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EVALUATION OF MAXILLARY MOLAR DISTALIZATION BY A MODIFIED PALATALLY ANCHORED EXPANDER

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ABSTRACT

Objectives: The present study was conducted to evaluate the dentoskeletal changes after distalization of maxillary molars using skeletally-anchored modified Hyrax appliance in the treatment of dental Class II orthodontic patients. **Subjects and methods:** Ten participants having Class II molar relation with deep overbite with age ranged from 11 to 14 years old were enrolled in the current study. All patients involved in the present study were selected from those seeking orthodontic treatment at different clinical orthodontic centers. Maxillary molar distalization was performed using modified skeletally anchored Hyrax palatal expander. The appliance was activated twice weekly. For each participant, skeletal and dental measurements were recorded from standardized cephalometric analyses before and after molar distalization. Statistical analyses including t-test were performed at a significance level of $p<0.05$. **Results:** The maxillary first molars were distalized successfully (6.16 mm) without tipping and Class I molar relation was obtained within a period of 6.2 months. Slight extrusion of the maxillary molars was observed which was reflected on the non-significant increase in lower anterior facial height, as the mandibular plane angle was increased by 0.58^0. A marked improvement of the deep bite was observed. **Conclusion:** The modified Hyrax can be used as palatally skeletally anchored distalizer to effectively move the maxillary first molars distally. They are effective, minimally invasive and compliance free alternative for molar distalization and hence, molar Class II correction without anchorage loss.

KEY WORDS: Class II, maxillary molar distalization, Hyrax and skeletal anchorage.

INTRODUCTION

Class II malocclusion has been considered one of the most common malocclusions in which successful results can be achieved if there is accurate diagnosis and proper orthodontic treatment[1]. Various strategies have been used to correct such condition, whereas current orthodontic treatment concepts have been directed towards conservative approaches, therefore, these approaches that avoid decreasing occlusal table is a main challenge in orthodontic research [2, 3].

Molar distalization is one of the techniques depending on the conservative concept; it is a non-extraction treatment modality for the correction of a Class II molar relationship and/or space gaining especially with orthognathic mandible and maxilla[4,5]. A common definition of molar distalization was reported by Sfondrini who defined it as “a procedure in orthodontics which is used to move molar teeth, especially permanent first molars, distally (backwards) in an arch” [6].

Distalization in the maxillary arch is easier than the mandibular arch due to the trabecular

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bone pattern in the maxilla rather than the cortical one in the mandible[3]. Distalization should be the treatment of choice for patients with long distal bases, Class II buccal segment relationship, mild to moderate crowding, well aligned lower arch, mesially inclined upper first molars, Class I canine relation with highly placed or impacted canine, preferable soft tissue profile, borderline cases, missed 3rd molars/2nd molars not yet erupted or lastly anchorage loss during active orthodontic treatment, while mainly contraindicated in vertical growth pattern, skeletal or dental open bite cases [5].

In other words, factors to be considered before application of distalization mechanics are: growth pattern weather vertical or horizontal, degree of overbite, 2nd molar weather erupted or not, dental age of the patient weather in mixed dentition or in adult dentition stage and presence of other force systems [7, 8, 5]. the previous studies revealed a great variation among the supporters of the different distalization techniques, some techniques require a patient's active compliance, whereas others do not require that [9, 11].

Some of conventional techniques for molar distalization are Cetlin removable plate, Wilson arches, extra-oral traction and First Class Appliance [10-15]. However, all these distalizing appliances have a number of drawbacks associated with the use of these appliances; risk of patient injury, the possibility of skin irritation and unphysiologic strain on the cervical spine and on the neck muscles that accompanied with the use of elastic cervical trap, in addition to considerable partial or total patient cooperation is generally required which in itself is frequently problematic [16-21]. Thus, a need has always been felt for other distalization force systems mainly the intraoral noncompliance distalizers; super-elastic nickel-titanium arch wires, K-loop, coil springs, looped NiTi wires, repelling magnets, Keles slider, pendulum appliance, distal jet, Jones Jig assembly and Frog appliance [22-31].

However, these appliances depend routinely on other teeth (the anterior teeth) or palatal acrylic pad as the anchorage units resulting in protrusion of incisors and anchorage loss [32-34]. Therefore, Many skeletal anchorages have been combined with conventional maxillary molar distalizing appliances (bone-borne appliances) for improvement and acceleration of orthodontic treatment [35]. Among these, the Keles Slider appliance with a palatal implant, bone-anchored pendulum appliance, a mini-screw implant-supported distalization system (MISDS) and timely relocation of mini-implants for uninterrupted full-arch distalization (jig) [37-40].

