Original Article

3-Year Follow-Up of Nonextraction Crowded Cases Treated With the Damon System

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ABSTRACT

Objective: The aim of this retrospective study was to investigate treatment efficiency and 3-year follow-up stability of the Damon system by evaluating peer assessment rating (PAR) index, posteroanterior-lateral cephalometric changes, and the intercanine and intermolar widths.

Materials and Methods: Fifty-five patients treated with a 0.022-inch slot Damon D3 MX bracket system were evaluated in this study. Cephalometric radiographs, dental models, and PAR scores were measured and evaluated pretreatment (T1), posttreatment (T2), and 3 years after treatment (T3). Repeated-measures analysis of variance (ANOVA)/paired *t* test were performed to evaluate the differences between the periods.

Results: The mean PAR score of 34.75 at T1 was reduced to 3.35 and 3.05 at T2 and T3, respectively, succeeding in a 90.35% reduction with treatment. At T1–T2 and T1–T3, maxillary intercanine and intermolar width and mandibular intercanine width increased significantly. Although intercanine and intermolar widths decreased in both arches at T2–T3, only maxillary intercanine width showed a small, but statistically significant decrease (0.09 mm, $p=0.001$). Value of SNB angle, Md1-NB (mm), Md1-NB (degrees), and E plane-lower lip increased significantly at T1–T2 and T1–T3. Therefore, treatment resulted in mandibular incisor and lower lip proclination. All of the posteroanterior cephalometric changes were statistically significant except facial width changes at T1–T2.

Conclusions: This study represented satisfactory results and a good follow-up stability with the Damon system. The Damon system can be used for nonextraction treatment in patients with moderate crowding. (*Turkish J Orthod* 2014;27:39–45)

KEY WORDS: Damon, long-term, PAR index, treatment outcomes

INTRODUCTION

Treatment planning is the most important part of orthodontic treatment to obtain functional and esthetic results. Patients with arch length discrepancy may require extraction; however, in some cases the profile may be affected negatively by extraction treatment, and orthodontic treatment can result in a narrow and nonesthetic smile with black buccal corridors.[1,2] The question arises whether such patients can be treated successfully with nonextraction treatment. The decision in borderline cases is generally based on whether orthodontic treatment will result in acceptable facial esthetics and stability of treatment.

Popularity of self-ligating brackets has increased in recent years, though it is a new concept. These bracket systems are claimed to be superior to those of conventional bracket systems.[3] Self-ligating brackets shorten the working durations with the patients, reduce treatment sessions and duration of treatment, and prolong the duration between appointments.[4–6] They enable a more controlled environment with milder forces by minimizing frictional forces in a more hygienic environment.[6–8] It has been suggested that they have superior qualities like reduced disturbance and pain, more enlargement in intermolar width in the arches, less

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To cite this article: Basciftci FA, Baka ZM, Bayram S, Erdur EA. 3 years follow-up of non-extraction crowded cases treated with the Damon system. *Turkish J Orthod*. 2014;27:39–45. (DOI: http://dx.doi.org/10.13076/TJO-D-13-00014)
Date Submitted: October 2013. Date Accepted: May 2014.

proclination of anterior teeth, and therefore a reduced need for tooth extraction.[9]

Self-ligating brackets are divided into 2 main groups—active and passive, depending on closure mechanisms. The Damon system takes its name from the clinician who developed it. It is one of the passive self-ligating bracket systems and has been used widely in orthodontic clinics.[10] However, no studies evaluating the long-term efficiency of self-ligating systems have been encountered in the literature.

The peer assessment rating (PAR) index, one of the parameters used to assess treatment efficacy, was developed as the result of the studies done on orthodontic models at the beginning and end of treatment by the British Orthodontics Standards Assessment Committee 1987.[11,12] The main purpose of the PAR index is to determine a single summary score for all of the occlusal anomalies that may be found in a malocclusion. Scores of each occlusal property are summed up and how far the case has deviated from the normal occlusion and the normal alignment is seen.[13] Richmond *et al.*[11] suggested that the mean PAR score reduction with treatment should be greater than 70% for a good standard orthodontic treatment.

