Original Article

Maxillary arch width and buccal corridor changes with Damon and conventional brackets: *A retrospective analysis*

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ABSTRACT

Objective: To evaluate the effect of Damon self-ligating and conventional bracket systems on buccal corridor widths and areas.

Materials and Methods: A retrospective sample of consecutively treated patients using either conventional (CG, n = 45) or Damon self-ligating (SL, n = 39) brackets was analyzed to determine any differences in buccal corridor widths and areas both within and between groups. Pretreatment and posttreatment frontal photographs were transferred to Photoshop CC, standardized using intercanthal width, and linear and area measurements were performed with tools in Photoshop CC. Ratios were then calculated for statistical analysis. Relationships between arch widths and buccal corridors were also examined.

Results: There were no significant differences in the posttreatment intercanine or intermolar widths either within or between the CG and SL groups. There were no significant differences in any buccal corridor width or area measurement either within or between the CG and SL groups. There were strong correlations with the intercanine width and the corresponding buccal corridor smile width measurements. There was an inverse correlation with the buccal corridor area in relation to the canine and the total smile width.

Conclusions: It is likely that posttreatment increases in arch width can be seen in patients treated with either a conventional bracket system or the Damon system. It is highly unlikely that there is any significant difference in buccal corridor width or area in patients treated with the Damon self-ligating system or a conventional bracket system. (*Angle Orthod.* 2016;86:655–660.)

KEY WORDS: Damon; Buccal corridors; Maxillary arch width

INTRODUCTION

In the past two decades, a paradigm has emerged in which frontal facial esthetics are paramount and, more important to orthodontists, how best to position the teeth (the maxillary incisors in particular) to maximize overall soft tissue facial esthetics.[1,2] As part of evaluating frontal facial esthetics, terms such as smile arc, broadness of smile, and buccal corridors have become increasingly important.[3–7] Additionally, claims have been made that one bracket system produces a fuller, wider smile with enhanced facial balance and esthetics.[8]

Following the introduction of Damon system brackets, it was claimed that by using this system, the patient would benefit by improved facial esthetics. According to proponents of the Damon system brackets, considerable expansion can be achieved in the buccal segments, producing a broader arch form (with reduced buccal corridors) that is more in balance with the tongue and cheeks.[8]

Buccal corridors can be defined as that space between the facial surface of the last visible posterior teeth and the corners of the lips when the patient is smiling.[9] Buccal corridors can be influenced by the anteroposterior position of the maxilla, arch form,

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Accepted: August 2015. Submitted: May 2015.
Published Online: September 22, 2015

Table 1. Pretreatment Sample Characteristics

Tx Group	Sex	Age (y) Mean	Age (y) SD	Treatment (Tx) Time (mo) Mean	Treatment (Tx) Time (mo) SD	FMA (°) Mean	FMA (°) SD	Crowding (mm) Mean	Crowding (mm) SD	OB (mm) Mean	OB (mm) SD
Damon (N = 39)	Female (N = 20)	15.15	3.08	21.80	3.55	26.52	6.36	3.30	3.16	3.00	2.20
	Male (N = 19)	15.46	5.08	23.95	7.26	24.96	5.72	1.47	2.80	4.89	2.56
	Damon total	15.30	4.12	22.85	5.70	25.76	6.03	2.41	3.09	3.92	2.54
Convent. (N = 45)	Female (N = 23)	15.23	4.13	26.43	8.00	23.91	5.16	0.35	5.01	4.09	3.01
	Male (N = 22)	14.74	2.71	29.77	5.67	27.05	4.93	3.09	2.49	4.41	2.67
	Convent. total	14.99	3.48	28.07	7.09	25.44	5.24	1.69	4.17	4.24	2.82
All Samples (N = 84)	Female (N = 43)	15.19	3.64	24.28	6.68	25.13	5.83	1.72	4.46	3.58	2.69
	Male (N = 41)	15.07	3.95	27.07	7.02	26.08	5.34	2.34	2.73	4.63	2.60
	Sample total	15.13	3.77	25.64	6.95	25.59	5.59	2.02	3.71	4.10	2.68

maxillary width, and facial pattern.[10–15] However, there is little to no supporting data that bracket systems influence buccal corridors.