Despite some studies [31, 35, 55] were conducted on the effects of the miniscrew-supported, modified Hyrax appliance on bilateral distalization of posterior teeth, these studies were case report studies with limited results. So, it was interesting to evaluate the effectiveness of one of the bone anchored distalizers, which is the modified palatally anchored expander to be used in maxillary molar distalization with a larger sample size to confirm the previous case report study suggestions.

SUBJECTS AND METHODS

The current study involved 10 orthodontic patients (out-patients) admitted for treatment at different orthodontic clinical centers.. The purpose of the study and the treatment procedures were explained to all patients, in addition, written informed consents were obtained from them considering the guidelines on human research adopted by the Research Ethics Committee, faculty of Dental Medicine, Al-Azhar University.

Ethical consideration:

The current study was approved by Ethical committee of Faculty of Dental Medicine, Cairo, boys, Al – Azhar University. The Ethical code for the present study is 777/307.

Selection Criteria

1) The patient's age ranged from 11 to 14 years at the start of the treatment, 2) non extraction treatment plan with molar distalization, 3) no medical problems or active periodontal disease, 4) good oral hygiene, 5) good patient compliance, 6) horizontal or normal growth pattern with symmetrical balanced facial appearance, 7) Class II molar relationship with deep overbite, 8) minimal crowding in the mandibular arch and 9) no previous orthodontic treatment.

On the other hand the discontinuation criteria were poor oral hygiene, bad patient compliances, and carless patients with repeated fractured appliance or brackets, continued inclusion of patients in the present study was planned. All the patients are clinically examined and the following records were taken before and after distalization: extra- oral and intraoral photographs, panoramic radiographs, lateral cephalometric radiographs and study models.

Treatment procedures

Treatment procedures began after extraction of maxillary third molars. Upper first permanent molars were separated by elastic separators for about 2-3 days then the elastic separators were removed after separation of the teeth. The ready-made bands were selected according to the size of the maxillary first permanent molars. An alginate impression was then taken with the upper molar bands in place, the bands were positioned in the impression, and a stone model was made.

Fabrication of the modified palatally anchored expander appliance: (Fig.1, 2)

A custom made distalizer was fabricated using four point support modified palatal expander (Dentaurum Ispringen, Germany). However, the expansion vector was set anteroposteriorly for bilateral distalization of maxillary molars. Posterior legs of Hyrax were bent in a way to be welded on the lingual surfaces of the maxillary first permanent molar bands as gingival as possible. While, the anterior legs were bent into eyelet form to be attached to the anterior palate with two surgical screws.

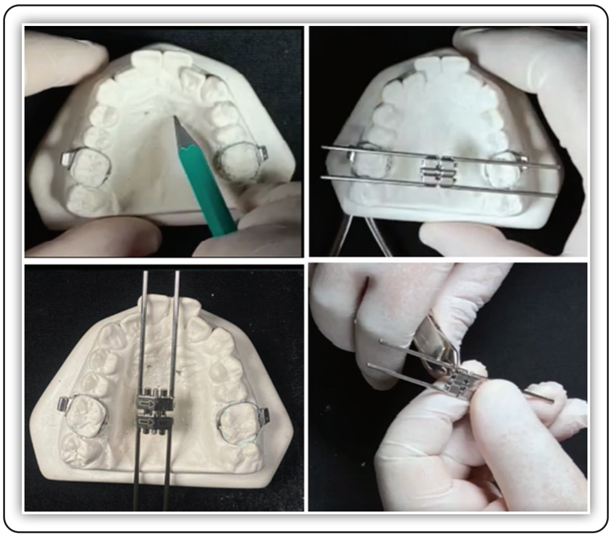

FIG (1) Fabrication of the modified palatally anchored expander appliance.

FIG (2) Bending and adaptation of the modified palatally anchored expander.

Intraoral insertion of modified palatally anchored expander appliance and implantation procedure (Fig.3, 4)

The distalizer appliance was checked for adaptation intraorally, the two bands of the maxillary first molars were fitted in their accurate position on the teeth. The maxillary first molars were dried and isolated before cementation. Then, the maxillary first molar bands were cemented with glass ionomer cement (Medicem; Promedica, Neumunster/Germany). Two surgical screws (2.0 × 9 mm: ANTON HIPP Gmbh, Fridingen/ Germany) were used as rigid bone anchors.

