is available that allow direct digitization on computers along with automated results of different angular and linear measurements, one of them being the Dolphin Imaging Software (Dolphin Imaging and Management Solutions, Chatsworth, CA).

The image can be improved and enlarged to help locate landmarks, with the application clearly describing landmarks and displaying their intended position, reducing landmark definition errors. When the digitization is finished, the software creates a traced image that can be manually adjusted for better fit if necessary. The choice analysis is then chosen to derive the measurement values.[7]

The effectiveness of the Frankel-2 appliance has been extensively studied. It consistently corrects a Class II malocclusion; however, there is considerable debate regarding nature of its action. The changes in the sagittal maxillo-mandibular discrepancy are usually assessed through a decrease in the ANB angle. Since ANB angle is influenced by many different variables, it would be more reliable to assess the skeletal changes after functional appliance therapy using a parameter that is independent of any other influences. Hence, primary research goal has been to evaluate sagittal skeletal changes following Frankel II appliance therapy with beta angle using Dolphin Imaging Software.

2. Materials and Methods

2.1. Source of the data

The Department of Orthodontics and Dentofacial Orthopedics file section contained lateral cephalograms obtained both before and after functional therapy for patients with Class II malocclusion receiving treatment with the Frankel II appliance. The institutional review board and ethics committee approved the study. (Reg.No.ECR/1652/Inst/ KA/2022/04-005)

