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Cover Page Footnote

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Original Article

A Comparison of Two TAD Techniques (Miniscrews Versus Miniplates) for Treating Class III Malocclusion and The Associated Skeletal and Dental Effects

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The aim of this study was to compare two different techniques for distalizing the mandibular dentition in patients with Class III malocclusion using either miniscrews or miniplates. We evaluated the skeletal and dento-alveolar changes associated with each method. The study also aimed at identifying cephalometric characteristics in the subjects associated with the most predictable, successful outcome of treatment.

Patients and Methods: Our sample consisted of 20 adult subjects (10 females and 10 males) that met the inclusion criteria. We examined pre and post treatment headfilms and analyzed the dental and skeletal changes using a computer program that provided the data for statistical analysis (TIOPS4).

Results: On average, both types of mechanics were successful in distalizing the lower dentition as seen by both the horizontal movement of incisors, premolars and molars and the changes in inclination of these teeth. A modest amount of vertical movement of incisors, premolars, and molars was observed in both groups, with the miniplates exhibiting slightly more vertical movement. When comparing the two types of anchorage, only the vertical level of the premolars and molars was statistically significant between the two groups with miniplates leading to more vertical change.

Conclusion: Mild to moderate Class III malocclusions can successfully be treated with distalization of the lower dentition using either one of two mechanics (miniscrews or miniplates) as skeletal anchorage in the lower jaw. ***(Taiwanese Journal of Orthodontics. 31(3): 132-141, 2019)***

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INTRODUCTION

The correction of a Class III malocclusion in a non-growing patient is commonly treated by either camouflage extractions, surgery, or with pronounced compensatory proclination of the maxillary incisors and retroclination of the mandibular incisors. An alternative method of treatment that is rarely attempted is distalization of the mandibular dentition. Distalization of the mandibular molars has been recognized as one of the more difficult treatment objectives in clinical orthodontics especially when compared to distalization of the maxillary molars.[1] Due to the difficulty and unpredictability of this treatment modality, it is rarely attempted, and the malocclusion is corrected surgically. There have been a variety of methods attempted to distally move the mandibular molars including lip bumper,[2] a distal extension lingual arch,[3] and even multiloop Edgewise archwires.[4] With most of these techniques, there is typically distal tipping of the mandibular molars rather than bodily translation, and treatment results rely heavily on patient compliance. However, presently, with the use of temporary skeletal anchorage devices (TSAD), distalization of the mandibular dentition can be achieved with less reciprocal side effects as compared to more traditional methods of mandibular dental distalization using simple Class III mechanics.[2-4] Currently, by using miniscrews the clinician can often correct anterior crossbite, mandibular asymmetry, distalize the mandibular dentition and relieve mandibular crowding and thereby avoid extractions.[5]

Success of mandibular molar distalization is a multifactorial challenge where the type of anchorage, direction of force, retromolar space, and dentofacial patterns all are important components. The direction of the retraction force is essential in order to reduce unwanted tooth movements such as tipping and extrusion. Park et al. evaluated at which vertical level the mechanics would offer the ideal amount of mandibular dental retraction while at the same time limiting the amount of side effects, they found the best level was at the cementoenamel junction.[6] Another important factor was the amount of retromolar space available for mandibular dental distalization. Choi et al used CBCT images to determine the amount of retromolar space typically present in Class I and Class III patients.[7] In favor of molar distalization, the authors found that in patients with Class III malocclusion and mandibular prognathism there was increased retromolar space, making this procedure easier. Dang et al. evaluated molar distalization in 11 patients treated with different types of anchorage preparation and found that only 2 of the 11 cases showed significant distalization.[8] In contrast, Yu et al. reported a much higher success rate of distalization in their population of 22 patients that were treated with ramal plates only.[9] On average patients experienced 2.1 mm of coronal retraction and 0.81 mm of apical retraction. The authors emphasized the importance of using bone plates for distalization because of the increased force needed to distalize the lower arch.

