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Distalization of the Mandibular Dentition for Skeletal Class III Malocclusion through a Ramal Plate among Yemeni Adult

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ABSTRACT

Objective: The purpose of this study was to introduce the placement of a ramal plate in the retromolar fossa as a novel temporary skeletal anchorage device (TSAD) for correction of skeletal Class III malocclusion by distalization of mandibular dentition among Yemeni patients of Sana`a university.

Methods: A clinical cohort study was carried out by pre- and post-treatment lateral Cephalometric and dental and dental cast of 6 patients (3 males and 3 females; mean age 20±2 years) who received ramal plate for mandibular molar distalization were analyzed. The treatment effects and amount of distalization of mandibular molars were calculated and tested for statistically significant. The significance level was set at $p \leq 0.05$).

Results: The mandibular first molar at the crown were 4.5±2.5 mm. respectively. In the evaluation of skeletal variables, there were a significant increase in the ANB, A-point/ N perpendicular (mm), Wit's appraisal, and FMA. In the evaluation of dental variable, there were a significant increase in U1/FH°, IMPA and Interincisor Angle. In the evaluation of soft tissue there were a significant in Nasolabial Angle, Ls-E Line mm, and Li-E line mm.

Conclusion: The mandibular molar showed a significant amount of distalization. A ramal plate may be a viable device for mandibular total arch distalization in Class III patients who are reluctant to undergo orthognathic surgery.

Keywords: Distalization, Mandibular dentition, Ramal plate, Skeletal class III malocclusion, Yemen

Abbreviations: CBCT: Cone Beam CT Scan Tomography; ICC: Intraclass Correlation Coefficient; M: Mean; Max: Maximum; Min: Minimum; SD: Standard Deviation; TSAD: Temporary Skeletal Anchorage Device; X^2: Chi Square

INTRODUCTION

It has always been challenging to achieve a pleasing profile in Class III patients who are treated non-surgically [1-3]. A severe anteroposterior skeletal discrepancy in a patient with a Class III malocclusion is generally treated with orthognathic surgery. However, a mild to moderate skeletal Class III malocclusion can be treated by either surgery or camouflage [1,2] but unfortunately, most require patient compliance. In the past, patients who were worried about undergoing surgical procedures to fix their Class III dental relationships opted for camouflaging orthodontic treatment with various extraction patterns based on the degree of negative overjet and the proclamation of the mandibular incisors [3-5]. In contrast to miniscrews, miniplates can withstand the greater forces needed to distalize the entire dentition [6]. Miniplates were applied to the mandibular

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body by Sugawara [7] in their report on the use of miniplates for mandibular distalization. The force vector from the retromolar area may be more favorable for some patients because it is more parallel to the functional occlusal plane in our case, so our ramal plates are installed medial to the anterior border of the ramus.

Tipping, anchorage loss, and flaring of the anterior teeth are common effects of non-compliant appliances, such as a distal extension lingual arch, Jones jig, or Franzulum appliance [8-10]. The use of transient skeletal anchorage devices has resolved these molar distalization problems (TSADs) [10,11]. Mini screws may need to be relocated during distalization if they are positioned between the interradicular spaces as this can interfere with the distalization procedure. This disadvantage was addressed by Poletti [12] placed a miniscrew in the retromolar region to distalize the lower dentition. However, it's possible that only one miniscrew on each side will not be strong enough to withstand the forces required for full arch distalization. Consequently, in two studies by Sugawara [13,14] a skeletal anchorage system was implanted at the mandibular body and the treatment's outcomes were evaluated.

The distalization of the mandibular dentition has recently been reported as being facilitated by the use of a plate positioned at the ramus' retromolar fossa by Kook [15] Compared to buccal miniscrews, which are exposed through the movable vestibular mucosa and buccal cheek, this device, which is exposed through the retromolar region, may have a force vector that is more parallel to the occlusal plane and should be less abrasive. In Yemen, many studies indicated high rates of malocclusions with class I, where malocclusion class I being the most common followed by class II malocclusion, and class III malocclusion was also reported at significant rates [16-19]. The introduction of Ramal plate placement in the retromolar fossa as a new temporary skeletal anchorage device (TSAD) to remotely correct Class III skeletal malocclusions in Yemen could benefit oral health procedures that may correct and prevent the development of serious types of malocclusions thereafter in patients' lives. Thus, the purpose of this study was to introduce the placement of a ramal plate in the retromolar fossa as a new TSAD to correct class III skeletal malocclusion by distalization of mandibular dentition among Yemeni patients.

