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Evaluation of Maxillary Transverse Arch Dimensions Following Leveling and Alignment with Different Archwire-Bracket Combinations During Fixed Appliance Treatment - A Retrospective Study

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ABSTRACT

Background- Arch expansion is one of the non- extraction methods of gaining space. This study aims to assess and compare the arch expansion achieved during initial leveling and alignment with three different bracket-archwire combinations.

Material and Methods- This was a retrospective study done in a university setup. From the available patient information archives, records of 30 subjects based on their advocated bracket system were identified and categorized into three groups. Their pre-treatment (T0) and post aligning (T2) 3D model maxillary scans were superimposed according to the reference points marked on the third palatal rugae using an OrthoAnalyzer software (3 shape version 19.0) to assess the changes in inter-canine width (ICW), inter-premolar width (IPW) and intermolar width (IMW) and arch length. For the recorded data, descriptive statistics, One-way ANOVA and Tukey HSD post hoc were analyzed using SPSS software.

Results- In Group 1 with MBT prescription with conventional nitinol archwires, the intra-group comparisons revealed no significant change (p value = 0.180). In Group 3 with ceramic MBT brackets with HANT archwires, the intra-group comparisons revealed no significant difference (p value = 0.414). However, in Group 2- Damon self-ligating bracket with broad archwires, intra-group comparisons revealed significant differences in inter-canine and inter-premolar widths (p value = 0.048 and p value = 0.044, respectively).

Conclusion- The study aimed at evaluating transverse maxillary arch dimension changes with different bracket-archwire combinations. Maximum changes in the transverse dimension at ICW and IPW were noticed among all the three groups with maximum in Group 2 (passive self-ligating bracket with broad archwires). Although the inter-group comparisons revealed no statistically significant difference, it was appreciated clinically in relieving dental crowding.

Keywords: Damon, MBT, arch dimension, 3D superimposition.

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INTRODUCTION

Treatment options to correct crowding in the maxillary/mandibular arches in adult patients, owing to tooth size-arch length discrepancy, are limited because growth in the transverse aspect is completed much earlier than that of anteroposterior and vertical aspects. [1] The amount of intra-arch transverse dimension and the arch length-tooth size discrepancy of an individual become crucial factors in decision between extraction and non-extraction treatment protocols. [2] Type of expansion is usually based on the underlying skeletal or dentoalveolar problems. In case of mild transverse discrepancies, expanded arch wires or any or auxiliary expansion arch wires like jockey wire can be used.[3]

Since Charles E. Boyd's introduction of the first self-ligating bracket design in 1930, there has been no turning back. In 1971, Dr. Jim Wildman of Eugene, Oregon, developed the Edge Lok bracket, the first to enjoy any sort of commercial success. [4] In the mid 1990's Dwight Damon popularized the concept of lateral expansion in the dentoalveolar arches by the use of mild expanded arch wires, with the introduction of Damon SL1 brackets. [5] He postulated a theory wherein the use of low friction and light forces contributed to more functionally stable occlusal results. Passive self-ligation employs the use of expanded CuNiTi archwires to reduce the coefficient of friction as compared to conventional bracket systems. [5] Since then, numerous bracket modifications have been introduced for tailored expression of efficient biomechanics. According to the Evans-Durning classification of orthodontic alloys, nickel titanium (NiTi) alloys are classified as phase III (super elastic – active austenitic) 2, II-III. These alloys often exist in two forms: the austenite phase at room temperature which converts to its martensitic phase 1,3 in response to stress, beyond their transitional temperature range (TTR) (well below the oral temperature between 22-28°). It can also be used for the HANT wire (Heat Activated NiTi). Previous studies have compared leveling-aligning efficiency of various archwires in the crowded dental arches. [6] Efficiency of the various arch wires in management of crowded arches has also been studied. [7,8] However, the conventional Nitinol wires also amount to a certain amount of arch expansion to alleviate crowding. Previous literature suggests and report no difference in maxillary arch dimensions with different Damon and the conventional fixed appliance therapy. [9,10)] A study reported lower working forces, but greater alignment efficiency associated with HANT wires. [11] However, most studies did not incorporate the role of ceramic brackets with HANT wire combination to study the maxillary arch transverse dimension changes, when comparing Damon system and conventional MBT prescription.

Therefore, the aim of this study was to evaluate and compare the maxillary arch dimension changes achieved with three bracket-archwire combinations, i.e., passive self-ligating brackets with broad arch wires, metal MBT brackets with conventional Nitinol wires, and ceramic MBT bracket prescription with HANT wires.