Mandibular molar distalization potentially offers a viable alternative to Class III correction rather than premolar extractions or orthognathic surgery. However, treatment outcome of this type of biomechanics still needs to be evaluated in more detail. Our study sought to investigate the treatment success of mandibular molar distalization for Class III patients using two specific types of anchorage preparation, miniscrews and miniplates. In this context it is important to thoroughly evaluate this modality of treatment and determine if mandibular dental distalization can be a predictable treatment alternative, and if the outcome is orthodontically acceptable. We focused our evaluation on the dental movements of the mandibular first molars, second premolars, and incisors between subjects. Our hypothesis is that distalization of the mandibular dentition, using one of two types of skeletal anchorage in a Class III non-growing patients will result in an acceptable orthodontic result.

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PATIENTS AND METHODS

In this retrospective clinical study, we evaluated the outcomes of orthodontic treatment of patients treated for a Class III malocclusion by mandibular dental distalization using either miniplates or miniscrews for anchorage. The miniplate seen in Figure 1A was connected to the mandibular posterior teeth with an elastic chain that was renewed regularly. Figure 1B shows a patient where a mandibular miniscrew was used as anchorage. In this patient occlusal build ups were placed to allow correction of the negative overjet. Similar to the patient seen in Figure 1A, elastic chains were used for retraction of the dentition. Records taken before and after treatment were evaluated and they included an initial (T1) lateral cephalometric headfilm, a panoramic radiograph, and pre-treatment dental casts. The post- treatment records (T2) included a lateral headfilm, a panoramic radiograph, and post-treatment dental casts. The subjects were all treated at The Division of Orthodontic and Dentofacial Orthopedics, Dental Department, National Taiwan University Hospital (NTUH) in Taiwan. Subject selection was based on completion of orthodontic treatment within the past five years that included the use of TSAD anchorage (miniscrews or miniplates) for mandibular dental distalization. Patients treated at NTUH signed consent forms for the protection of their clinical data that permitted evaluation of the records after de-identification. IRB approval was also obtained at NTUH reference # 201306034RINC and UCSF reference # 13-11083.

Initially, 27 total subjects were selected. However, only 20 subjects met the inclusion criteria. The criteria included: 1) A Class III molar relationship (unilateral or bilateral) of ½ cusp or more; 2) distalization of mandibular dentition intended in the original treatment plan; and 3) patient's stage of maturation was post puberty with little or no growth left prior to treatment. The exclusion criteria included of: 1) incomplete records; 2) previous extractions with subsequent space closure; 3) additional growth to be expected; and 4) orthognathic surgery.

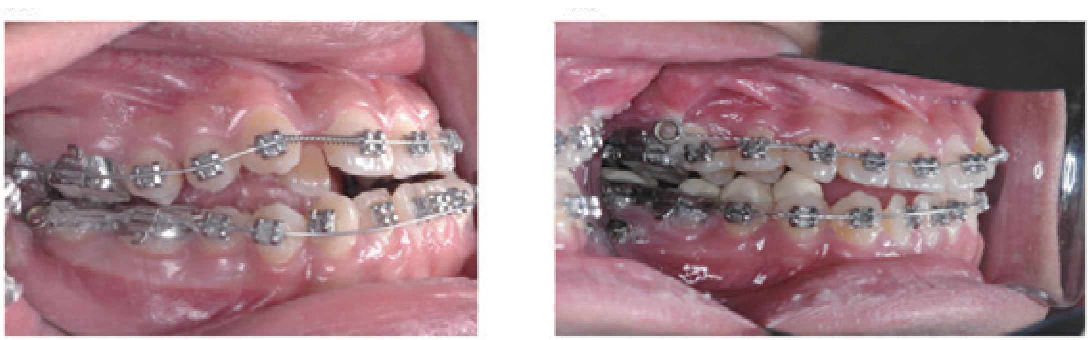

Figure 1. Retraction set-up using miniplates and miniscrews.
A: *The plate has been placed in the body of the mandible posterior to the dentition. The retraction is done using elastic chains connected to the plate and first bicuspids.*
B: *Occlusal built-up on the posterior teeth in the mandible have been placed to permit retraction of the lower front teeth, The retraction force is from an elastic chain from a miniscrews to the lower first bicuspid.*