METHODS AND MATERIALS

A clinical cohort study was carried out. The sample consisted of pre-and post-treatment CBCT lateral cephalometric of 6 patients (3 males and 3 females; mean age 20±2 years) who received a ramal plate for mandibular molar distalization. In the Department of Orthodontic, Sana`a University, Al-Kuwait University Hospital. The sample size required to detect a difference of at least 1.5 units with a standard deviation of 2 units using a power of 0.8 and a probability of type I error (α) = 0.05 was 6 patients. Approval was obtained from the institution review master degree committee of Faculty of Dentistry, (20-01-222) and informed consent was obtained from all subjects. The inclusion criteria were:

(1) A patient over 18 years of age at the start of treatment

(2) Features of clinically validated and cephalometric Class III skeletal malocclusion, panoramic cone beam CT scan and with Class III dental malocclusion with more than half of the molar discrepancy

(3) Anterior cross bite

(4) A full set of permanent teeth with a low index of caries and periodontal disease

(5) Free from any systemic diseases or congenital anomalies

(6) They do not have previous orthodontic treatment

Appliance description: All patients were prepared to make miner operation at AL-Kuwait University Hospital under local anesthesia. The local anesthetic solution (2% lidocaine or Abniphrin with 1:80000 Adrenalin 1.8mL) was then administered as mandibular block for both sides, followed by orthodontic fixing treatment for alignment and arrangement teeth. A ramal plate is placed in the retromolar fossa, located between the anterior border of the mandibular ramus and the temporal crest **Figure 1**. After doing the flap in the retromolar area, the L-plate bending **(Figure 2) (**LeForte System; Jeil Medical, Seoul, Turkia; length of the short arm, 10 mm; length of the long arm, 20 mm; diameter, 2.5 mm) is adapted to fit the bone surface. The third molars are extracted during the procedure. The anterior hole of the plate that extends into the oral cavity is positioned horizontally to be 3 mm lateral to the buccal surface of the second molar, and between the buccal groove of the second molar and its distal surface, anterioposteriorly **(Figure 1).** The plates were fixed with 2 screws **(Figure 3)** with a pilot drill **(Figure 4).** Pilot holes were then created using a low-speed surgical hand piece at 800 rpm, under NaCl irrigation, 2 mm in diameter, and 6 mm in length by a bore drill. The flap (usually two flaps) is sutured above the plate, and the hook is extended beyond the mucosa, vertically to the level of the second molar tube and laterally within 3 to 6 mm horizontally to the buccal surface of the second molar. The power elastic chain may be looped around the front screw hole of the plate, or it may be snap-cut to convert to a hook to facilitate the placement of elastic straps or closed coil springs of nickel-titanium attached to 0.019-by-0.025-in arc-wire crimped hooks of stainless steel between the side cutouts and canines immediately after plate placement **(Figure 1).** Power elastics chain were attached from Ramal plate hooks to the hooks between the lateral and canine to deliver a force of 250 g to 400 g per side and were replaced every 3 weeks, during the insertion of the elastic chain, tension and pressure gauges were used in order to measure

the force. Antibiotics and anti-inflammatory were prescribed after the operation as a cover-up. Painkillers were also prescribed for some time to relieve any pain after the surgery and during the stretch **(Figure 5)**.

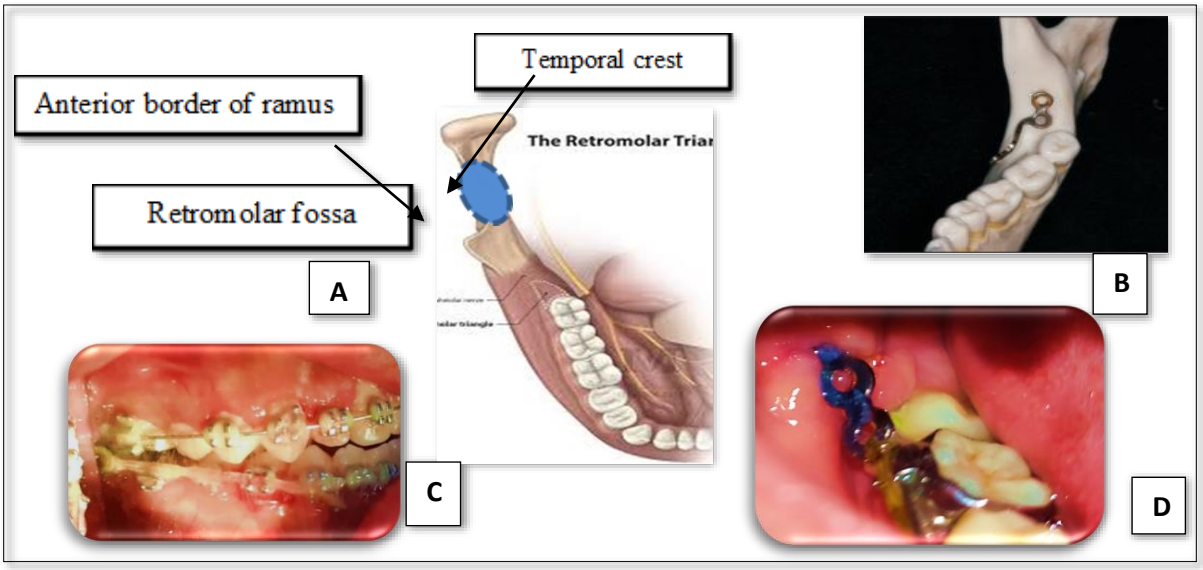

Figure 1. The placement site of the ramal plate showing the retromolar fossa. A, the placement site of the ramal plate; B, the ramal plate after adjustment to fit into the retromolar fossa; C, the ramal plate emerging through the attached gingiva; and D, the ramal plate connected to an arch wire with a power chain elastic.