The aim of this retrospective study was to investigate treatment efficiency and 3-year follow-up stability of the Damon system by evaluating the PAR index, posteroanterior-lateral cephalometric changes, and the intercanine and intermolar widths at pretreatment, posttreatment, and 3 years after treatment.

MATERIALS AND METHODS

Fifty-five patients (35 female and 20 male) who met the inclusion criteria and were treated with the Damon D3 MX bracket system at the Department of Orthodontics of Selcuk University were evaluated in this retrospective study. An experienced orthodontist treated the patients. Inclusion criteria were as follows:

(1) skeletal Class I and dental Class I and Class II (maximum 3 mm discrepancy) relationship,
(2) patient in permanent dentition with no congenitally missing teeth,
(3) moderate crowding in both arches,
(4) nonextraction treatment in the maxillary and mandibular arches,
(5) no adjunctive treatment like stripping, molar distalization, and maxillary expansion,
(6) patient age between 12 and 21 years, and
(7) all records were available at the time: T1, before treatment; T2, after treatment; and T3, 3 years after treatment.

Treatment and Retention Procedure

All 55 patients underwent orthodontic treatment with a 0.022-inch slot Damon D3 MX bracket system (Ormco, Glendora, California, USA). The mean age of the sample was 15.62 ± 3.65 years. According to Nance analysis, arch length discrepancies were found 5.49 ± 0.27 mm in the lower arch and 7.06 ± 1.61 mm in the upper arch. Discrepancy of 5.1 mm or more was considered moderate crowding.[14] At the stage of bonding of orthodontic brackets, all teeth ligated directly. The archwire sequence was 0.014-inch Damon copper-nickel-titanium (Cu NiTi) (35°C, Ormco), followed by 0.014 × 0.025 Cu NiTi (35°C, Ormco), and 0.018 × 0.025 Cu NiTi (35°C, Ormco), and finally 0.019 × 0.025 stainless steel. Open-coil springs were used to correct persistent crowding in anterior dentition as required. The archwire sequence used in every patient was the same. Before final lower archwire placement, the archwire was adapted with arch turret according to the individual ideal arch. Intermaxillary elastics were used in accordance with the needs of the patients. The patients were reviewed at approximately 6- to 8-week intervals, and the mean of total treatment time was 20.7 months. After orthodontic treatment 2-2 lingual retainer in the upper arch and 3-3 lingual retainer in the lower arch were bonded, and the patients were instructed to use maxillary Hawley appliance for 2 years for retention. The procedure of using Hawley appliance was as follows: the first 8 months, full time or all day; the second 8 months, 12 hours in a day (only at nights); and the last 8 months, 12 hours every other day.

All records including dental casts; extraoral and intraoral photographs; and panoramic, lateral, and posteroanterior cephalometric radiographs were taken at the beginning of treatment (T1), immediately after treatment (T2), and 3 years after treatment (T3).

Model Measurements

The PAR measurements were carried out using PAR ruler by 1 calibrated examiner (S.B.). The difference between posttreatment and pretreatment PAR scores (PAR T2–T1) and the percentage of PAR score reduction were calculated to express the