The screw insertion was carried out with the patient under local anesthesia. They were placed inside the two eyelets of the anterior legs of the modified Hyrax attaching the appliance with the anterior palate and covered by glass ionomer cement. These two screws were actually placed in the anterior paramedian region of the median palatal suture, 7–8mm posterior to the incisive foramen and 3–4mm on both sides of the median line. This distalizer, with its two palatal screws and two molar bands, guaranteed stable and 4-point support for the appliance when placed parallel to occlusal plane.

FIG (3) Intraoral insertion of modified palatally anchored expander appliance

FIG (4) Intra oral implantation of modified palatally anchored expander appliance.

After screw insertion, the patients received hygiene instructions; regular tooth brushing, daily use of a mouthwash and cleaning the screws with a soft brush. Non-steroidal anti-inflammatory analgesic was prescribed for only one day. Clinical assessment of the stability of the appliance, palatal screws, soft tissue health around the screws, oral hygiene evaluation and patient comfort were recorded at every monthly clinical appointment. Activations of Hyrax were performed at the rate of 0.5 mm per week (twice activations/week). Lateral cephalometric radiographs were used to assess the extent of ditalization.

Lateral cephalometric x-ray analysis

Standardized lateral cephalometric radiographs were taken before (T1) and after distalization (T2). Each cephalogram was traced and analyzed by the same operator. The variables were re-measured after a period of 2 weeks, and the readings of the first estimation were compared to the second one. Casual errors were calculated according to Dahlberg's formula [41]. $Se^2=\Sigma d2/2n$ where (Se^2) is the error variance, (d) was the mean difference between repeated measurements, and (n) was the number of measurements.

Skeletal and dental measurements: (42-48) (Tab. 1, Fig 5. 6)

Skeletal and dental measurements were made on each cephalometric radiograph for each subject in order to identify the amount of distalization; (1) SNA, (2) SNB, (3) ANB, (4) FH/MP, (5) Wits appraisal, (6) Overjet, (7) Overbite, (8) U1-VRL, (9) L1-VRL and (10) U6-VRL, (11) U6/PL.

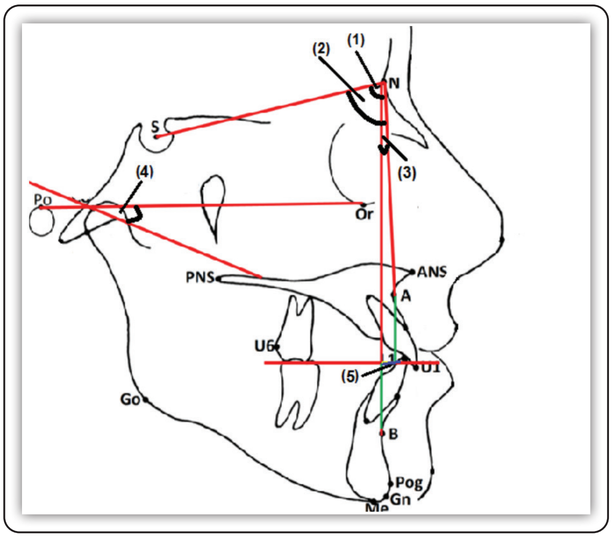

FIG (5) Skeletal measurements: (1) SNA, (2) SNB, (3) ANB,(4) FH/MP and (5) Wits appraisal.

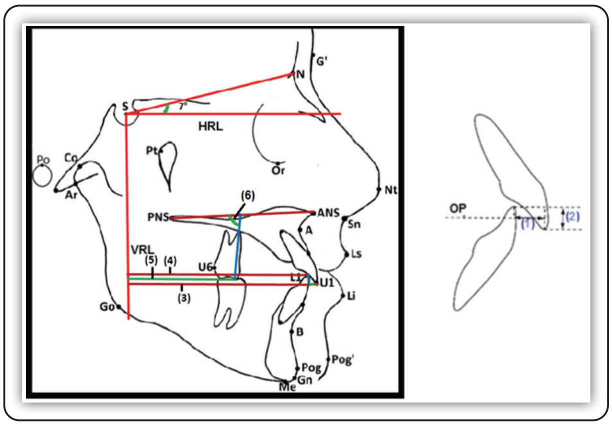

FIG (6) Dental measurements: (1) Overjet, (2) Overbite, (3) U1-VRL, (4) L1-VRL and (5) U6-VRL, (6) U6/PL.