The purpose of this study was to retrospectively evaluate the effect of the Damon self-ligating bracket system and conventional edgewise brackets on buccal corridor widths and areas. Our null hypothesis is that there is no difference in buccal corridor widths or areas between patients in a general orthodontic population treated with Damon self-ligating and conventional edgewise brackets.

MATERIALS AND METHODS

Approval was obtained from the University of Pittsburgh IRB prior to performing this study. A retrospective sample of 411 consecutively treated patients using either conventional 0.022-inch Roth edgewise brackets (Victory Series, 3M Unitek, Monrovia, Calif) or 0.022-inch Damon 3 appliance system (Ormco/A Company, Orange, Calif) was selected. Inclusion criteria were all patients (irrespective of Angle classification) who had permanent dentitions, no congenitally missing teeth, no supernumerary teeth, and comparable before-and-after smile widths. No expansion appliances were used. All patients were treated nonextraction with the aim to provide an ideal occlusion according to Andrews' six keys[16] and Roth's guidelines.[17] For each patient in the conventional group, after the teeth were leveled and aligned with 0.014- to 0.018-inch NiTi archwires, 0.018- to 0.018 $\times$ 0.025-inch stainless steel OrthoForm III Ovoid arch forms (3M Unitek) were customized according to the original mandibular arch form. In the Damon group, 0.014- to .018 $\times$ 0.025-inch Ormco copper NiTi (Cu-NiTi) arch wires in the Damon arch form were used out of the box with no customization. We based our sample size calculation on the number of patients necessary to achieve an 80% power with a $P < .05$ to detect a difference in the means in the buccal corridor measurements between groups. The total sample consisted of 84 patients with a mean age of 15.13 years. The conventional group contained 23 female and 22 male patients, whereas the Damon group had 20 female and 19 male patients (Table 1).

Each patient's pretreatment and posttreatment photographs were taken in the standard location in the orthodontic department with ambient lighting. The patients were asked for a relaxed smile with their head in a natural head position. The photos were then uploaded to the Dolphin Imaging System 11.7 Premium (Dolphin, Chatsworth, Calif). The frontal smiling photographs were then transferred to Photoshop CC, wherein all photographic measurements were taken. The pretreatment and posttreatment photographs were maximized to fill the computer screen (17-inch Dell 1707FP monitor; Dell, Inc, Round Rock, Tex).

Linear and area ratios were determined as follows: intercanine distance to smile width (IC:SW); interlast visible maxillary tooth distance to smile width (IL:SW); buccal corridor area in relation to the canine to total smile area (BCC:TSA); buccal corridor area in relation to the last visible maxillary tooth to total smile area (BCL:TSA). Ratios were calculated according to the methods of Hulsey,[18] Johnson and Smith,[12] and Ritter et al.[15] (Table 2). The linear measurement tool was used for linear measurements (0.01 mm). The magnetic lasso tool was used for area measurements to select the smile area (Figures 1 through 3) according to the methods described by Yang et al.[13] The area was recorded as the number of pixels.

Pretreatment and posttreatment maxillary arch digital models (Orthocad Version 3.5, San Jose, Calif) were measured using the arch measurement tool, rather than the traditional method of digital calipers and plaster models, as the measurements have been shown to be equally as accurate.[19,20] To minimize any effects of tipping the teeth buccally, measurements were made using the minimum distance between the linguogingival surface of the maxillary canines and molars and recorded to the nearest 0.1 mm (Table 3).

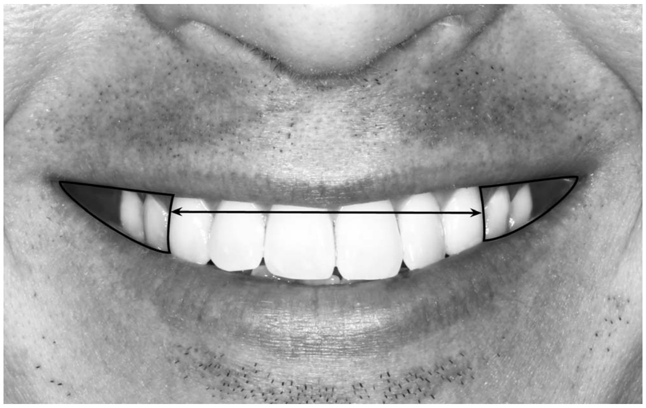

Figure 1. Canine smile width and buccal corridor area distal to the canine.