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Evaluation of Mandibular Dental Distalization

Lateral head films taken before (T1) and after treatment (T2) were digitized and entered digitally into the computer program, "Total Interactive Orthodontic Planning System" (TIOPS4; Copenhagen, Denmark). The lateral head films were then superimposed using the computer program TIOPS4. Occlusograms of upper and lower study casts (Figure 2 and Figure 3), pre and post treatment were also digitized with the help of this program. In order to assure the correct molar location on the lateral headfilm, the distances from the labial surface of the mandibular incisors to the mesial portion of the second premolars, as well as to the first molars were measured on the digitized occlusograms and adjusted when needed.[10] In cases where unilateral distalization treatment was performed, only the measurement of the distalized side was used in the analysis. If treatment included bilateral distalization of the second premolars and first molars, a point median to the mesial surface of both sides of these teeth was recorded. The measured distances were then used to accurately position the second premolar and first molar on the digital tracings of the lateral headfilms. All occlusograms and lateral cephalograms were digitized by one investigator and checked by another examiner. The second examiner checked for accuracy of landmark location and superimposition accuracy. Any disparities between landmarks or superimposition were resolved after careful analysis and by mutual agreement.

Using the TIOPS4 program the post treatment headfilm (T2) was superimposed on the initial lateral

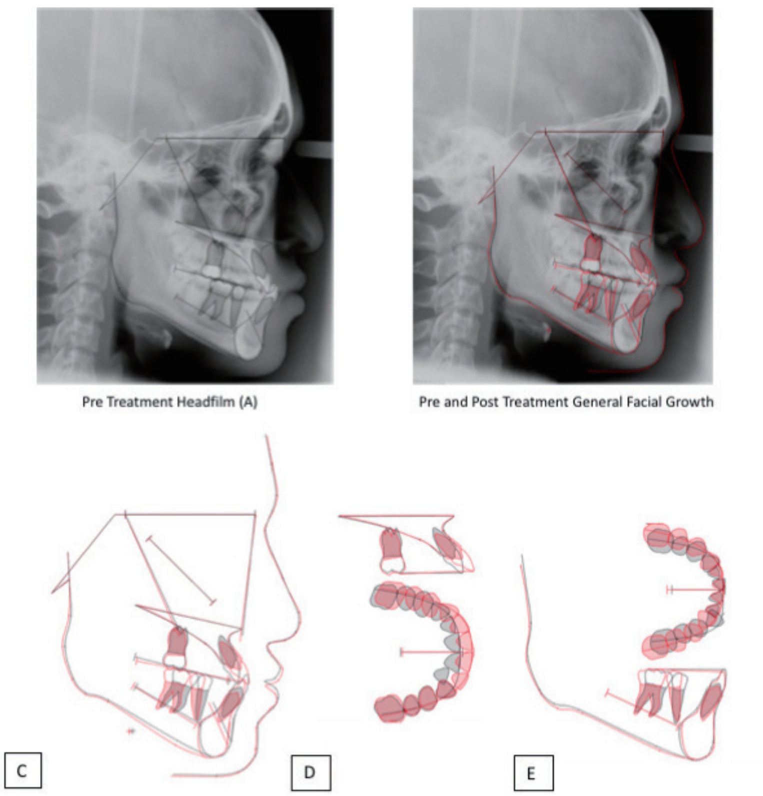

Figure 2. Class III malocclusion with mandibular Overjet (Case 1).
*Pre and posttreatment headfilms of a patient treated with distalization of the lower dentition using miniscrews. **A**, The pretreatment headfilm show a Class III molar occlusion with negative overjet. **B**, Superimposition of the headfilms is made on stable structures in the cranial base and shows no mandibular growth during the treatment period. **C**, Superimpositions on cranial base and on stable structures in the maxilla and the mandible. **D**, Maxillary superimposition showing no growth and proclination of the maxillary incisors during treatment. **E**, Mandibular superimposition showing no change of the lower incisors, but the posterior teeth were uprighted correcting the molar occlusion and alleviating the crowding.*