TABLE (1): Definitions of cephalometric measurements

Skeletal measurements	
1) SNA (°):	The angle formed by the intersection of SN and NA.
2) SNB (°):	The angle formed by the intersection of SN and NB.
3) ANB (°):	The angle formed by the intersection of NA and NB.
4) FH/MP (°):	The angle formed by the intersection of mandibular plane and Frankfort horizontal plane.
5) Wits appraisal (mm):	It is the horizontal distance along the occlusal plane between two perpendiculars drawn from points A and B on the maxilla and mandible , respectively, onto the occlusal plane.
Dental measurements	
1) Overjet (mm)t:	Horizontal distance between the maxillary and mandibular incisal edges.
2) Overbite (mm):	Vertical distance between the maxillary and mandibular incisal edges.
3) U1-VRL (mm):	Distance of a perpendicular line (parallel to HRL) from the incisal tip of most prominent maxillary central incisor (U1) to VRL.
4) L1-VRL (mm):	Distance of a perpendicular line (parallel to HRL) from the incisal tip of most prominent mandibular central incisor (L1) to VRL.
5) U6-VRL (mm):	Distance of a perpendicular line (parallel to HRL) from the mesiobuccal cusp tip of the maxillary first molar (U6) to VRL.
6) U6/PL (°) :	The angle formed by the intersection of long axis of maxillary first molar and palatal plane.

Statistical analysis

Descriptive statistics were presented as mean ± SD and range by SPSS 23, IBM, Armonk, NY, United States of America. Independent samples t-test of significance was used when comparing between two means. A $p \leq 0.05$ is considered statistically significant where $p \leq 0.001$ is considered statistically highly significant.

RESULTS

The lateral cephalometric x-ray analysis of the skeletal measurements revealed that there were no significant differences in any measured cephalometric skeletal variables between pretreatment and post-distalization stage. Regarding the cephalometric analysis of the dental linear and angular measurements, there was a significant reduction in overjet and overbite by 1.67 mm and 1.32 mm respectively (p≤ 0.001). Furthermore, there was a significant distalization movement of the maxillary first molar (U6-VRL) by 4.6 mm (P< 0.05). However, no significant differences of U1-VRL, L1-VRL and U6/PP (upper first molar distal tipping) were observed after distalization period **(Tab.2, Fig 7)**.

TABLE (2): Changes in the cephalometric measurements after distalization.

Skeletal measurements		Range			Mean	±	S. D	t. test	p. value
SNA (°)	T1	78.1	–	85.1	82.34	±	2.17	0.189	0.853
	T2	78.5	–	85.3	82.56	±	2.07		
SNB (°)	T1	70.1	–	80.1	76.87	±	3.30	0.173	0.865
	T2	70.8	–	80.5	77.17	±	3.17		
ANB (°)	T1	4.4	–	8	5.47	±	1.27	0.123	0.904
	T2	4.2	–	7.7	5.39	±	1.33		
FH/MP (°)	T1	22	–	26.1	24.33	±	1.33	0.847	0.413
	T2	22.9	–	26.5	24.91	±	1.26		
Wits appraisal (mm)	T1	2.5	–	6.1	4.19	±	1.53	1.065	0.308
	T2	1.5	–	4.6	3.43	±	1.10		
Dental measurements									
Overjet (mm)	T1	3.5	–	5.1	4.23	±	0.62	3.193	0.002*
	T2	2	–	3.5	2.56	±	0.59		
Overbite (mm)	T1	4	–	5.2	4.76	±	0.46	3.208	0.002*
	T2	2.8	–	4	3.44	±	0.49		
U1-VRL (mm)	T1	50	–	63	54.61	±	5.29	1.832	0.092
	T2	45	–	58	49.36	±	5.44		
L1-VRL (mm)	T1	55	–	59	56.30	±	1.46	1.716	0.112
	T2	55.2	–	61	57.81	±	1.82		
U6-VRL (mm)	T1	29.3	–	42.3	34.86	±	5.43	2.310	0.039*
	T2	24.7	–	37.3	28.70	±	4.50		
U6/PP (°)	T1	87	–	88.5	87.83	±	0.52	0.511	0.618
	T2	86.5	–	89	88.03	±	0.90		