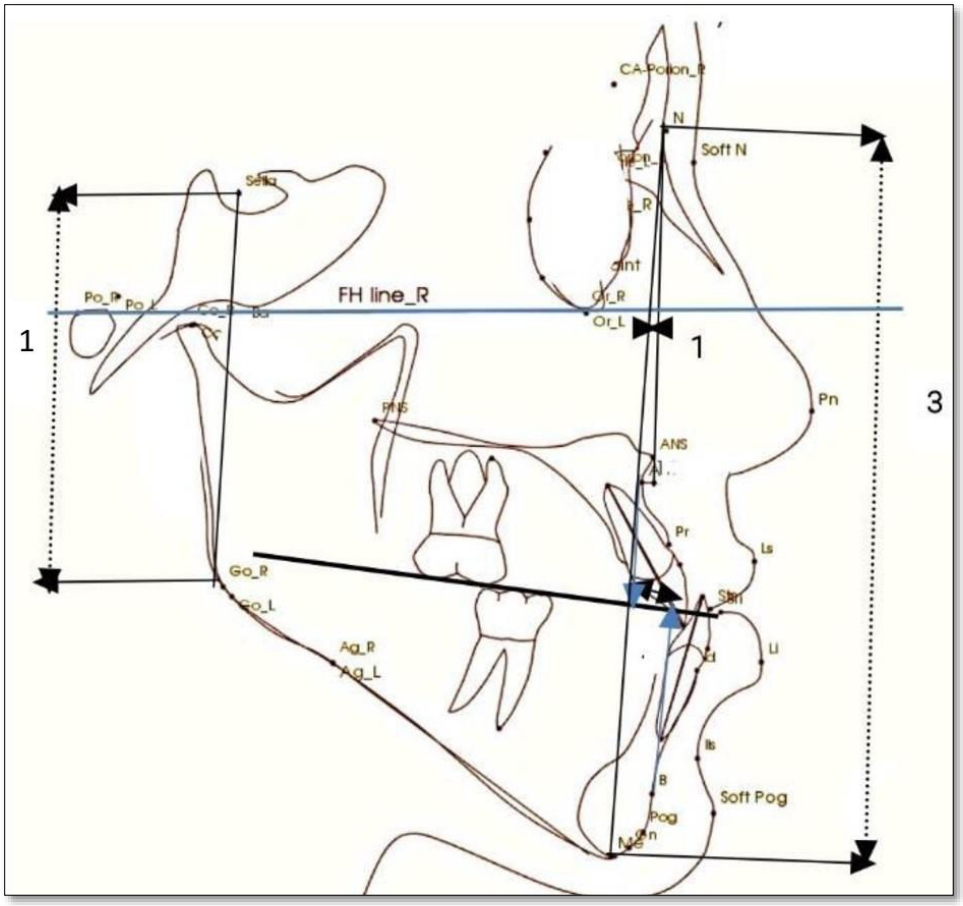

Figure 2. Skeletal Liner Measurements. 1. A Point to N Perpendicular. 2+3-Facial Height Ratio (%). 4-Wits Appraisal.

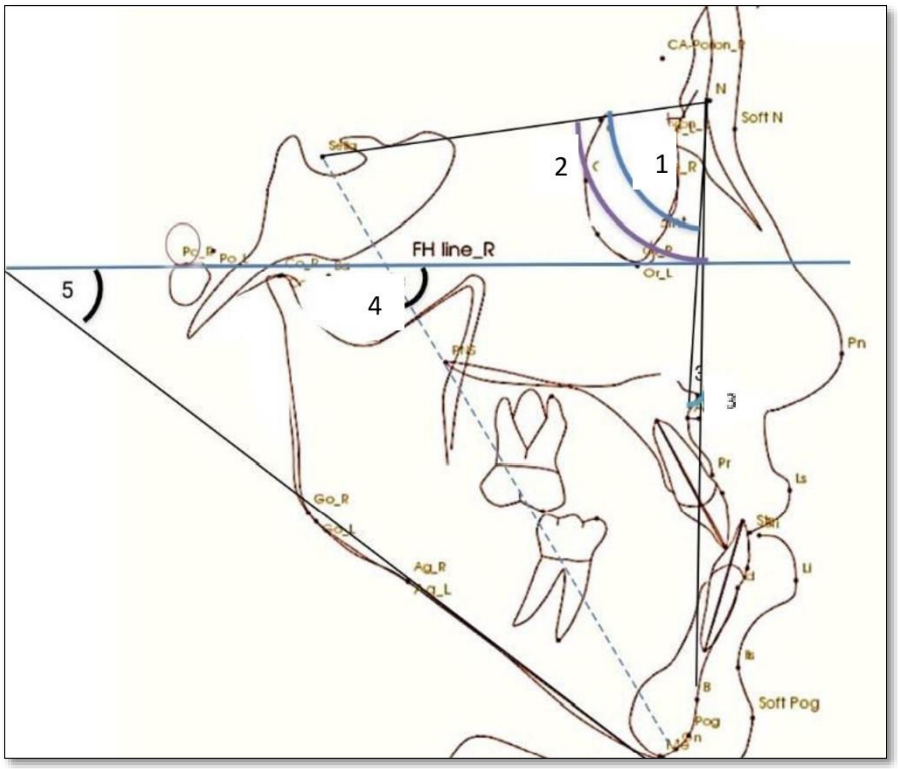

Figure 3. Skeletal Angular Measurement. 1. SNA, 2. SNB, 3. ANB, 4. Y-AXIS and 5. FM.

