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EFFECT OF FUNCTIONAL BITE RAISERS USING THREE-DIMENSIONAL PRINTING TECHNOLOGY ON FACIAL PROFILE ENHANCEMENT OF SKELETAL CLASS II CASES

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ABSTRACT

Objective: The aim of this study was to evaluate the effectiveness of beveled functional bite raisers combined with fixed orthodontic appliance in the correction of skeletal class II malocclusion due to retrognathic mandible, regarding its soft tissue effects using 3D printing technology.

Materials and Methods: Sixteen patients, eight females and eight males, having horizontal or normal growth pattern and cervical vertebral maturation stages (CVMS) III and IV were recruited. Bite raisers were digitally designed on the 3-shape software after intraoral scanning of the advanced bite of the patients. The models were 3D printed and Erkodur sheet was pressed over the models. Composite resin was used to fill the Erkodur template and was cured inside the patient's mouth. Pre-treatment and post-treatment lateral cephalometric radiographs were analyzed and compared.

Results: Kolmogorov-Smirnov test of normality was used to test normality of all quantitative variables. Variables were found to be normally distributed. Paired sample t test was used for comparing pre-treatment and post-treatment measurements. A P-value < 0.05 was considered significant (S); while a P-value < 0.01 was considered highly significant (HS). The soft tissue facial angle showed an increase that was statistically significant.

Conclusion: The digitally driven bevelled bite raisers could improve the facial profile.

KEYWORDS: Skeletal class II, bite raisers, mandibular deficiency, functional.

INTRODUCTION:

Skeletal class II malocclusion is one of the most frequently encountered and widely spread malocclusions in orthodontics.[1] It represents 20% of Egyptian schoolchildren. One third of the population exhibits a deficient mandible.[2] Mandibular deficiency has been demonstrated by many studies to be the main cause of skeletal class II malocclusion.[3,4]

One of the modalities of skeletal class II treatment is modifying growth by various appliances such as functional appliances and headgear.[3,4] There are various fixed and removable functional appliances that have been used for a century.[5] They are intended to change mandibular anteroposterior and vertical position delivering forces to dental and skeletal structures causing favorable skeletal and dental changes.[6,7]

Removable functional appliance usage has diminished significantly over the world because they depend mainly on the patient's compliance. The fixed functional ones are still

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in use. Despite the fact that fixed functional appliances (FFA) are called non-compliance appliances, they still need a high degree of compliance for patient acceptance. Many patients either choose not to use them or be successful in becoming serial destroyers.[8]

Undoubtedly, a fixed functional appliance replacement that is more patient-friendly and simpler for the clinicians to apply is demanded to be a practical option for class II repair that can be applied unilaterally and bilaterally.

Bite planes have been in use in orthodontics long ago, they are mainly used for the correction of deep bites, they can be fixed or removable, mainly made of acrylic resin. Bite turbos are supposed to be placed anteriorly in hypodivergent patients and posteriorly on the supporting cusps of lower molars in hyperdivergent cases to avoid unwanted extrusion.[9]

Recently, there is a belief that we can bevel the bite turbos in specific directions that can change the way of mandibular closure, these beveled turbos can be called Functional turbos. They are mainly used for relieving anterior cross bites.[9] In class II patients, functional bite turbos can also promote disarticulation acting like bonded Twin-Block appliance, they are placed on premolars causing mandibular repositioning due to premolar sliding along the beveled surfaces.[9]

Different authors have used resin bites bonded on occlusal surfaces of posterior teeth to disarticulate the mandible and sliding it in a more advanced position and gave them different names.[8–11] Yet all were case reports, that could not provide a statistical data to assess the true effects of the appliance and none of them used a digital workflow.

3D printing technology comprises the addition of different materials layer by layer to form a pre-designed object. It is first introduced by Chuck Hull in 1984.

Nowadays, the whole dental field and not just the dental but also the medical is moving toward digitization of every single step to increase accuracy, eliminate technical sensitivity and improve the quality of different treatment approaches.

In this study, a new simple and accurate method to treat skeletal class II mandibular deficiency cases was introduced and investigated. In this study we aimed to get over some of the drawbacks of the earlier techniques using a digital workflow.

MATERIALS AND METHODS:

A power analysis was performed using G-Power Software (version 3.1; Germany, to calculate sample size according to the study of Baysal, “Soft tissue effects of Twin Block and Herbst appliances in patients with Class II division 1 mandibular retrognathy”),[12] it was found to be 11 participants to achieve 80% power. Sixteen participants were included to account for dropouts. The participants were eight females and eight males from the outpatient clinic of the Orthodontic Department, Faculty of Dentistry, Ain Shams University. The patients had mandibular deficiency, normal or horizontal growth patterns with Frankfort mandibular plane angle (FMA ≤30) and CVMS III and IV. The pre-treatment chronological age ranged from 10 to

14 years. The overjet ranged from four to 10 mms. The ethics committee at the Faculty of Dentistry, Ain Shams University approved the study design.