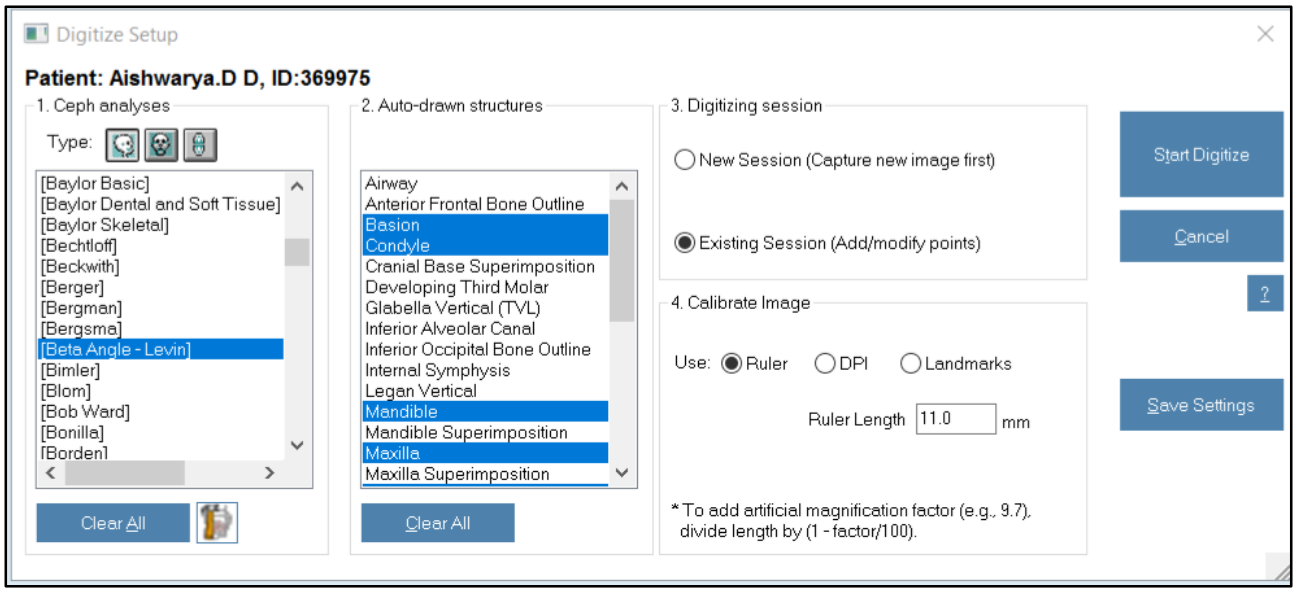

Figure 2: Digitization of pre-treatment and post-treatment lateral cephalograms

2.2. Selection of study samples

The study required 30 sample size to estimate a mean with 95% confidence and precision of 0.95. After a thorough assessment, 30 eligible individuals' records (23 females as well as 7 males), aged among 8 and 12 years, were chosen for this research. Inclusion criteria had been as follows: (1) Individuals having an ANB ≥ 4°, (2) Frankel II appliance has been utilized for treating individuals who have Class II skeletal malocclusion, (3) Patients in growth phase (CVMI stages 2, 3, and 4), and (4) Good condition lateral cephalometric radiographs. Exclusion criteria included: (1) Individuals having craniofacial trauma/surgery's history, (2) Individuals having congenital syndromes/anomalies, and (3) Patients with any Temporomandibular Joint Disorders (TMDs).

2.3. Methodology

Each lateral cephalogram had carefully been examined for making sure they fulfilled research's standardized requirements, like teeth in occlusion and having lips at rest. Standardization had been accomplished by utilizing identical machine (Planmecca Proline XC) to capture each cephalogram. Each radiograph's digital version had then subsequently been uploaded into Dolphin Imaging software ver. 11.95 (Patterson Dental, Chatsworth, CA, USA) (**Figure 2**) for evaluation. Software had also been utilized for performing digital calibration of each lateral cephalogram using a measurement ruler.

Pretreatment (T0) and post-functional therapy (T1) lateral cephalograms of the individuals treated with Frankel II appliance in digital form were uploaded. The location of each landmark was digitally identified and recorded using the software (**Figure 3**). Pre and post-treatment Beta angle for each patient was calculated by the software (**Figure 4**). The changes between T0 -T1 were determined. The mean difference between T0 -T1 was compared to assess the impact of the Frankel II appliance and analyzed.

2.4. Measurement accuracy and reproducibility

6 individuals had randomly been chosen, moreover, their radiographs had been uploaded. Landmarks were identified, and the parameter was measured twice: once by same investigator further by 2ndinvestigator. Entire procedure had been conducted after 2weeks of initial measurement analysis, for avoiding any possible bias. ICC (Intra-class correlation coefficient) had been utilized for evaluating both intra-examiner as well as inter-examiner accuracy, employing 2-way mixed and absolute agreement model. Correlation coefficient for inter-examiner as well as intra-examiner accuracy had been demonstrated as excellent at >0.9 (**Table 1**, **Table 2**, **Table 3**). The exceptional inter-examiner, as well as intra-examiner accuracy, can be authorized to handle software often for practice.

Table 1: Intra class Correlation Coefficient (Examiner1)

Values	Attempt	Correlation coefficient	P value
Pre-treatment	1 vs 2	0.990	<.001
Post-treatment	1 vs 2	0.977	.001

There was an excellent (coefficient value >0.9) significant (p≤.001) correlation between the values of the two attempts by the first examiner (both for pre and post values).

Table 2: Intra class correlation coefficient (Examiner2)

Values	Attempt	Correlation coefficient	P value
Pre-treatment	1 vs 2	0.987	<.001
Post-treatment	1 vs 2	0.981	.001

There was an excellent (coefficient value >0.9) significant (p≤.001) correlation between the values of the two attempts by the second examiner (both for pre and post values).

Table 3: Inter class correlation coefficient

Values	Examiner	Correlation coefficient	P value
Pre-treatment	1 vs 2	0.994	<.001
Post-treatment	1 vs 2	0.972	.001

There was an excellent (coefficient value >0.9) significant (p≤.001) correlation between the values of the two examiners and this was seen for both pre and post values.

2.5. Statistical analysis

Data was tabulated using Microsoft Excel, Version 2004 (Build 12730.20270 Microsoft Store), entered into IBM SPSS software (Version 25, Armonk NY IBM Corp.), and subsequently analyzed. The mean, and standard deviation for differences between the pretreatment and post functional values of beta angle were calculated. Paired t test was used to compare the statistical differences between the pretreatment and post treatment outcomes of the parameter used (Beta angle). P values of <0.05 were considered statistically significant.