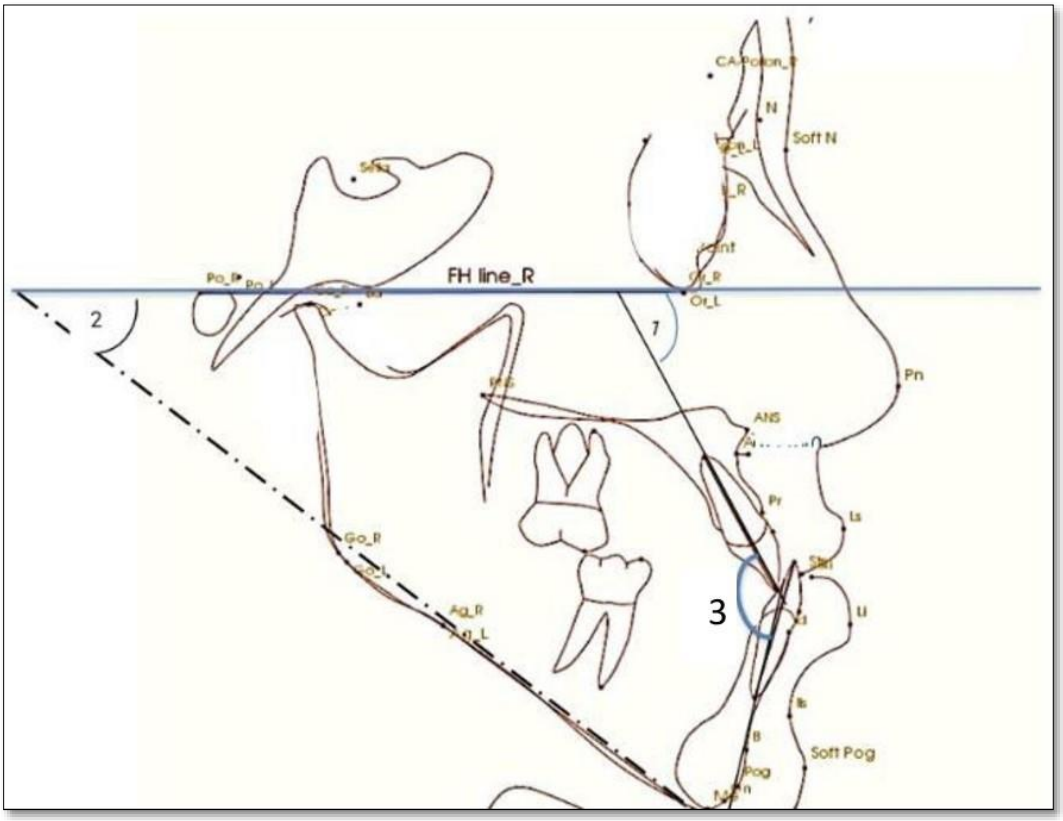

Figure 4. Dental Angular measurements. 1. UI to FH. 2. MPA 3. Interincisal Angle.