Comprehensive diagnosis was performed and essential orthodontic records were taken before the treatment. Intraoral scanning using 3 shape Trios** intraoral scanner was performed for each patient following the manufacturer's instructions. Two bite scans were recorded, one in the centric occlusion and the second in the advanced mandibular position. The George guage bite fork was used to record the advanced bite. It was adjusted to zero mm in the upper component indicating edge to edge anterior teeth position, using the two mm fork and then inserted in the patient's mouth to keep the same advanced bite stable while recording it via intraoral scanning.

The STL (Standard Tessellation Language) files of the intraoral scan with the advanced bite were then transferred to the 3-shape orthosystem. The upper and lower arches in the advanced relation were shown in the appliance designer module of the 3-hape orthosystem. The upper bite raisers were designed to have a bevel mesially to enable the distal bevel of the lower bite raiser of the same side to slide along it, and a plateau area distally to prevent the patient from biting posteriorly and lock the mandible in its advanced position. This was derived from the bite raiser described by Elbokle D and Abbas N in 2020.[10] The upper raisers extended as much palatally on the occlusal surface to allow for interlocking with the lower ones, while the lower raisers extended as much buccal for the same reason.

After creating the upper and lower raisers of each side, they were subtracted from each other to be able to slide freely along each other without any interferences. The upper raisers were combined with the upper model to have a single STL file for the model and the raisers. The same was done for the lower arch.

The two STL files were transferred to the slicer software to be prepared for 3D printing. A slicer is a software used to translate an STL file into the precise instructions needed by the 3D printer to produce the desired object. These instructions include the location of the 3D object on the construction platform, the printing orientation, and the creation of support structures.[13,14] When the aforementioned conditions were performed, the software automatically slices the STL file. The STL files after slicing were then transferred to be printed.

Anycubic Photon Mono 3D printer*** was used for printing. It uses LCD-based SLA technology. STL files were stored on USB device and connected to the printer. Savoy dental model resin**** was poured in the basin of the printer, then printing started and proceeded till finishing. Post-processing of the printed models was performed including removal of models, cleaning, post-polymerization, and removal of supporting structures. The models were removed, cleaned from uncured resin by isopropyl alcohol for 10 minutes and then cured for another 10 minutes in the wash and cure machine.

** Trios S1A Dental Intraoral Scanner, 3shape, Copenhagen, Denmark.

*** Anycubic Photon Mono, Shenzen, China.

**** Savoy Digital systems, china.

Erkodent (erkodur)[γ] 0.6 mm sheets were pressed over the upper and lower casts using ministar pressing machine.[Ω] The excess was trimmed and any sharp edges were smoothened.

The whole occlusal surface and part of the labial and lingual surfaces were etched and bonded to increase the surface area of adhesion. Grengloo composite resin was used to fill the negative replicas of the raiser of the template. It changes its color to green when it gets wet or when temperature increases, this facilitated bite raiser removal. The template was accurately fitted on the upper and lower arches and the composite was light cured.

The patient was advised to usually bite in the advanced position and if he couldn't adapt to this at the start of treatment or during sleeping, he was instructed to use light and short class II elastics to aid him in this advancement. The elastics here only acted as a reminder for the patient to remind him of the new bite and it also helped to interdigitate teeth in this new bite which keeps the class I relation.

MBT prescription brackets[α] with 0.022 x 0.025" slot were bonded on the maxillary and mandibular teeth and bondable tubes were bonded on the first permanent molars. Full ligation of both arches took place. Follow up visits were scheduled every month to align, level and perform normal comprehensive orthodontic treatment and also to detect the changes made because of the appliance. Alignment and leveling were carried out using the conventional wire sequence until "0.019 x 0.025" stainless steel archwires were inserted in both the maxillary and mandibular arches. The "0.019 x 0.025" stainless steel archwires were cinched back distal to the tubes of the first molars.

Class II correction was monitored via comparing both centric relation and centric occlusion bites, if they coincided maintaining the class I molar and canine relationships, this meant that correction occurred, if a discrepancy still existed this meant more time is needed to correct class II malocclusion.

This study ended after class II correction when centric relation coincided with centric occlusion keeping the class I molar and canine relation or after eight months of bonding both the blocks and the brackets. Figure one shows pre-treatment and post-treatment profile pictures of one of the patients.