3. Results

The pre-treatment and post-functional changes in beta angle had been computed utilizing Dolphin imaging software. Beta angle measured among groups revealed statistically significant difference (**Table 4**). The mean Beta angle for pre-treatment was 22.39^0, ranging from 15.9^0 to 27^0 and for post-functional therapy was 27.04^0 ranging from 21^0 to 32.5^0 with p-value <0.001 which is highly significant. Beta angle was increased significantly indicating that the skeletal malocclusion was improved.

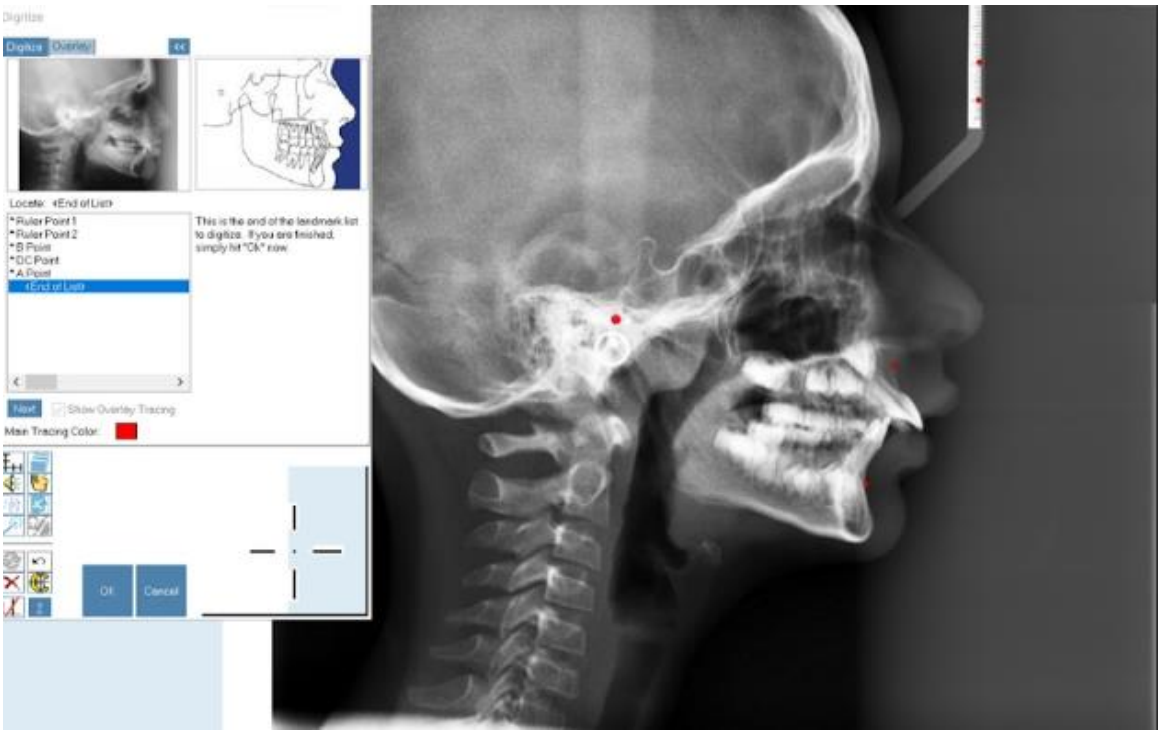

Figure 3: Digital identification and location of landmarks in Dolphin Imaging software.