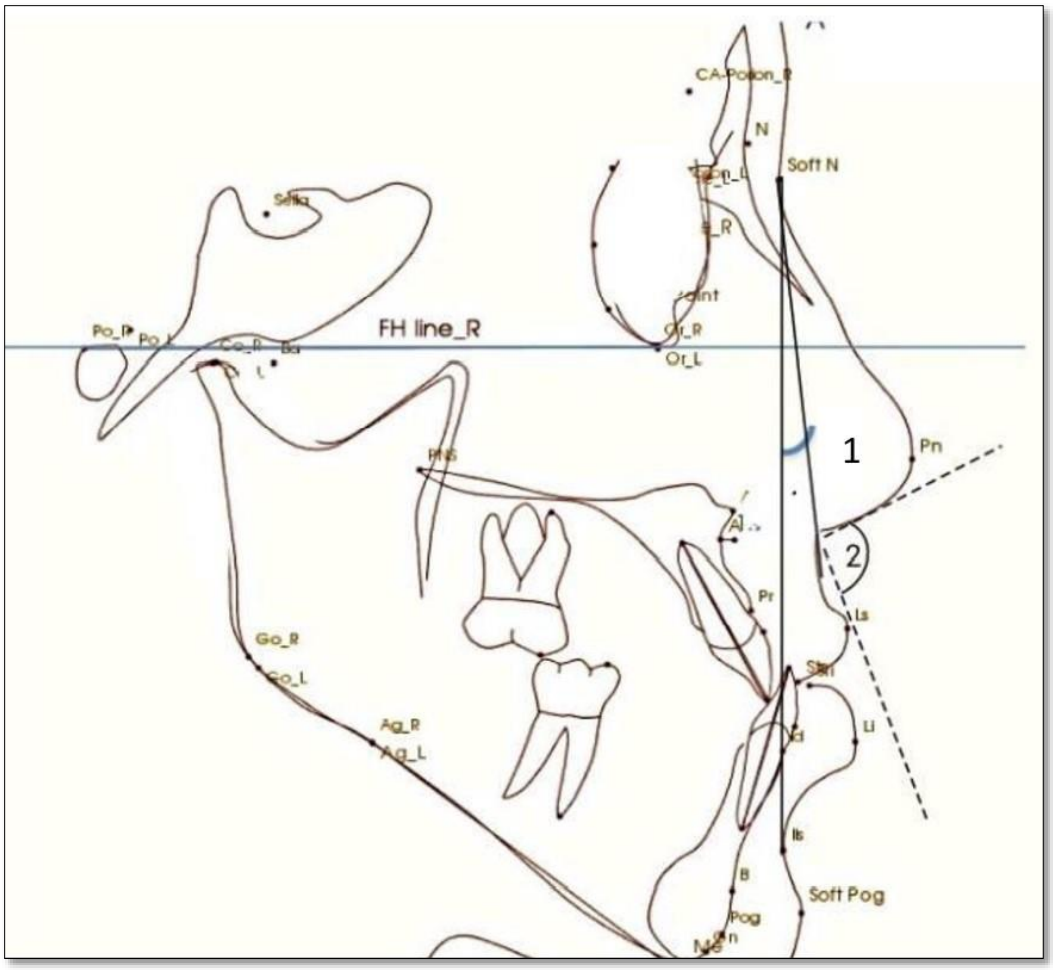

Figure 5. Soft Tissue Angular Measurements. 1. ANB of Soft Tissue and 2. Nasolabial Angle.

Important notice: There is a possibility that the posterior foramen may be close to the placement area when the ramal plate is inserted. However, the probability of this happening is between 9% and 25% [20-22]. Because the neurovascular bundle is connected to the pulp and periodontal tissues of the third molar through the foramen. Therefore, the placement position must be examined after flap reflection in relation to the position of this foramen.

Cephalometric analysis: Pre and post treatment lateral cephalometric radiographs were digitized. All the subject heads were fixed by means of two ear rods inserted into the external auditory meati. The Frankfort horizontal plane was oriented parallel to the floor and the midsagittal plane was maintained parallel to and at a fixed distance of the film. A constant distance of (1745mm) was maintained between the x-ray source and midsagittal plane. The subject was asked to close the mouth in centric occlusion.

Eighteen linear and angular measurements were calculated electronically using the software *In-Vivo*-Dental-Intel Application Version 6.0 **(Figures 2-5).** The same examiner repeated the cephalometric digitization of three randomly selected cases two weeks later. To assess intra-examiner reliability, the intraclass correlation coefficient (ICC) was used. For all variables, the ICC ranged between 0.360 and 0.342.

Statistical analysis: Some descriptive statistical analysis parameters were calculated using Minitab 20. All values presented were for measurements that were performed during the study, including horizontal and vertical skeletal patterns, dental analysis, and soft tissue analysis for patients in this study. The mean and the standard deviation (SD) for all measurements are presented for pre- and post-treatments. The minimum (Min) and maximum (Max) values for all measurements were also presented in **Table 1**. The differences between the means of the pre- and post-treatments were calculated by subtracting their means. The P-value was calculated using GLM ANOVA in Minitab 20 and compared to a p-value of ≤ 0.05 to find out if the treatments achieved the goal of this study.

Table 1. Comparisons between Pre-Post-treatment cephalometric and soft tissue variables.

Measurement	Pre-treatment				Post-treatment				X^2	p-value *
	Mean	SD	Min	Max	Mean	SD	Min	Max		
Horizontal skeletal pattern										
SNA°	77.17	3.6	71	80	78.50	2.35	75.00	80.00	1.33	0.226
SNB°	80.75	3.87	74	74	79.50	2.81	76.00	82.00	-1.25	0.657
ANB°	-3.58	1.69	-5	-0.5	1.00	0.89	0.00	2.00	4.58	0.004
Y-axis°	61.00	3.35	58	67	59.33	2.16	57.00	63.00	-1.67	0.209
A-point to N perpendicular (mm)	56.33	4.23	48	59	63.17	0.98	62.00	65.00	6.84	0.015
Wits (mm)	-6.17	3.54	-10	-1	-0.50	0.55	-1.00	0.00	5.67	0.006
Vertical skeletal pattern										
Facial height ratio (posteroanterior)	59.33	8.64	45.00	69.00	62.46	2.26	60.00	66.00	3.13	0.447
FMA°	32.17	4.49	25.00	39.00	28.46	1.85	26.00	30.00	-3.71	0.139
Dental analysis										
U1 to FH°	68.33	5.47	62.0	78.0	111.78	5.21	105.00	117.0	43.45	0.000
IMPA°	80.17	5.42	73.0	87.0	96.67	2.50	93.00	100.00	-16.5	0.081
Interincisal angle	133.67	9.91	120.0	150.0	124.56	3.32	122.00	130.0	-9.11	0.071
Soft tissue analysis										
ANB°	3.000	0.894	2.000	4.00	6.667	0.985	5.000	8.000	3.66	0.000
Nasolabial angle	77.67	17.24	44.00	93.00	100.67	9.00	90.00	115.0	23.00	0.012
Ls-E Line mm	-5.00	3.22	-10.00	-2.00	-0.333	2.146	-3.000	2.000	4.67	0.014
Li-E Line mm	-0.33	2.88	-4.00	4.00	-0.500	1.225	-2.00	1.00	0.17	0.014

RESULTS

In the evaluation of tooth movement in relation to the FH as craniofacial reference line, there was a significant in clinical observation and some of Cephalometric analysis. The total treatment time for distalization of a whole mandibular jaw was 7 months and 3weeks with a range of 7-8 months. But the total treatment as a finishing case took 36months.