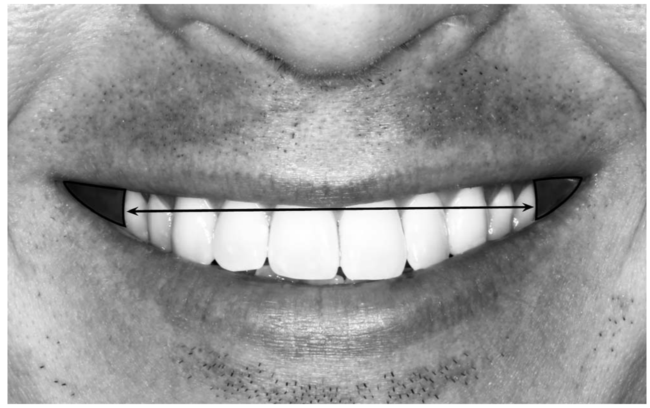

Figure 2. Last visible tooth width and buccal corridor area distal to the last visible tooth.

All pretreatment cephalograms were digitized using Dolphin Imaging 11.7 Premium and digitized with Dolphin software. These measurements were done to determine the vertical facial pattern according to the mandibular plane angle and the anteroposterior dentoalveolar relationship of each subject.

Statistical Analysis

SAS software (version 9.3; SAS Institute, Cary, NC) was used for statistical analysis. Descriptive statistics were calculated for all raw demographic, Orthocad, and photographic measurements. Mean pretreatment and posttreatment values and changes (posttreatment–pretreatment) were calculated for each dependent variable (all Orthocad and photographic measurements). The photographic measurements were converted to percentages for ease of interpretation (Table 2). Potential confounding factors were analyzed prior to any formal testing.

The two treatment groups were compared across all outcomes with multivariate analysis of covariance. The change in posttreatment vs pretreatment scores as the dependent variables and the bracket system (conventional vs Damon) as the main factor of interest were analyzed.

Orthocad measurements were examined to check normality and homogeneity of variance, and 95% confidence intervals were calculated throughout. Additionally, partial correlation coefficients were then calculated to look for any significant relationships between arch width and buccal corridor width and area percentages. Statistical significance was established at $P < .05$.

Table 2. Pretreatment and Posttreatment Buccal Corridor Percentages Within and Between Treatment Groups

	Damon (N = 39)		Convent. (N = 45)		
	Mean (%)	SD	Mean (%)	SD	Absolute Mean Difference (%)
IC:SW[a]					
Pretreatment	63.2	5.9	63.5	7.0	0.3 NS
Posttreatment	63.0	9.7	63.4	5.9	0.4 NS
Mean difference	0.2 NS		0.1 NS		0.1 NS
IL:SW[b]					
Pretreatment	78.0	7.6	79.4	7.6	1.4 NS
Posttreatment	81.7	9.1	82.5	8.9	0.8 NS
Mean difference	3.7 NS		3.1 NS		0.6 NS
BCC:TSA[c]					
Pretreatment	21.8	8.6	22.3	7.6	0.5 NS
Posttreatment	21.9	8.1	23.0	5.9	1.1 NS
Mean difference	0.1 NS		0.7 NS		0.6 NS
BCL:TSA[d]					
Pretreatment	9.9	5.2	8.7	5.8	1.2 NS
Posttreatment	7.2	5.4	6.4	4.8	0.8 NS
Mean difference	2.7 NS		2.3 NS		0.4 NS

[a] IC:SW Indicates intercanine distance to smile width.
[b] IL:SW Indicates interlast visible maxillary tooth distance to smile width.
[c] BCC:TSA Indicates buccal corridor area in relation to the canine to total smile area.
[d] BCL:TSA Indicates buccal corridor area in relation to the last visible maxillary tooth to total smile area.