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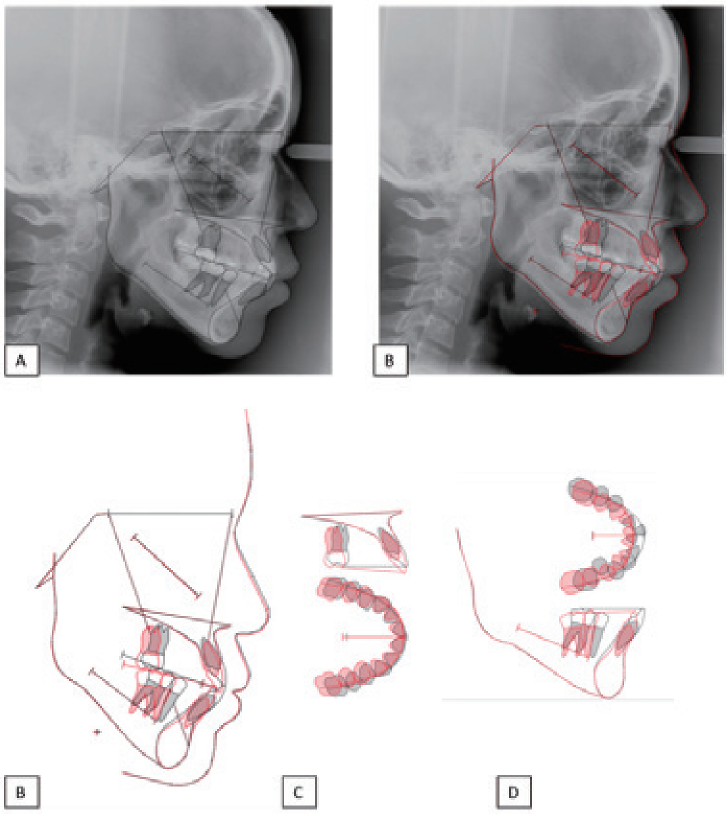

Figure 3. Class III malocclusion with edge to edge anterior occlusion (Case 2).
Patient treated with Miniplates. Class III malocclusion with edge to edge anterior occlusion. The malocclusion is primarily dento-alveolar, and the patient has bimaxillary dentoalveolar protrusion. ***A****, Shows the pretreatment headfilm.* ***B****, Superimposition of the pre and posttreatment headfilms on cranial base showing no facial growth.* ***C****, Superimpositions on cranial base and on stable structures in the maxilla and the mandible.* ***D****, Maxillary superimposition demonstrates retroclination of the maxillary incisors and distalization of the upper posterior teeth.* ***E****, Mandibular superimposition shows distalization of the mandibular dentition with uprighting of the molars and bicuspids as well as retroclination of the incisors.*

headfilm (T1), using the "structural technique," that included stable structures in the anterior cranial base and part of the median cranial base. These structures are the ethmoid bone, the anterior portion of sella turcica, the cribiform plate and the median border of the orbital roof.[11]

Individual superimpositions were made on stable structures of the maxilla and mandible. The maxillary superimposition was made on the anterior surface of the zygomatic process of the maxilla correcting for apposition on the orbital floor and resorption of the nasal floor. Mandibular superimposition was made on the anterior contour of the chin, the inner lower border the mandibular symphysis and the inferior alveolar canal.[12] In Figure 2, we are showing the records of a patient with a Class III malocclusion and mandibular overjet treated to Class I occlusion and normal overjet and overbite relationships. The general superimposition shows no growth during the treatment period. The change in occlusion took place through a combination of proclination of the maxillary incisors and distalization and uprighting of the mandibular dentition. A second patient's treatment is illustrated in Figure 3 here the initial malocclusion was a Class III with bimaxillary protrusion and edge to edge anterior occlusion. In this patient the Class III malocclusion is primarily dento-alveolar. The superimpositions demonstrated both distalization of the mandibular dentition and uprighting of these teeth. There is some distalization of the maxillary posterior teeth as well, but

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to a lesser degree than in the mandible. The changes in the mandible resulted in alleviating the crowding both anteriorly and in the bicuspid region.