Clinical Observation: The following observations were seen in all cases as in **Figure 6**:

1. The normal overjet of an anterior teeth and canine (2±2mm of overjet), molar Class I relationship (5±2mm distalized) was seen in all patient in the end of 7-8 months since the distalization procedure started.
2. By applying a force (250-400g) parallel to the functional occlusal plane and Counterclockwise around

a point just apical to the mandibular dentition's center of resistance, the mandibular occlusal plane was moved distalized and no rotated.

3. As seen in the patients, this resulted in distalization of the entire dentition, as well as posterior tooth intrusion and front tooth extrusion.
4. Additionally, in all patients, there were no signs or symptoms of gingival recession, mobility, or bone loss.

Figure 6. A; Pretreatment Photographs Showing Concave Shape and Subsequently facial Appearance. B; Post treatment photographs Showing Correction of Reverse Overjet and the Concurrent Facial Appearance After Treatment.

The Result Cephalometric Analysis will be Presented as a follow: Angle degree measurements were taken before and after treatments for SNA°, SNB°, ANB°, and Y-axis°. Statistical analysis showed in **Table 1** that there is a significant p-value ≤ 0.05 between some of the measures that are important and considered critical to evaluating the treatments. In the evaluation of skeletal variables, there was a significant change in the sagittal relationship between the mandible and maxilla (Wits, 2.4 mm; p =0.006), A point-nasion-B point (ANB; p =0.004) and A-point to N perpendicular (mm). However, the sella-nasion-A point (SNA) angles, and the sella-nasion-B point (SNB) were not changed significantly. Moreover, the FMA angle did not increase significantly and facial height ratio **(Table 1).** In the evaluation of dental variables, there was a significant change in (U1 to FH°, p=0.000, IMPA, p=0.018, and interincisor Angle, p=0.017). In the evaluation of soft tissue, there was significant effect on upper lip position (nasolabial angle, p = 0.000; Esthetic line-upper lip, p = 0.014). However, the lower lip showed a significant retraction of 3.2 mm (p = 0.014).

Values are presented as mean ± standard deviation.

ANB, A point-nasion-B point; SNB, sella-nasion-B point; Pog, pogonion; SNA, Wit's appraisal, Y-axis N, nasion

DISCUSSION

The diagnosis and treatment of Class III malocclusion are considered to be one of the most difficult problems for orthodontists because its etiology is complicated**.** Not much literature has been published about treatment of Class III malocclusion with fixed appliances using recent application of a Novel ramal plate (TSADs) conducted in Yemen, and previous research has been conducted on dental caries, oral and facial abscesses of odontogenic origin, localized aggressive gingivitis (LAP), periodontitis, bacterial and fungal oral infections, interleukin-1 levels in human gingival sulcus, prevalence and association of the maxillary sinus septum with sex and location in the maxillary among adults, factor analysis and pattern of permanent tooth extraction, effect of removable dentures on aerobic bacterial colonization, and clinical effects of platelet-rich fibrin (prf) after surgical extraction of impacted lower third molars [23-33], there is no information regarding the treatment of class III malocclusion in Yemeni adult. Therefore, it was the aim of this work to study treatment of class III malocclusion in Yemeni adult.

In this study, the treatment time for distalization treatment ranged from 7 to 8 months, including correction of the negative overjet of an anterior tooth as well as the canine and molar Class I relationship, which were seen in all patients at the end of 7-8 months from the initiation of this medically exclusion procedure and photos. The recent application of TSADs to split the dental arch of the mandible reduced the range of orthodontic treatment in our study and this is similar to the findings of previous studies and confirmed the previous results [16,34-38].

Clinical resulting from the treatment: In the current study, all of the cases had correction of negative overjet and class I canine and molar relationship **(Figure 6),** these results agreed with Yu [34] Yeon [35] Kook [38]. Some patients included in our study had discrepancies greater than ½ or 2/3 molar relation Class III, this differs from other research, as their research included patients with discrepancies of ½ or 2/3 molar relation of Class III molar relationship, and this may have resulted in a reduction of the mean dimension in our study, as confirmed by some other studies also Ludwig [39]. Therefore, we show the full capacity of the ramal plate where some patients had a severe condition unlike the rest of the research by Yu [34], Kook [38].

Although the miniscrew can only pull the mass of teeth to a certain extent, because of the inter-radicular space, it is difficult to distalize more than 2-3 mm with the miniscrew because the interradicular space [38,39] but with ramal plates as in the current study it distilize more than 4± 2.5mm and this is similar to that reported by Kim [40]. Also, plates, in general, can withstand high forces, and their stability is enhanced by the use of two screws [6,38]. Several studies have found that miniplates fail at a lower rate than miniscrews [38] The plate's hook exposed through the retromolar area, which may cause less discomfort than when it is exposed through the moveable vestibular mucosa, and contrary to the report of excessive distal tipping with mini screw, the distalization with distal tipping ratio was minimum with ramal plate as in the current study and recent conducted studies [15,37].