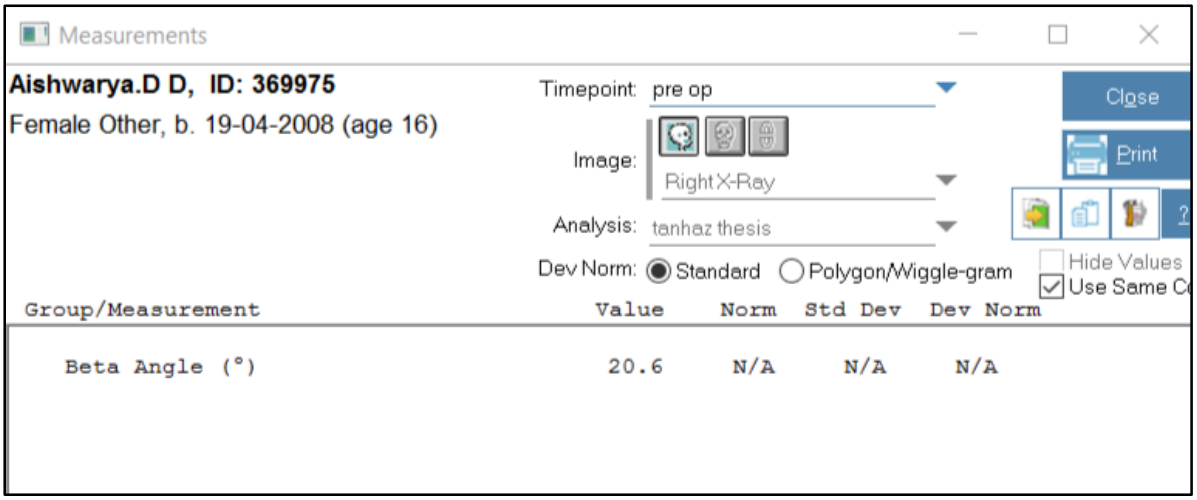

Figure 4: Beta angle recorded using the Dolphin Imaging software measurement function

4. Discussion

Class II malocclusion is prevalent orthodontic issue, affecting 20-25% of the population globally.[8] This type of malocclusion is affected in all three planes of space: anteroposteriorly, vertically and transversely. In the sagittal plane, it can manifest as a normal maxilla with a retrognathic mandible, prognathic maxilla with a normal mandible, or combination. About 75% of people having class II malocclusion have mandibular retrognathism.[9]

The advantage of early treatment in Class II patients, has potential of altering patient's development pattern lowering maxillary incisor trauma risk, increasing airway space in oropharyngeal region moreover resulting in stable along with ideal occlusion.[9]

Various treatment approaches are reported in literature to manage skeletal as well as dental Class II malocclusions in growing individuals. These include, 1) Two-phase treatment, 1st utilizing functional appliance followed by fixed mechanotherapy 2) one-stage treatment using a fixed appliance in addition to an extraoral appliance and 3) Using mandibular fixed protraction appliance along with fixed appliance.[9]

Table 4: Intra-group comparison of pre-treatment and post-functional values.

Parameter	Pre treatment		Post treatment		T statistic	P value
	Mean	SD	Mean	SD		
Beta Angle	22.39	3.11	27.04	3.14	-9.50	<.001

Functional appliances have been in use since the early 20th century and have gained global acceptance over time. Among these is the function regulator (FR-2), introduced by Frankel in the 1960s. This appliance was created as a myofunctional device aimed at improving the function of the circumoral muscles. Frankel suggested that establishing a normal muscle activity pattern supports proper skeletal and dental development, thereby helping to sustain the corrected mandibular position.[1,2,3,9,10]

Research on the impact of the FR appliance in treating Class II malocclusions has shown enhanced mandibular growth, with no significant changes in maxillary growth, when compared to control groups, as reported by Creekmore and Radney in 1983.[11] According to McNamara[12] the outcomes observed in FR-II treated cases were attributed to the forward positioning of the mandible along the facial axis. The discrepancy between the maxilla and mandible showed significant improvement, with the pogonion shifting more anteriorly in the FR-II group compared to the untreated group (Falck and Frankel, 1989).[13] In 1996, Perillo et al.[3] reported that the use of FR-II therapy combined with a subsequent phase of post-functional appliance treatment led to an increase in mandibular length. In the FR-II treated group, the correction of Class II malocclusion is primarily skeletal, with minimal dentoalveolar modifications as concluded by Toth and McNamara[14] in 1999. Other investigators such as Nielsen in 1984 have found no enhancement in mandibular growth as a result of using the FR appliance in the treatment of Class II malocclusions.[15] Hamilton et al[16] (1984) found minimal Class II skeletal correction with no restraining effect on the maxilla or stimulation of mandibular growth in cases treated with the FR-II appliance.