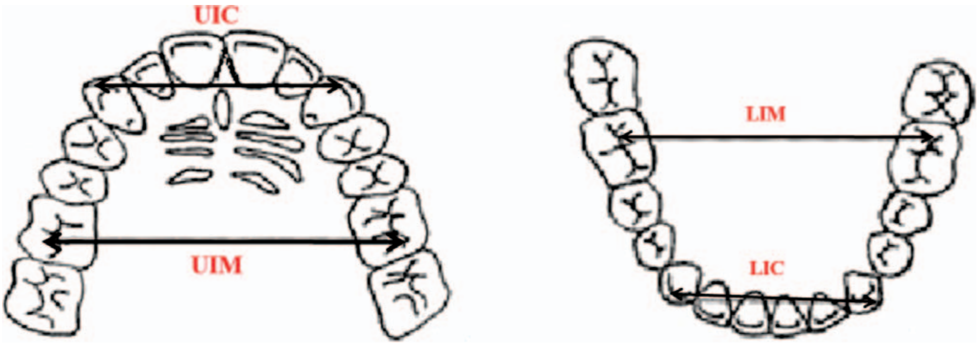

Figure 1. Dental model measurements. UIC indicates upper intercanine width measurement; UIM, upper intermolar width measurement; LIC, lower intercanine width measurement; and LIM, lower intermolar width measurement.

amount of correction with treatment using the following formula: %PAR = PAR T2–T1 × 100 / PAR T1.

Other measurements on dental casts were intercanine and intermolar widths in both arches. They were measured by the same researcher (S.B.). Intercanine widths were measured from the cusp tips of the canines with a digital caliper (Dentaurum, Ispringen, Germany) with an accuracy of 0.01 ± 0.02 mm. Intermolar widths were measured from the occlusal sulcus of the mandibular and maxillary first molars because sulcus was more clearly than the cusps on the impression (Fig. 1). After a 2-week interval from the first measurement, 60 randomly selected dental models (20 from pretreatment, 20 posttreatment, and 20 three years after treatment) were remeasured by the same examiner. The method error was calculated according to Dahlberg formula ($S^2 = \sum d^2/2n$).[15] In this formula, S^2 is the error variance and d is the difference between the first and the second measurements. The systematic error was evaluated with paired *t* tests, for $p < .05$.

Radiographic Measurements

All radiographs were digitally traced with Quick Ceph2000 (San Diego, CA, USA) software by 1 researcher (E.A.E.). After all of the cephalometric tracings were completed, 20 posteroanterior and 20 lateral cephalograms were randomly selected and retraced after a 2-week interval by the same researcher (E.A.E.). Dahlberg formula was used to calculate the method error.[15] The method error did not exceed 0.7° for angular measurements and 0.4 mm for linear measurements. Lateral cephalograms were traced to evaluate skeletal, dental, and soft tissue changes. Four linear and 10 angular measurements were used for assessment (Fig. 2). Posteroanterior cephalograms were traced to evaluate maxillofacial changes. Four linear measurements were used for assessment (Fig. 3).

Statistical Analysis

Statistical analysis was performed by using Statistical Package for Social Sciences (SPSS Inc, Chicago, IL, USA), version 16.0. The descriptive statistics were calculated, and normality of the data was tested using the Kolmogorov-Smirnov test. All of the data exhibited normal distribution except PAR scores. Parametric tests (repeated-measures anal-