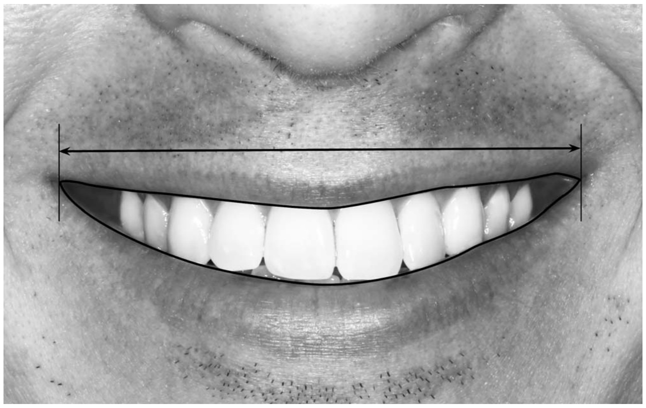

Figure 3. Total smile width and area.

Measurements were repeated 4 weeks after the initial measurements on 20 randomly selected subjects, 10 from each treatment group. The reliability of these repeated measurements was tested using the intraclass correlation coefficient (ICC) with a 95% confidence interval. ICC values ranged from 0.94 to 0.97, indicating a high degree of reliability.

RESULTS

Baseline demographic and clinical characteristics of the patients are given in Table 1. There were no significant differences in any of the pretreatment characteristics.

For between-group buccal corridor outcomes (Table 2), there were no significant differences between any pretreatment or posttreatment measurements of either the conventional edgewise bracket group or the Damon self-ligating bracket group. Interestingly, from pretreatment to posttreatment, the IL:SW ratio increased 3.1% in the conventional group and 3.7% in the Damon group with a corresponding decrease in the BCL:TSA ratio of 2.3% and 2.7%, respectively.

For the within-treatment group outcomes (Table 3), the mean intercanine pretreatment and posttreatment widths were not significantly different in either the conventional group (0.29 mm) or the Damon self-ligating group (0.10 mm). Similarly, there was a measurable (0.42 mm) but not significant intercanine width difference between the pretreatment conventional and Damon group and essentially no difference between the posttreatment conventional and Damon group; however there was an absolute mean difference of 0.39 mm between groups.

Outcomes for the within-treatment intermolar group showed positive width increases of 0.53 mm within the Damon self-ligating group and 0.86 mm within the conventional group; however, neither was statistically significant. Similarly, in the between-treatment group, there were measurable increases in intermolar width between the Damon and the conventional group (0.64 mm), but not statistical significance (Table 3).

We checked for correlations between arch widths and buccal corridors (Table 4). In the pretreatment group, a strong correlation (0.460, $P < .0001$) was found between intercanine width and the IL:SW ratio, whereas a moderate inverse correlation (-0.350, $P < .001$) was shown between the intercanine width and the BCC:TSA ratio. A significant positive finding was seen between the intermolar width and the IL: SW ratio and a significant negative finding with the BCL:TSA ratio.

In the posttreatment group, a significant inverse relationship was found between the intercanine width and the ratio between the buccal corridor area in relation to the canines and the total smile area (BCC: TSA). None of the others reached statistical significance.

DISCUSSION

The marketing of one bracket system as producing broader smiles and smaller buccal corridors than conventional brackets and archwires has been open to debate for a number of years. Manufacturers can make these claims with little or no real evidence to support them. The concept that one type of bracket system produces broader or narrower arches is not

Table 3. Pretreatment and Posttreatment Arch Widths Within and Between Treatment Groups

	Damon (N = 39)		Convent. (N = 45)		Absolute (mm) Mean Difference
	Mean (mm)	SD	Mean (mm)	SD	
Intercanine					
Pretreatment	24.96	2.52	25.38	2.35	0.42 NS
Posttreatment	25.06	1.92	25.09	1.68	0.03 NS
Mean difference	0.10 NS		−0.29 NS		0.39 NS
Intermolar					
Pretreatment	32.78	2.54	33.09	2.59	0.31 NS
Posttreatment	33.31	2.22	33.95	2.45	0.64 NS
Mean difference	0.53 NS		0.86 NS		0.33 NS

Table 4. Pretreatment and Posttreatment Arch Width Correlations* Across Both Groups