[γ] Erkodent Erich Kopp GmbH, Germany.
[Ω] Ministar SR, SCHEU-DENTAL, Germany.
[α] American Orthodontics, Mini Master, Sheboygan, Wisconsin, USA.

Bite raisers were removed using high speed handpiece with caution to preserve the enamel. Class II correction was maintained using settling elastics with class II component.

Figure 1: Profile picture, a. Pre-treatment. b. Post treatment.

Digital lateral cephalometric radiographs were taken at the beginning of treatment (T0) and at the end of the study (T1), digitized and analyzed using a special orthodontic tracing software program. The machine parameters were set to 85 kV and 10 mA while exposure time was 12.94 sec. Cephalometric imaging sensor was Scan type and the magnification was 1:14. Each cephalometric radiogragh was opened from CD using EzDent-I viewer and imported to the computer in the form of JPEG image. Dolphin Ver.6.4□ software was used in this study. This program allowed analysis of cephalometric data as well as superimposition of pre-treatment and post-treatment cephalometric radiographs. A custom cephalometric analysis was created to assess the effects of treatment in every patient. Then landmark digitization took place and measurements recorded.

The custom analysis included the soft tissue facial angle as shown in table one.

Table 1: Custom analysis showing soft tissue facial angle.

Measurement	Abbreviation	Definition
ST Facial Angle	FHN'Pg’	Angle formed between Frankfort horizontal plane that joins Porion point with Orbitale point and line joining soft tissue Nasion and soft tissue Pogonion.

In the digitization tool, lateral cephalometric images were loaded, the custom analysis was selected, then the landmarks required for the custom analysis were digitized.

Table 2: Landmarks used for the digitization of lateral cephalograms.

Landmark	Abbreviation	Definition
Porion	Po	Most superior point of the external auditory meatus.
Orbitale	Or	Most inferior point of the external border of the orbital cavity.
Soft tissue Nasion	N'	The deepest midpoint on the soft tissue contour of the base of the nasal root at the level of the frontonasal suture.
Soft tissue Pogonion	Pg'	The most anterior point on the soft tissue contour of the chin in the midsagittal plane.

The lateral cephalometric measurements for each patient at T0 and T1 were generated by the software and exported to a Microsoft excel sheet. Figure two shows tracing superimposition of the pre and post treatment lateral cephalograms.

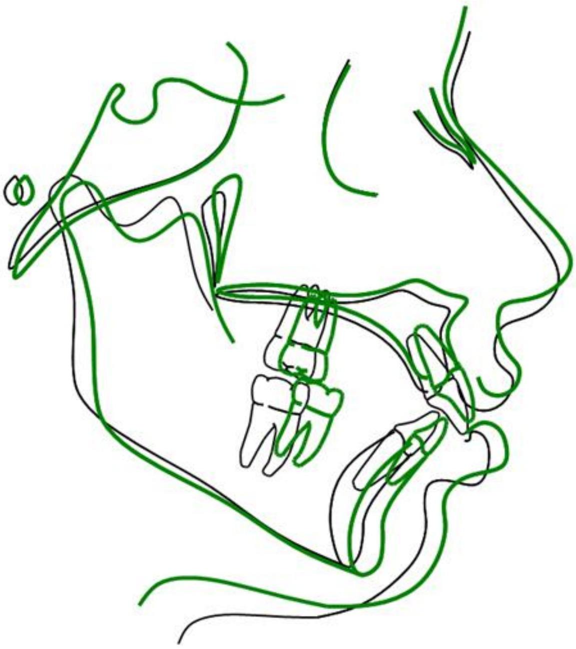

Figure 2: Superimposition of the pre-treatment (black) and post-treatment (green) lateral cephalograms.

Statistical Analysis

All Data were collected, tabulated, and subjected to statistical analysis. Statistical analysis was performed by IBM* SPSS$^{\alpha}$ (version 17), while Microsoft office Excel was used for data handling and graphical presentation. Quantitative variables were described by mean, standard deviation (SD), the range (minimum – maximum), standard error (SE) and 95% confidence interval of the mean. Kolmogorov-Smirnov test of normality was used to test normality hypothesis of all quantitative variables for further choice of appropriate parametric and non-parametric tests. Most of the variables

* IBM Corporation, NY, USA.
$^{\alpha}$ SPSS, Inc., an IBM Company.

were found normally distributed allowing the use of parametric tests. Paired sample t test was used for comparing pre-treatment and post-treatment measurements. Significance level was considered at P < 0.05 (S); while for P < 0.01 was considered highly significant (HS).