Clinically the standard overjet of an anterior teeth and canine, molar Class I relationship was seen in the all patient by used the ramal plate for distalization procedure started the current study clinical result agreed with that of [34,35,38]. All our patients received orthodontic treatment by applying a force parallel to the functional occlusal plane and counterclockwise around a point just apical to the mandibular dentition's center of resistance using an elastic bower chain. The mandibular occlusal plane was moved distalization and not rotated, this result is in accordance with the results of [34,35,39,40] **(Figures 7-9).** As seen in our patients clinically, this resulted in distalization of the entire dentition, as well as posterior tooth intrusion and front tooth extrusion. This result agreed with that reported [34,35,38]. Additionally, in all patients of the current study, there were no signs or symptoms of gingival recession, mobility, or bone loss. This result is in comparison, with studies by Yu [34], Krishnamurthy [36], Kook [38] **(Figure 6).**

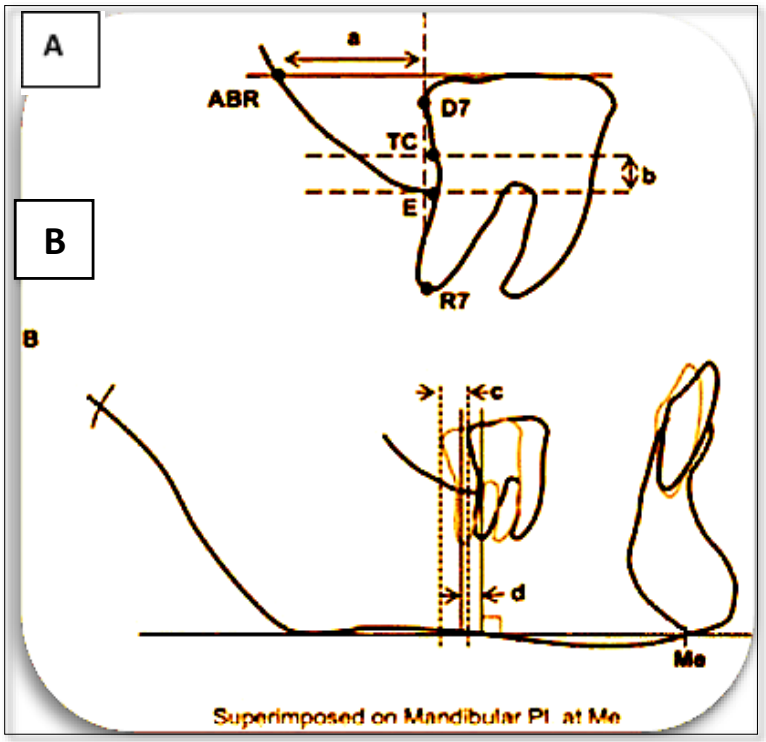

Figure 7. A. Construction of Landmarks and Lines on the Lateral Cephalograms B. Cephalometric Tracings Before Treatment (black line) and After Treatment (orange line) are Superimposed on the Mandibular Plane at the Mention (Me).

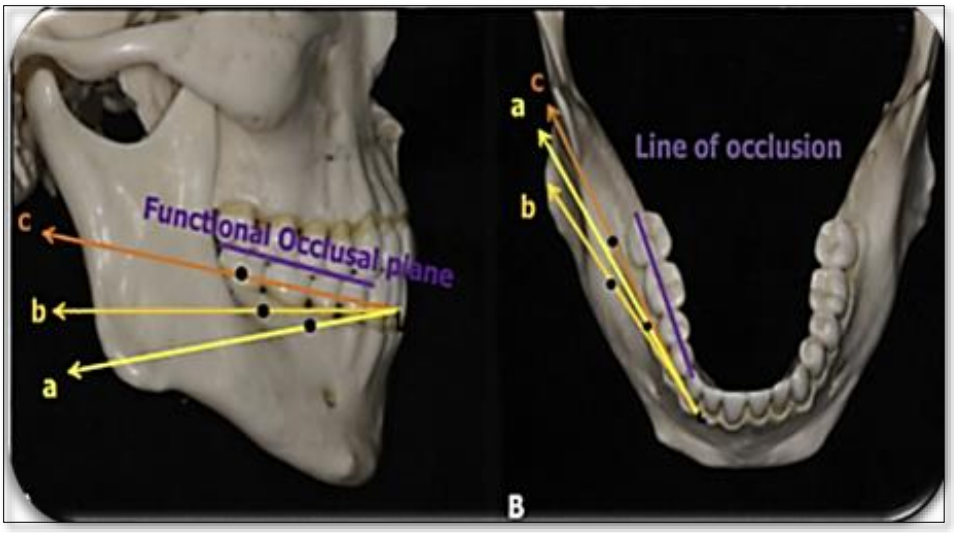

Figure 8. Comparison of the Force Vector in each Device: A, Lateral View; B, Occlusal View. Dots Indicate the Positions of the Miniscrew Head and the Ramal Plate Hook: a, Interradicular Miniscrew; b, Buccal Shelf Miniscrew; c, Ramal Plate Hook.