	IC:SW[a]	IL:SW[b]	BCC:TSA[c]	BCL:TSA[d]
Intercanine				
Pretreatment	0.460 (<0.0001)	0.081 (0.46)	−0.350 (0.001)	−0.073 (0.51)
Posttreatment	0.118 (0.29)	0.095 (0.39)	−0.279 (0.01)	−0.086 (0.44)
Intermolar				
Pretreatment	0.023 (0.84)	0.248 (0.02)	0.047 (0.67)	−0.225 (0.04)
Posttreatment	−0.160 (0.15)	−0.003 (0.98)	0.067 (0.54)	0.024 (0.83)

* Pearson correlation coefficients (and *P* values).
[a] IC:SW Indicates intercanine distance to smile width.
[b] IL:SW Indicates interlast visible maxillary tooth distance to smile width.
[c] BCC:TSA Indicates buccal corridor area in relation to the canine to total smile area.
[d] BCL:TSA Indicates buccal corridor area in relation to the last visible maxillary tooth to total smile area.

supported by the results of our study. Between the two groups, there was a slight absolute mean difference of 0.33 mm increase in the conventional group arch width; however, this was not statistically significant (Table 3).

In contrast to our findings, both Pandis et al.[21] and Vajaria et al.[22] found a greater intermolar arch width increase in patients treated with the Damon system than in the conventional edgewise group. This difference might be partly explained in the Pandis et al. article by the use of rectangular Cu-NiTi arch wires in the Damon group, while using only round NiTi in the conventional group. In Vajaria et al., significantly larger finishing arch wires in the Damon group coupled with a smaller slot size for the conventional group might explain the greater arch width increase in the Damon group vs the conventional group.

In the pretreatment sample characteristics (Table 1), there was more crowding on average in the Damon female group than there was in the conventional female group. This was due to the excessive spacing in a few female patients of the conventional group, bringing the average crowding in that group closer to zero. By constricting the arch form to close space rather than expanding to relieve crowding, one might expect to see an increase in buccal corridors in the conventional female group; however, our data do not support this. Others have found no predictable relationship between arch widths and buccal corridors.[12]

Additionally, the average Damon treatment time was approximately 5 months less than the conventional group treatment time. However, given that the average age of our test subjects was 15 years of age and that we standardized the photographs using the intercanthal width, this shorter treatment time should affect neither the buccal corridor linear nor area measurements.

Ideally, the same manufacturer and slot size should be used when comparing conventional and self-ligating bracket systems. In our study, the same slot size was used in both treatment systems to remove slot size as a variable, but the brackets were manufactured by different companies. Additionally, the type of NiTi for leveling and aligning was different between the groups (standard NiTi in the conventional group and Damon Cu-NiTi in the Damon group). Again, no statistical differences in any measurements were apparent.

Some interesting correlations were shown between pretreatment Orthocad arch width and corresponding intercanine and intermolar ratios (Table 4). In our study, the strongest positive correlation was between the pretreatment intercanine width and the IC:SW. This is in contrast to the findings of Meyer et al.,[10] who found a correlation in posttreatment widths. These authors[10] noted that several pretreatment measurements were based on a best parallel estimate, so this may have produced an unreliable correlation between arch width and buccal corridor. Posttreatment arches were well aligned, so the measurements were less likely to be skewed. This may be partly explained by fewer ectopically displaced canines in our sample, allowing our pretreatment width to better correlate with smile width.

It can be seen from the standard deviations in Table 2 that there were considerable individual variations in all the linear and area measurements. Consequently, it would not be possible by simply looking at the arch width changes to distinguish that a particular patient was treated with either the Damon system or conventional brackets.

To our knowledge, this is the first study to compare pretreatment and posttreatment buccal corridor widths and areas with different bracket systems. No statistically significant differences were found between the conventional and Damon self-ligating groups of any posttreatment values of the buccal corridor measurements, in relation to either the canines or the last visible maxillary teeth. This is consistent with the findings of Yang et al.,[13] who also found no difference between the mean posttreatment buccal corridor areas for their extraction and nonextraction groups. So, although we determined in this study that significant arch width changes are likely to occur during treatment, the magnitude of difference between the conventional and Damon groups would not appear to be large enough to have clinically relevant effects on buccal corridor widths and areas.

Limitations of this study can be attributed mainly to its retrospective nature, since retrospective data might introduce selection and detection bias. To reduce selection bias, all patients who fulfilled the inclusion criteria were included in the study. Detection bias is unlikely to be an issue because the raters were blinded to the bracket type. Other limitations of this retrospective study would involve information about treatment that was limited to what was available in the patient electronic health records.