Statistical Analysis

Due to the limited number of subjects that met the inclusion and exclusion criteria we restricted our statistical analysis to student t-tests comparing the two types of implant technique and the extent of distalization achieved relative to the null hypothesis of 0 mm and 0 degrees for translation and inclination respectively. De-identified data was exported from excel into Stata for T-test analysis (College Station, Tx). Additionally, with the limited number of subjects we felt comfortable only evaluating two variables in limited regression models (ANB and U1-PP). These two variables were chosen a priori due to their representation of the skeletal base and potential dental compensation.

RESULT

Demographics

The 20 subjects that met the latter criteria were an average age of 23.5y (SD 5.9y) and consisted of 10 males and 10 females. The average treatment time for these subjects was 28.3- mo (SD 6.8mo). The subjects were treated with either miniscrews or miniplates as a form of skeletal anchorage that aided in mandibular dental distalization. The sample distribution can be seen in Table 1. The data shown has been divided into two groups based on the type of mechanics used, miniscrew (1) and miniplate distalization treatment (2). When comparing the initial cephalometric values between the two groups we found that the only cephalometric difference between the patients of the two groups was in the mandibular prognathism (Table 2) (miniplate-86.9 degrees and miniscrews-82.0 degrees).

Table 1. *Patient Age and gender of the patients and types of anchorage.*

	Miniscrews (N= 15) Mean (SD)	Miniplates
Sex	M = 7	M = 3
Age at start of tx	23.0 yrs (4.2 yrs)	24.7 yrs (9.7 yrs)
Treatment time	26.5 mo (7.2 mo)	31.8 mo (4.3 mo)

Table 2. *Pretreatment cephalometric measurements of treatment groups.*

	Miniscrews (N= 15)	Miniplates
SN-SS (Mx sagittal)	81.7 degrees	84.4 degrees
SN-SM (Mn sagittal)	82.0 degrees	**86.9 degrees ***
SS-N-SM (interarch)	-0.2 degrees	-2.5 degrees
Overjet	-0.2 mm	-0.5 mm
Overbite	0.79 mm	0.7 mm
Ils-NL (upper incisor angulation)	118.6 degrees	124.7 degrees
Ili-ML (lower incisor inclination)	90.4 degrees	84.7 degrees

* *denotes P < 0.05 between miniscrew and miniplates.*

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Distalization Measurements

Both types of distalization mechanics were on average successful in distalizing the lower arch when we measured the linear horizontal movement of incisors, premolars and molars as well as inclination of these teeth (Table 3). We did find that at all levels of the lower arch there was a slight amount of increased vertical movement of incisors, premolars, and molars in both groups, with the miniplates showing slightly more movement (Table 3). We understand that each subject could have a different response to the type of distalization so to make it clearer we plotted individual bar graphs for the horizontal linear changes and the inclinational changes at the incisors, premolars, and molars. In general, most subjects responded very favorably to the distalization mechanics with only a few showing an unfavorable response (Figure 4). The negative responses were localized primarily to the movement of the incisors, in only three subject, but these changes did not affect the premolars or the molars.

Distalization Comparison

We looked at each distalization dental value between the type of TADs and made an overall comparison to the null hypothesis of no change in our student t-test analysis. When comparing the two types of anchorage we

Table 3. *Dental changes by types of anchorage device.*

Dental changes by	Miniscrews (N= 15)	Miniplates
Difference Horizontal	-0.9 mm	-0.7 mm
Difference	0.6mm	1.8 mm
Difference	-1.0 degrees	-3.1 degrees
Difference Horizontal	-1.8 mm	-3.7 mm
Difference	0.5 mm	**2.4 mm ***
Difference	-4.2 degrees	-7.5 degrees
Difference Horizontal	-1.6 mm	-3.1 mm
Difference	0.6 mm	**2.0 mm ***
Difference	-6.3 degrees	5.4 degrees