RESULTS:

Comparison between the mean pre-treatment and post-treatment changes:

An increase was found in the ST facial angle (2.32 ± 0.70) that showed to be highly significant as shown in table three and figure three.

Table 3: Mean, SD, paired difference, CI of the difference and P-value of the soft tissue measurements, P-value < 0.05 was considered significant, and a P value < 0.01 was considered highly significant.

Soft tissue measurements	Pre	Post	Mean difference	95%CI of difference		Test value	P-value
	No. = 12	No. = 12	Mean ±SE	Lower	Upper		
	Mean±SD	Mean±SD					
ST Facial Angle FHN'Pg'	88.03 ± 3.80	92.38 ± 2.49	2.32 ± 0.70	0.780	3.853	3.318	0.007

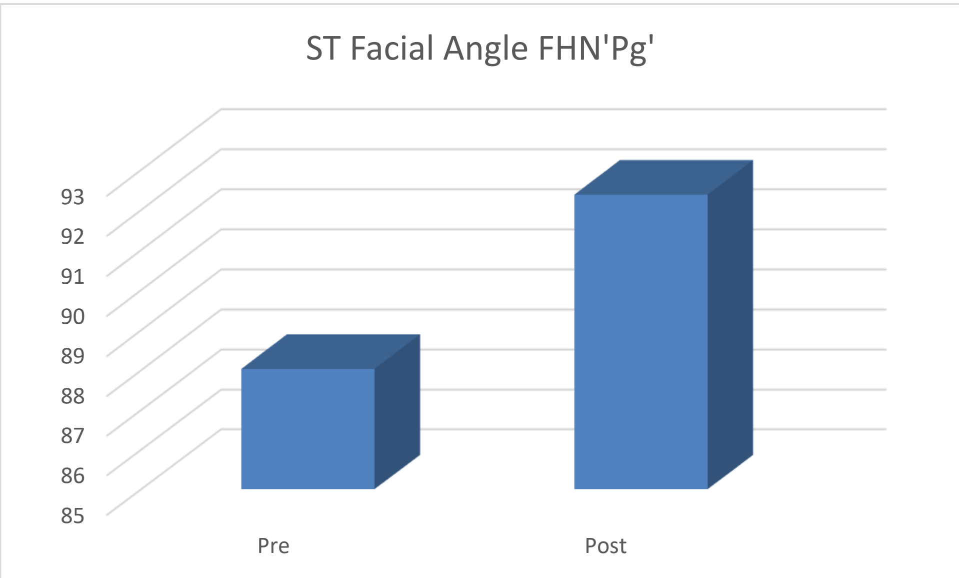

Figure 3: Bar chart showing pre-appliance and post-appliance soft tissue changes.

DISCUSSION:

In this study, a new simple and accurate method to treat skeletal class II mandibular deficiency cases was introduced and investigated. Many techniques and appliances have been developed to treat such malocclusion but each of them has its merits and drawbacks. In this study we aimed to get over some of the drawbacks of the earlier techniques using a digital workflow.

Different authors have used resin bites bonded on occlusal surfaces of posterior teeth to disarticulate the mandible and sliding it in a more advanced position and gave them different names.[8–11] Yet all were case reports, that could not provide a statistical data to assess the true effects of the appliance and none of them used a digital workflow. Only three recent papers showing case reports have used digital workflow, one for bonded milled bite raisers,[15] the second for a direct 3D printed removable twin block appliance[16] and the third is for a 3D printed fixed twin-block combined with customized brackets.[17]

This study is the first one to use a digital workflow to create fixed bite raisers and investigate their effect on class II mandibular deficiency correction combined with orthodontic brackets. It provides a simple, non-expensive, no compliance appliance compatible with fixed orthodontic appliance that can be used as one phase treatment approach in permanent dentition or late mixed dentition patients.

Paired samples t-test was used for comparing (post-pre) treatment changes. A P-value < 0.05 was considered significant, and a P value < 0.01 was considered highly significant. In this study, comparing the pre-treatment and post-treatment measurements, patients showed an increase in ST facial angle (2.32 ± 0.70) that was found to be highly significant.

Similar to our study, the study of Dong T et al.[17] demonstrating 2 case reports treated with 3D printed twin-block, showed profile improvement in the young patient like our study but the profile worsened in the adult one. ST facial angle increased from 89.5 to 90 in the young case report but decreased in the adult case report.

CONCLUSION:

Functional bite raisers combined with fixed orthodontic appliance could achieve profile enhancement in skeletal class II cases with mandibular retrognathy.

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