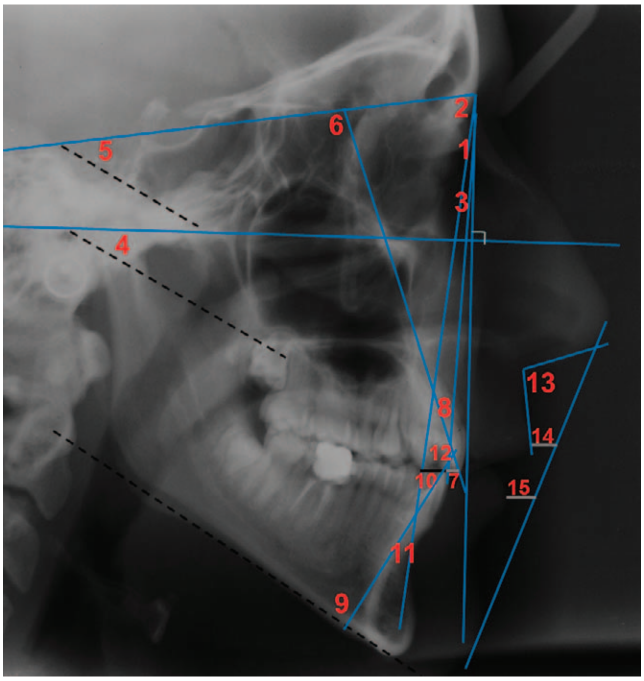

Figure 2. Lateral cephalometric measurements. (1) SNA, degrees. (2) SNB, degrees. (3) ANB, degrees. (4) FMA, degrees. (5) SN-GoGn, degrees. (6) Mx1–SN, degrees. (7) Mx1-NA, mm. (8) Mx1-NA, degrees. (9) IMPA, degrees. (10) Md1–NB, mm. (11) Md1–NB, degrees. (12) Interincisor angle, degrees. (13) Nasolabial angle, degrees. (14) E plane-upper lip, mm. (15) E plane-lower lip, mm.

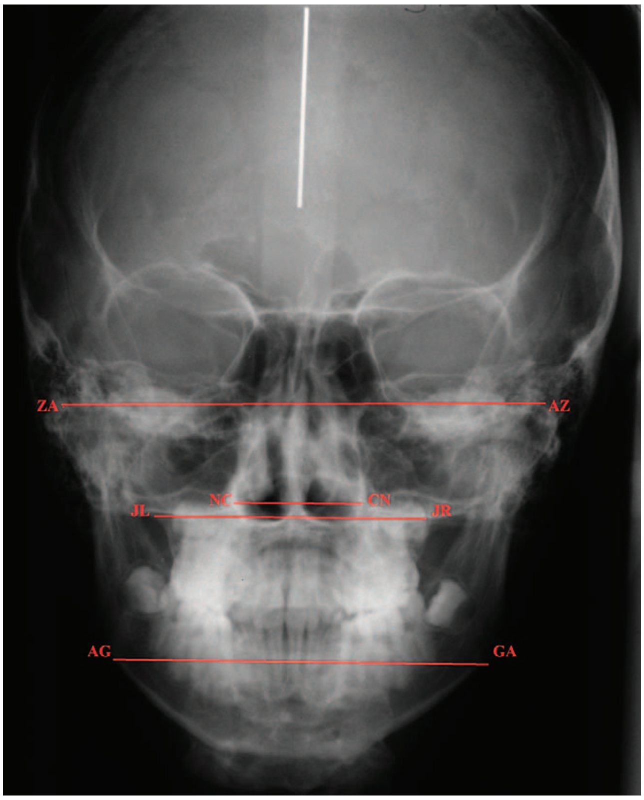

Figure 3. Posteroanterior cephalometric measurements. Facial width (ZA-AZ): ZA, the center of the left zygomatic arch; AZ, the center of the right zygomatic arch. Internasal width (NC-CN): NC, in frontal cross-section of the distal point of the widest region of the nasal cavity on the left side; CN, in frontal cross-section of the distal point of the widest region of the nasal cavity on the right side. Maxillary width (JR-JL): JR, the intersection point of the zygomatic arch and tuber maxilla on the jugular process on the right side; JL, the intersection point of the zygomatic arch and tuber maxilla on the jugular process on the left side. Mandibular width (AG-GA): AG, the lateral and inferior side of the left antegonial notch; GA, the lateral and inferior side of the right antegonial notch.

ysis of variance (ANOVA)/paired *t* test) were performed to evaluate the differences between the periods if normal distribution was present. If the data were not normally distributed, nonparametric tests (Friedman/Wilcoxon signed rank test [Bonferroni correction $p=0.017$]) were used. A *p* value of 0.05 was considered statistically significant with a 95% confidence interval for all tests.