* *denotes P < 0.05 between miniscrew and miniplates.*

Table 4. *Statistical differences compared to a mean change of 0.*

Dental Measurement	Mean Measurement	SD Measurement	P-Value
Difference Horizontal L1s	-0.8 mm	1.9 mm	0.07
Difference Vertical L1's	***0.9 mm***	***1.6 mm***	***0.02***
Difference Inclination L1s	-1.5 degrees	6.8 degrees	0.3
Difference Horizontal L5s	***-2.3 mm***	***1.9 mm***	***0.00001***
Difference Vertical L5's	***1.0 mm***	***1.6 mm***	***0.01***
Difference Inclination	***-5.0 degrees***	***4.5 degrees***	***0.0001***
Difference Horizontal L6s	***-1.9 mm***	***2.0 mm***	***0.0004***
Difference Vertical L6's	***1.0 mm***	***1.4 mm***	***0.004***
Difference Inclination	***-6.1 degrees***	***4.8 degrees***	***0.00001***

* *denotes P < 0.05 between miniscrew and miniplates.*

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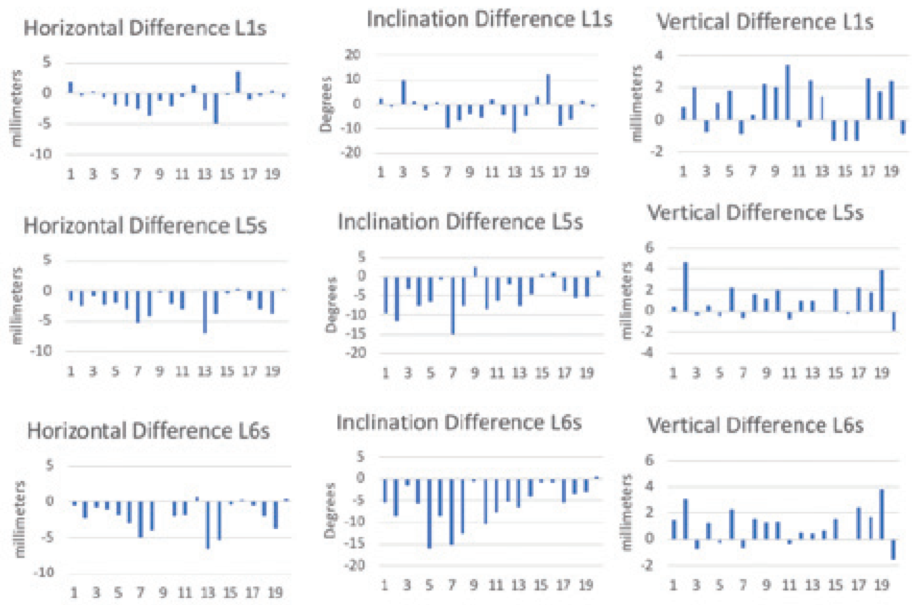

Figure 4. *Individual changes at the incisor, premolar and molar levels.*

found only the vertical level of the premolar and molar was statistically significant between the two groups with miniplates leading to more vertical change (Table 3). This could be due to treatment mechanics, where vertical elastics were needed for finishing or to resolve posterior open bite that occurs often with maxillary distalization or as a consequence of significant posterior bite turbos used to alleviate anterior crossbite (Figure 1). When we compared an average of each distalization measurement to the null hypothesis we found that all values were statistically significant except the incisor horizontal change and their inclination. All other values were $P < 0.05$, and in some cases significantly less. We were concerned that applying multiple t-tests would be associated with some inherent bias, but as the p-values were extremely low it justified our assessment (Table 4).

Regression

In the evaluation of distal tooth movement, there was a significant correlation between the inclination of the palatal plane and the upper incisors (PP to U1), as well as the distal horizontal movement of the L5 and L6.

DISCUSSION

This retrospective study evaluated the outcome of treatment in 20 subjects, treated with mandibular dental distalization utiliizing TADs for anchorage. The subject pool was entirely of Taiwanese descent and was treated in Orthodontic Department at National Taiwan University Hospital. The lateral head films assessed were taken at pretreatment (T1) and post-treatment (T2) time points. The second lateral cephalogram was not in all cases taken immediately after distalization of the mandibular dentition so all dental movement cannot be directly attributed to distalization mechanics, but to complete biomechanics used in Class III orthodontic correction as a whole. Our study illustrates that both methods of mandibular arch movement are effective at distalizing the dentition at all levels including incisors, premolars, and molars.