*P> 0.05 (Non significant)*p ≤ 0.05 (significant)*

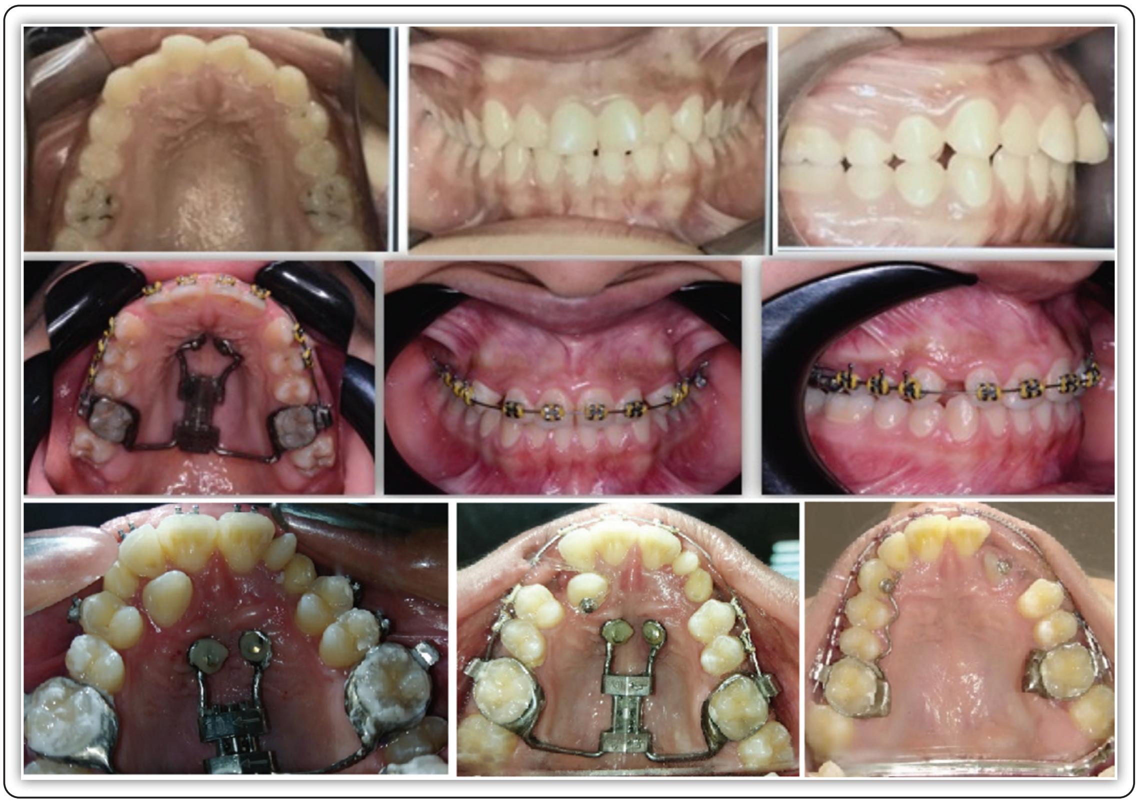

FIG (7) Before and After distalization intra – oral photographs

DISCUSSION

The treatment of Class II malocclusions has always been a subject of great interest for orthodontists. Meanwhile, it is a topic of controversy, may be due to the wide variation of treatment strategies by which this malocclusion can be managed. Based on conservative concepts, maxillary molar distalization as a non-extraction strategy is a cornerstone for these goals in the treatment of Class II molar relationship and in the resolution of tooth size / arch length discrepancy in the maxillary arch.

Conventional intraoral distalizers frequently cause anchorage loss, which does not always give favorable treatment outcomes [42-46]. Since these conventional appliances are connected to first or second premolars during distalization, the presence of counteracting moments is frequently inevitable leading to forward movement of premolars and anterior teeth and finally increased overjet [47-50]. To reduce and may even reverse these variables, some attempts have been carried out (subsequent multibracket appliance and intermaxillary class II elastics), however, anterior protrusion during distalization still can hardly be avoided [51, 52].

Extraoral appliances can overcome the problem of anterior proclination, whereas the success is correlated highly with patient's compliance. Moreover, these appliances may cause molar extrusion with distal rotation and non- physiological strain concerning neck muscles and the cervical spine especially in case of cervical headgear [39, 4]. Thus, there is a strong trend towards bone-anchored devices (titanium mini-implants and mini-plates). The advantages of mini-implants are as follows: no need for osseointegration, great variety of locations, no need for particular surgical procedure during insertion and removal, relative cost if compared with other conventional methods and most importantly, no need for patient cooperation and no anchorage loss [53, 54, 17, 49].