The development of cephalometric radiography as an orthodontic diagnostic technique made it possible to accurately assess skeletal relationships with various types of malocclusions.[17] Commonly utilized metrics for assessing the anteroposterior (A-P) relation of the apical bases are the ANB angle and Wits assessment. Despite their extensive use, several authors have questioned their validity in the literature and have proposed a number of distorting factors, such as the angulation of the functional occlusal plane and position of Nasion.[4,5] A measurement that is not dependent on dental occlusion or cranial reference planes is proposed as a desirable addition for assessing the apical base relationship. Chong Yol Baik describes one such measurement, the Beta angle. Three distinct landmarks are used to measure the angle- point A, point B, and the apparent axis of the condyle. The landmarks are housed within the maxilla-mandibular complex.[6] Studies in the literature have examined the Beta angle in various anteroposterior and vertical malocclusion combinations, confirming its validity and reliability.[18-20]

Traditional cephalometric analysis involves tracing radiographic landmarks on acetate overlays and measuring both linear and angular dimensions. The method has the drawback of being prone to both systematic and random mistakes. Digital tracing has gradually taken the place of manual tracing techniques due to the quick advancement of computer radiography.[7] Dolphin imaging software is one such software. Several researchers have evaluated the reliability of Dolphin Imaging software and concluded that it can be dependably used for diagnosis, treatment planning, monitoring, and assessment of orthodontic therapy in both clinical and research environments.[7,21-23]

Numerous studies have been published in the literature that use standard metrics like Wits and the ANB angle to determine the skeletal effects of the FR-II appliance.[1-3] The present study evaluated the skeletal changes in sagittal dimension with the Beta angle in patients treated with Frankel-II appliance using Dolphin Imaging Software.

The sagittal skeletal change was recorded with Beta angle in the current study using the pre-treatment and post-functional lateral cephalograms of patients treated with Frankel-II appliance. On comparison of pre-treatment and post-functional Beta angle values, we found statistically significant differences in the parameter, suggestive of significant improvement in the anteroposterior relationship between the maxilla and mandible following Frankel -II appliance therapy. Similar kind of results were observed in the studies performed by Freeman et al,[1] Femiano et al,[2] Perillo et al,[3] Rodrigues et al,[4] Fernanda et al,[10] Guilherme et al,[15] wherein treatment effects of FR-II appliance were checked in the class II malocclusion patients. The researchers observed that FR-2 treatment led to improvements in the maxillomandibular relationship, evidenced by significant changes in the ANB angle and Wits appraisal. The use of Beta angle, a parameter independent of all other factors aided in evaluation of skeletal correction brought about by FR-II appliance.

5. Conclusion

In conclusion, Beta angle increased significantly following Frankel II appliance therapy suggesting considerable improvement in skeletal discrepancy. The Frankel II appliance can be utilized in young children with class II malocclusion to treat maxillomandibular sagittal problems. Beta angle can also be used with other parameters to analyse

sagittal skeletal malocclusions. Dolphin imaging software is a useful tool for digital measurement of various analyses.

Limitations

1. The current study utilizes a single parameter for evaluating sagittal skeletal discrepancy.
2. Inclusion of a control group would have enhanced the relevance of the study.

Future research perspectives

1. A prospective research design would be preferable since it would allow many aspects of approach to be controlled.
2. A long-term study can be used to examine the stability of the results of the Frankel II appliance.
3. Additional research can be done assessing true anteroposterior apical base discrepancy in different growth patterns using beta angle.

6. Source of Funding

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7. Conflict of Interest

There is no conflict of interest.

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