CONCLUSIONS

Within the parameters already defined,

- Posttreatment arch width increase is likely to be seen in patients treated by either conventional or Damon self-ligating brackets.
- It is highly unlikely that there is any significant difference in buccal corridor width between patients treated with the Damon system or conventional brackets.

REFERENCES

1. Proffit WR. *Contemporary Orthodontics*. 3rd ed. St Louis, MO:CV Mosby; 2000.
2. Sarver D. The importance of incisor positioning in the esthetic smile: the smile arc. *Am J Orthod Dentofacial Orthop*. 2001;120:98–111.
3. Parekh S, Fields H, Beck F, Rosenstiel S. Attractiveness of variations in the smile arc and buccal corridor space as judged by orthodontists and laymen. *Angle Orthod*. 2006;76: 557–563.
4. Tjan H, Miller G, Josephine G. Some esthetic factors in a smile. *J Prosthet Dent*. 1984;51:24–28.
5. Arnett G, Bergman R. Facial keys to orthodontic diagnosis and treatment planning. *Am J Orthod Dentofacial Orthop*. 1993;103:299–312.
6. Moore T, Southard K, Casko J, Qian F, Southard T. Buccal corridors and smile esthetics. *Am J Orthod Dentofacial Orthop*. 2005;127:208–213.
7. Martin A, Buschang P, Boley J, Taylor R, McKinney T. The impact of buccal corridors on smile attractiveness. *Eur J Esthet Dent*. 2007;29:530–537.
8. Damon D. Damon system: *The Workbook*. Orange, CA:Ormco; 2004.
9. Frush J, Fisher R. The dynesthetic interpretation of the dentogenic concept. *J Prosthet Dent*. 1958;8:558–581.
10. Meyer A, Woods M, Manton D. Maxillary arch width and buccal corridor changes with orthodontic treatment. Part 1: Differences between premolar extraction and nonextraction outcomes. *Am J Orthod Dentofacial Orthop*. 2014;145: 207–216.
11. Ghafari J. Emerging paradigms in orthodontics—an essay. *Am J Orthod Dentofacial Orthop*. 1997;111:573–580.
12. Johnson D, Smith R. Smile esthetics after orthodontic treatment with and without extraction of four first premolars. *Am J Orthod Dentofacial Orthop*. 1995;108:162–167.
13. Yang I, Nahm D, Baek S. Which hard and soft tissue factors relate with the amount of buccal corridor space during smiling? *Angle Orthod*. 2008;78:5–11.
14. Janson G, Branco N, Fernandes T, Sathler R, Garib D, Lauris J. Influence of orthodontic treatment, midline position, buccal corridor and smile arc on smile attractiveness. *Angle Orthod*. 2011;81:153–161.
15. Ritter D, Gandini L Jr, Pinto A, Locks A. Esthetic influence of negative space in the buccal corridor during smiling. *Angle Orthod*. 2006;76:198–203.
16. Andrews L. The six keys to normal occlusion. *Am J Orthod*. 1972;62:296–309.
17. Roth R. Functional occlusion for the orthodontist: part 3. *J Clin Orthod*. 1981;174:182–198.
18. Hulsey C. An esthetic evaluation of lip-teeth relationships present in the smile. *Am J Orthod*. 1970;57:132–144.
19. Mullen S, Martin C, Ngan P, Gladwin M. Accuracy of space analysis with emodels and plaster models. *Am J Orthod Dentofacial Orthop*. 2007;132;346–352.
20. Santoro M, Galkin S, Teredesai M, Nicolay O, Cangialosi T. Comparison of measurements made on digital and plaster models. *Am J Orthod Dentofacial Orthop*. 2003;124:101–105.
21. Pandis N, Polychronopoulou A, Eliades T. Self-ligating vs conventional brackets in the treatment of mandibular crowding: a prospective clinical trial of treatment duration and dental effects. *Am J Orthod Dentofacial Orthop*. 2007; 132:208–215.
22. Vajaria R, BeGole E, Kusnoto B, Galang MT, Obrez A. Evaluation of incisor position and dental transverse dimensional changes using the Damon system. *Angle Orthod*. 2011;81:647–652.