RESULTS

The means and standard deviations at T1, T2, and T3 are presented in Table 1 for PAR score and intercanine and intermolar widths; in Table 2 for lateral cephalometric measurements; and in Table 3 for posteroanterior cephalometric measurements.

Table 1 shows the comparison of PAR score and intercanine and intermolar widths at T1–T2, T2–T3, and T1–T3. PAR scores decreased from T1 to T3. A mean PAR score of 34.75 ± 9.49 at T1 was reduced to a mean of 3.35 ± 2.63 at T2 and a mean of 3.05 ± 2.44 at T3. PAR score changes were statistically significant at T1–T2 and T1–T3 but not at T2–T3. Intercanine and intermolar widths increased at T1–T2 and T1–T3 in both arches; all of the changes were statistically significant except mandibular intermolar width changes ($p=0.212$, $p=0.276$). Mandibular intermolar expansion was approximately 0.2 mm. At T2–T3, intercanine and intermolar widths decreased in both arches; the changes were not statistically significant except maxillary intercanine width changes ($p=0.001$). There was a small (0.09 mm) but statistically significant contraction in maxillary intercanine width.

Table 2 shows the comparison of lateral cephalometric values at T1–T2, T2–T3, and T1–T3. Value of SNB angle, Md1-NB (mm), Md1-NB (degrees), and E plane-lower lip increased significantly at T1–T2 and T1–T3. Therefore, treatment resulted in mandibular incisor and lower lip proclination. There was 2°–3° proclination of mandibular incisors according to Md1-NB (degrees). The other measurements had no statistically significant difference at any time period.

Table 3 shows the comparison of posteroanterior cephalometric values at T1–T2, T2–T3, and T1–T3. All values increased from T1 to T3. All of the changes were statistically significant except facial width changes at T1–T2.

DISCUSSION

Many studies have evaluated efficiency of treatment and initial orthodontic alignment with self-ligating systems.[16–24] However, we did not encounter any study in the literature that evaluated the long-term treatment efficiency of self-ligating systems. The result of the Damon system was not followed after treatment, and the stability of the treatment was not researched. Therefore, in this study we aimed to assess the record of 55 patients at pretreatment, posttreatment, and 3 years after treatment to evaluate the follow-up stability.

In the present study, the PAR index was used to evaluate the treatment effects. The index was specifically developed to objectively audit orthodontic treatment outcomes. However, it has limitations for evaluation of the total effectiveness of treatment.

Table 1. Descriptive statistics and comparison of peer assessment rating (PAR) score and intercanine and intermolar widths at T1, T2, and T3[a]

	T1		T2		T3		Difference Between		
	Mean	SD	Mean	SD	Mean	SD	T1–T2	T2–T3	T1–T3
PAR score	34.75	9.49	3.35	2.63	3.05	2.44	−31.40***	−0.30 NS	−31.70***
Maxillary intercanine width, mm	32.59	2.32	35.26	2.07	35.17	2.09	2.67***	−0.09**	2.58***
Maxillary intermolar width, mm	44.92	2.66	45.81	2.06	45.79	2.07	0.89**	−0.02 NS	0.87**
Mandibular intercanine width, mm	25.93	1.93	26.71	1.59	26.65	1.56	0.78***	−0.06 NS	0.72**
Mandibular intermolar width, mm	40.72	2.22	40.95	1.98	40.93	1.97	0.23 NS	−0.02 NS	0.21 NS

[a] T1 indicates pretreatment; T2, posttreatment; and T3, 3 years after treatment.
** $p < 0.01$; *** $p < 0.001$. NS indicates not significant. n = 55.