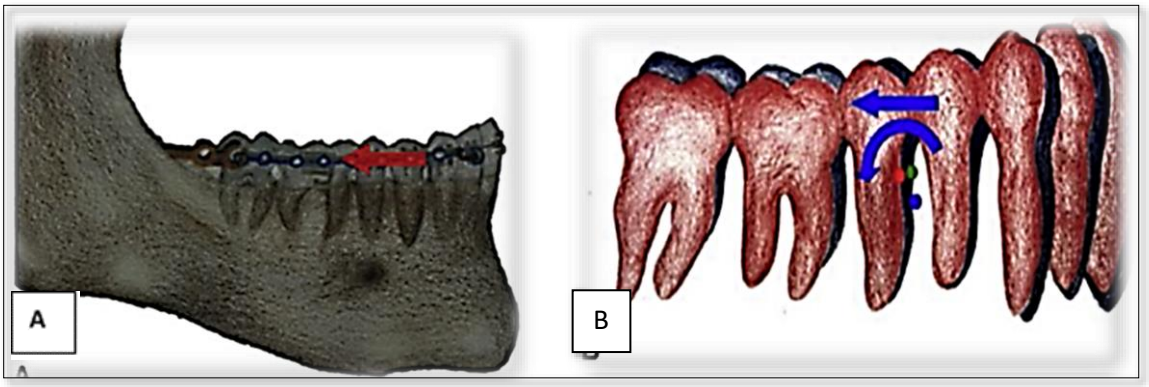

Figure 9. Force System and Tooth Displacement: A, Distalization Force Parallel to the Occlusal Plane at the Vertical Level of the Archwire; B, Distalization and Counterclockwise Potation of the Mandibular Occlusal Plane Around the Center of Rotation (Blue Dot), which is Slightly Apical to the Center of Resistance of the Mandibular Dentition (Green Dot, Pretreatment; Red Dot, Posttreatment); Blue Dentition, Pretreatment; Red Dentition; Posttreatment.

Lateral CBCT Cephalometric: Selected CBCT lateral cephalometric variables were identified for each cephalogram, representing skeletal, dentoalveolar, and soft tissue measurements **(Figures 2-5).**

Skeletal Change: Analysis of the treatment result indicated that there was a statistically significant change in the sagittal relationship between the mandible and maxilla. This result was highly statistically significant Wit's appraisal, p = 0.006. This result agreed with Yu [34], Yeon [35] Also, the current study result got a high statistically significant ANB° P-Value = 0.004 as shown in **Table 1,** this result was not in agreement with [34] However, statistically significant levels of SNA° and SNB° did not change significantly between pre- and post-treatment **(Tables 1).**

The two variable of Facial high ratio and FMA° result indicated limited craniofacial change after treatment since no statistically significant difference observed in most of cephalometric Skeletal angular parameter **(Table 1).** This result is agreed with that of Yu [34] but was disagreed with that reported by Yeon [35] where the FMA° had significant result.

Dental Changes: Evaluation of the post-treatment outcome showed improvement in most of the bilateral alveolar variables as shown in **Table 1** by highly significant in U1 to FH °P-Value = 0.000, IMPA °p-Value = 0.081 as well as the interincisal angle. [38] did not perform any statistical analysis in their research on this variable, and [34] did not take the same measurement parameter in their statistical analysis as the one that worked in this research. Our findings indicate that correction of the anterior reverse overjet and

overlay without significant change in the mandibular plane resulted in distalization of the mandibular teeth. This study improvement of interincisor angle was very significant while U1 to FH° and IMPA° were statistically highly significant as shown in **Table 1.**

Soft Tissue Changes: In the current study, four variables were used in an attempt to understand possible changes in different aspects of face, such as ANB° of soft tissue, nasolabial angle, upper lip and lower lip of esthetic plane line. Evaluation of the soft tissue profile in the 6 patients revealed an improvement a high statistically significant, especially in the ANB° of soft tissue has a high statistically significant p-value =0.000 as shown in **Table 1**. There is no agreement between our study and Yu [34] where there was no statistically significant effect on the position of the upper lip and nasolabial angle but their results agreed with our study in the lower lip.

CONCLUSION

After alignment and leveling the patients using recent application of Noval ramal plate in retromolar fossa, the retromolar fossa is an anatomically appropriate location. The force vectors that result is parallel to the occlusal plane, resulting in efficient molar distalization. With ramal plates, there was no significant change in the vertical position of the mandibular molar or in the MP angle. In the evaluation of dental variable, there were a statically significant in U1 to FH°, IMPA° and Interincisor Angle. In the evaluation of soft tissue there was a statically significant in Nasolabial Angle, Ls-E Line (mm), and Li-E line (mm). Therefore, ramal plates are an effective treatment option for Class III patients who are apprehensive about undergoing extraction teeth and or orthognathic surgery for mandibular complete arch distalization.

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CONFLICT OF INTEREST

No conflict of interest associated with this work.

AUTHOR'S CONTRIBUTIONS

This research is part of a master's degree in the Orthodontics, Pedodontics and Prevention Department, Faculty of Dentistry, Sana'a University, Yemen, first author Reem Hussein Sheikh Omar AL-Kaff, who conducted field work, and who did clinical work and other authors contributed to data analysis, drafting and review of the paper, and gave final approval to the research.

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