Although mandibular dental distalization can achieve a successful outcome when treating Class III malocclusions, it is important for clinicians to appreciate the limitations and possible side effects of this type of treatment. When we evaluated how the Class III was corrected we found significant changes of the overjet, maxillary incisor inclination, as well as in maxillary and mandibular molar angulation. It has previously been reported by Enlow that the cant of the occlusal plane can be manipulated to compensate for skeletal discrepancies between jaws in order to achieve a Class I occlusal relationship.[13] Our study confirms Enlow's findings by showing a significant flattening of the occlusal plane of on average 3.25 degrees (data not shown). In a study by Donovan, he found that dentoalveolar compensation for skeletal Class III jaw relationship can be achieved by counterclockwise rotation change of the dentoalveolar complex.[14] This compensatory rotation results in changes in proclination of the maxillary incisors, and a change of the interincisal angle between the maxillary and mandibular incisors. His findings were all supported by our study. Although the values of these measurements may be beyond the range of the normal population, they may well lie within the range of subjects with Class III malocclusion.

When evaluating the amount of distal movement of the mandibular dentition, it is important to focus on the type of movement that occurred. More specifically, how much distal horizontal tooth movement, tooth extrusion, or how much tooth inclination changed. From the nine dental movements evaluated, it was found that the horizontal movement and inclination change of the mandibular incisors did not change significantly. This may be explained by the results of a study by Kim et al.[15] In this study patients with Class III skeletal discrepancies and normal overjet were compared to patients with a Class III skeletal discrepancy and negative overjet, and the results showed that mandibular incisor inclination did not differ significantly between the two groups. This notion is also supported by a study by Björk and Skieller who found that the inclination of the mandibular incisors remains constant in their relationship to the sella-nasion line despite rotations of the mandible.[16] They attributed this to the influence of lips and tongue that maintain a functional incisal occlusion. We found that the lower incisors, second bicuspids, and first molars on average extruded about 1-mm which is to be expected during most orthodontic treatment. The distal movement of the second bicuspids and the molars appear to be associated mostly with distal crown tipping without uprighting of these teeth.

In a study evaluating dentoalveolar compensation in skeletal Class III patients, Kim et al. found that in a group with positive overjet, the maxillary incisors were compensatorily more proclined and the mandibular incisors more retroclined.[15] This study may help understand the correlation between the upper incisor inclination and the amount of distal movement of the mandibular teeth. This association may be present possibly because some patients did not experience normal dentoalveolar compensation. Instead they were compensated through orthodontic treatment with even greater than normal distalization. Another finding of concern was that increased proclination of the upper incisors was a side effect in some patients with a pronounced negative jaw relationship, which could have occurred through limited distalization associated with anatomical restrictions in the mandible or arch length discrepancies in the maxilla. The distalization approach may under those circumstances be contraindicated and a surgical approach might offer a better result.

CONCLUSION

Our study shows that distalization of the mandibular dentition is a predictable and acceptable correction option for patients seeking non-surgical treatment of their Class III malocclusion. Whereas surgical correction of a Class III malocclusion may be the more ideal type of treatment, this study examined an alternative non-surgical approach to correcting this type of malocclusion. Based on the clinical picture and the esthetic concerns of the patient correcting the malocclusion using either TADs or miniplates is a variable alternative to surgical

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correction in patients with a mild to moderate skeletal Class III malocclusion and mandibular overjet. Our study demonstrated that distalization of the lower arch, using miniscrews or miniplates, can achieve ideal results in a broad range of sagittal jaw discrepancies. Dental correction resulted in some retroclination of lower incisors, resulting from distal tipping of lower posterior teeth. While we did see some proclination of the upper incisors, this could mostly be associated with the correction of upper arch crowding.

Whether to choose miniscrews or miniplates for patients who decline orthognathic correction, to be used in the distalization depends on the severity of the sagittal jaw discrepancy of the patient.

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