Changes in facial profile, cephalometric measurements that reflect skeletal features, are not considered in the PAR index. It also does not evaluate functional occlusion, periodontal health, root resorption, tooth angulations, patient satisfaction, patient compliance, and enamel lesions.[25] The PAR index gives an overall impression of the occlusion and the alignment without taking into account all of the variables. The results of this study showed a mean PAR score of 34.75 ± 9.49 before treatment, which was reduced to a mean of 3.35 ± 2.62 after treatment, and a mean of 3.05 ± 2.43 three years after treatment. It was previously mentioned that the mean PAR reduction with treatment should be greater than 70% for a good standard orthodontic treatment.[11] Our results showed a 90.35% mean PAR score reduction, and treatment exhibited a high standard of orthodontic finishing. No statistically significant change occurred at T2–T3; the decreases in PAR score at this time could be explained by occlusal surface settling of the teeth so the follow-up stability was good in our sample.

Intercanine and intermolar widths increased at T1–T2 and T1–T3 in both arches; all of these changes were statistically significant except mandibular intermolar width. Increases in transverse

Table 2. Descriptive statistics and comparison of lateral cephalometric values at T1, T2, and T3[a]

	T1		T2		T3		Difference Between		
	Mean	SD	Mean	SD	Mean	SD	T1–T2	T2–T3	T1–T3
SNA, degrees	79.77	3.79	80.10	3.58	80.14	3.36	0.33 NS	0.04 NS	0.37 NS
SNB, degrees	77.23	3.81	77.75	3.84	77.91	3.75	0.50*	0.16 NS	0.68**
ANB, degrees	2.51	1.63	2.37	1.46	2.21	1.33	−0.14 NS	−0.16 NS	−0.30 NS
FMA, degrees	26.90	5.36	27.45	5.05	27.10	5.06	0.55 NS	−0.35 NS	0.20 NS
SN-GoGn, degrees	35.96	5.60	35.98	5.57	35.64	5.47	0.02 NS	−0.34 NS	−0.32 NS
Mx1-SN, degrees	101.82	6.85	102.89	5.40	103.01	5.16	1.05 NS	0.11 NS	1.19 NS
Mx1–NA, mm	6.04	2.84	6.38	2.22	6.47	2.45	0.34 NS	0.11 NS	0.43 NS
Mx1-NA, degrees	22.17	6.07	22.97	5.21	23.19	4.80	0.80 NS	0.22 NS	1.02 NS
IMPA, degrees	92.35	6.11	93.67	5.55	93.78	5.43	1.32 NS	0.11 NS	1.43 NS
Md1–NB, mm	5.35	2.57	6.40	2.76	6.38	3.15	1.05***	−0.02 NS	1.03**
Md1-NB, degrees	25.78	6.21	27.82	4.73	27.68	4.70	2.04**	−0.14 NS	1.90**
Interincisor angle, degrees	128.33	9.21	126.78	7.89	127.02	7.75	−1.55 NS	0.24 NS	−1.31 NS
Nasolabial angle, degrees	110.46	10.13	111.11	7.42	110.48	10.52	0.65 NS	−0.63 NS	0.02 NS
E plane-upper lip, mm	−3.45	2.87	−3.02	2.54	−3.06	2.43	0.43 NS	−0.04 NS	0.39 NS
E plane-lower lip, mm	−2.38	2.97	−1.48	2.75	−1.77	2.59	0.90***	−0.29*	0.61*

[a] T1 indicates pretreatment; T2, posttreatment; and T3, 3 years after treatment.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. NS indicates not significant. n = 55.

Table 3. Descriptive statistics and comparison of posteroanterior cephalometric values at T1, T2, and T3[a]

	T1		T2		T3		Difference Between		
	Mean	SD	Mean	SD	Mean	SD	T1–T2	T2–T3	T1–T3
Facial width, mm	120.13	6.41	121.06	6.00	121.82	6.12	0.93 NS	0.76**	1.69**
Nasal width, mm	29.59	2.95	30.91	2.56	31.34	2.78	1.32***	0.43***	1.73***
Maxillary width, mm	63.68	4.37	65.37	4.82	65.98	5.18	1.69***	0.61***	2.30***
Mandibular width, mm	84.25	5.91	86.33	5.28	87.05	5.70	2.08***	0.72**	2.80***