Hyrax appliance is actually used for transverse maxillary expansion. If the expansion vector was set anteroposteriorly instead of transversely, a new indication of that appliance could be created as a distalizer for maxillary molars, hence the name modified Hyrax appliance. Therefore, the purpose of this study was to evaluate the skeletodental changes after distalization of maxillary first molars using bone anchored modified Hyrax appliance in non-extraction Class II cases.

According to Chandra and Prasad and Sreevalli, maxillary molar distalization is linked spontaneously to backward rotation of the mandible and decrease in the overbite. So, the patients selected for the present study showed a deep overbite which by distalization, could be corrected [5, 55]. In the current study, the implantation site was the midpalate (anterior para-median region). This site proved to be clinically accessible for implantation because of its thin overlying keratinized soft tissue which is more advantageous for screw implantation than the thick soft tissue that can be present in the palatal slope [56].

Additionally, it provided flapless implantation that allowed for simple attachment between the exposed head and the orthodontic appliance. The placement site of surgical implants in the anterior mid-palate is a bone stock for safe implantation in the maxillary arch. High bone density and thickness in this region ensures primary stability and this would be subsequently reflected on a higher success rate [57]. Moreover, lack of root interference risk eliminates the need for implant transposition during distalization [17]. However, Kaya et al. used the zygoma as anchorage site for maxillary molar distalization with drawbacks of invasive surgical procedures and expected post-surgical facial inflammation and infection [58, 59].

The results of the present study revealed that there was no effect on the sagittal position of the maxilla and the mandible (SNA, SNB). These skeletal findings confirming the previous findings of some studieswhich stated that bone anchored distalizers had no significant effect on sagittal skeletal measurements [60, 61].

The assessment of the clockwise mandibular rotation was made by mandibular plane angle. Although the treatment results exhibited a posterior mandibular rotation, but this change didn't reach the statistically significant level. This degree of clockwise rotation of the mandible can be attributed to the movement of the maxillary molars distally into the wedge of occlusion and to the cusp interferences. That was in agreement with Noorollahian et al [17]. On the other hand, Hilgers et al**,** Bussick et al. and Fuziy et al. reported a statistically significant clockwise mandibular rotation. This contrast may be related to their conventional distalization mechanics [24, 62, 63].

The upper incisors showed a statistically non-significant backward movement because of distalization of the whole maxillary posterior segments which led to the distalization of the anteriors as well due to driftodontics. As regard to the overjet and overbite, they decreased significantly; 1.67 mm and 1.32 mm respectively. This occurred due to the slight distal movement of the upper incisors and mesial movement of lower incisors. The amount of overjet in this study was more than the value obtained by Amasyalı et al; in the case report, the overjet decreased by 0.4 mm while the overbite increased by 0.6 mm [49].

In the present study, the maxillary first molars were successfully distalized as the amount of distalization (U6-VRL) was statistically significant by a mean of 6.16 mm. Compared to other trials that also used the modified Hyrax appliance for bilateral distalization of maxillary first molars, the amount of distalization achieved was 3.5 mm and 2.7 mm respectively [17,49]. This difference might be related to the variance of the Hyrax opening rate or different distalization forces. Amasyalı et al. achieved the class I molar relation in a period of 4 months while in the current study, the treatment duration for correction of class II molar relation was

6.2 months[49]. This could be explained by difference in age or distalizing force.

Meanwhile, the mean distalization time in this study was longer than those reported in other studies [63,15] due to the achieved en-masse bodily distalization without tipping of posterior teeth as evidenced by the non-significant change in U6/PP angle; the vector of distalizing force pass through the center of resistance of the target segments.

CONCLUSIONS

The new strategy bone anchored modified Hyrax appliance applied in the present study could be used effectively for correction of class II molar relation through en-masse, bodily and bilateral distalization of maxillary posterior teeth without anchorage loss.

RECOMMENDATIONS

- Further studies both after completion of the treatment and in the retention phase are needed.
- Since the sample size of the present study was limited and the results might not be the same with a larger sample size, further investigations and comparative studies are necessary with a larger sample to confirm the study suggestion.

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