[a] T1 indicates pretreatment; T2, posttreatment; and T3, 3 years after treatment.
** $p < 0.01$, *** $p < 0.001$. NS indicates not significant. n = 55.

dimension could be explained by the use of the wide Ormco Cu NiTi archwires during the initial treatment. The use of adapted final lower archwire to the individual ideal arch and increased bone density of the mandible may be blocking the mandibular molar expansion. Vajaria *et al.*,[23] in a study that compared treatment efficiency of the Damon D3 MX bracket systems and conventional edgewise bracket systems, found that maxillary and mandibular intercanine, interpremolar, and intermolar widths increased significantly after treatment with the Damon system. Pandis *et al.*,[22] in a similar study that evaluated mandibular dental arch changes associated with nonextraction treatment in crowded patients using Damon 2 bracket systems and conventional edgewise bracket systems, found small but statistically significant increases in mandibular intercanine and intermolar widths with the Damon system. Pandis *et al.*[22] and Vajaria *et al.*[23] found about 2-mm mandibular molar expansion, whereas we found approximately 0.2-mm mandibular molar expansion. Other results of these studies are similar to our findings. At T2–T3, intercanine and intermolar widths decreased in both arches, and the changes were not statistically significant except maxillary intercanine width. There was a small (0.09 mm) but statistically significant relapse in maxillary intercanine width. This could be explained by the use of 2-2 lingual retainer in the upper arch and the disuse of the Hawley appliance after 2 years or the use of removable appliance was under the control of patient; therefore, it could have not been used according to the procedure was given.

The results of this study indicated that SNB angle, Md1-NB angle, Md1-NB distance, and E plane-lower lip distance increased significantly at T1–T2 and T1–T3 according to lateral cephalometric radiographs. There were no statistically significant changes at T2–T3, and these results showed a good follow-up stability. In our study, the Md1-NB angle increased approximately 2° to 3°, which is similar to the result of a study by Pandis *et al.*[22] in which Damon 2 bracket systems were used. There was 7° to 8° proclination of mandibular incisors associated with crowding alleviation. Proclination of the incisors was observed by Wahab *et al.*[26] in a study that investigated the difference in clinical efficiency between Damon 3 bracket systems and Mini Diamond conventional ligating bracket systems. Scott *et al.*[19] also found proclination of mandibular incisors and mentioned that excessive proclination may predispose to relapse. However, according to our results 3 years after treatment, there was no statistically significant relapse when incisors were evaluated with lateral cephalograms and PAR index values. However, the presence of fixed retainers should be taken into consideration. Vajaria *et al.*[23] evaluated incisor position and dental transverse dimensional changes using the Damon system in their study, and they found only mandibular incisors were proclined significantly and also advanced anteroposteriorly, supporting our Md1-NB distance results. Proclined teeth may result in gingival recessions, but in this study incisor proclination was relatively less. Therefore, we did not encounter such a problem according to our clinical observation. Increased E plane-lower lip distance could be related to mandibular incisor proclination and advancement.

Also, the results of this study indicated that the value of facial width, nasal width, maxillary width, and mandibular width showed small increases from T1 to T3 according to posteroanterior cephalometric radiographs. Although most of the transverse growth is finished, these results are possibly related to the growth and development have not completed, yet.

This retrospective study evaluated nonextraction treatment in patients with crowding with the Damon system and 3-year follow-up stability. But, in this study we used retainers that may affect the long-term stability. To achieve more reliable results regarding long-term stability, the fixed retainers need to be removed.

CONCLUSIONS

This retrospective study represented a high-standard orthodontic treatment and good follow-up stability with the Damon system. The results of this study suggests that the Damon system can be used for nonextraction treatment in patients with moderate crowding.

The results of this study may give an idea about long-term effects of self-ligating systems to clinicians and will be a reference for future studies.

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