MATERIAL AND METHODS

Sample size calculation

This is a retrospective study performed in a university setting. A priori test with an alpha error of 0.05 and power of 0.90 was conducted with G power software (version 3.0.10, Kiel, Germany) using IMPA values from a study by Eslami et al [12] 3D intraoral scan models of 30 patients of both sexes (17 females, 13 males) in the age group of 18-40 years of age with skeletal and dental Class I malocclusion and a complete complement of permanent teeth having

moderate (4-6 mm) crowding in the maxillary arch according to Little's irregularity index, treated with the above-mentioned bracket-archwire combinations with a non-extraction treatment plan. Case records of patients with a history of extraction treatment protocol, malpositioned premolars, periodontal compromise, anomalies of tooth size and number and craniofacial syndromes were excluded from the study. Both arches were treated simultaneously but our study aimed at evaluating changes in the transverse dimensions in the maxillary arch alone. The sample size was set at 10 per group involving archived case records of subjects with mild to moderate crowding treated with either of the three bracket-archwire combinations from April 2021-May 2022, resulting in 30 subjects in total. A convenience sampling method was employed.

The treatment groups were as follows,

1. Group A: Subjects treated with MBT brackets and nitinol archwires.
2. Group B: Subjects treated with Passive self-ligation brackets (Damon™ Q brackets, Ormco™ , California USA) and the broad archwires.
3. Group C: Subjects treated with Ceramic MBT prescription with HANT wires.

The treatment effects of Damon clear self-ligating brackets were not studied since this group did not have adequate subjects that were treated with this modality to meet the sample size criteria. The wire sequencing during the course of the leveling-aligning stage in each group were as follows:

1. Group I- 0.014- 0.016inch NiTi, 0.016 x 0.022- 0.019 x 0.025inch NiTi, 0.019 x 0.025 inch stainless steel (SS) Euroform wire
2. Group II- 0.013 round CuNiTi, 0.014 x 0.025- 0.018 x 0.025inch Ormco Copper NiTi in the Damon arch form, 0.019 x 0.025 inch SS wire
3. Group III- 0.012-0.014inch HANT, 0.016-0.016 x 0.022inch NiTi, 0.017 x 0.025- 0.019 x 0.025 inch SS Euroform wire.

The 3D intraoral scan models of the patients were used for analyzing treatment changes in the groups. Pre- treatment and post-leveling 3D intraoral scan models were collected and analyzed.

Superimposition

All intraoral scans of the patients taken at the beginning of the study (T0) and at the completion of leveling and aligning stage (T1) with the TRIOS intraoral scanner (3Shape, Copenhagen, Denmark) were used for this study. The parameters measured in this study were evaluated on a 3D software program (OrthoAnalyzer; 3Shape).

Only one superimposition procedure was carried out, using the third palatal rugae as a reference landmark. In the first step, the palatal area was manually selected between the pre and post 3D intraoral scan models and viewed in side-by-side superimposition mode on OrthoAnalyzer software. Three reference points on the most prominent points on the third palatal rugae were marked, which was reported to be a stable landmark point for reference. [13] The models were then superimposed by the software according to its best fit algorithm to reach the optimal level of match between the models. The superimposition was illustrated in a difference map, in which the discrepancies were observed by the

color-coded scale. The yellow color depicts the pre-treatment scan model. The green color depicts post-leveling and aligning scan models (Figs 1 & 2).

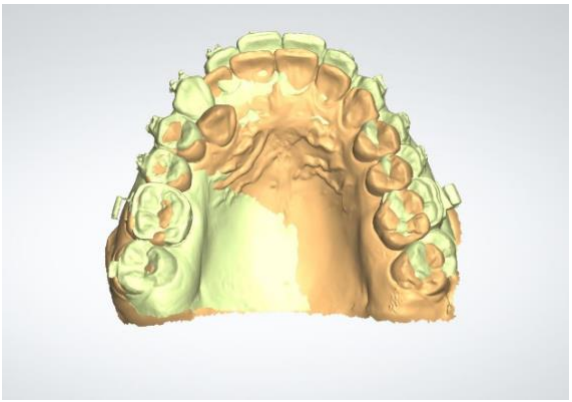

Fig 1: Superimposition of pre (yellow color) and post-aligning (green color) 3D models treated with MBT prescription.

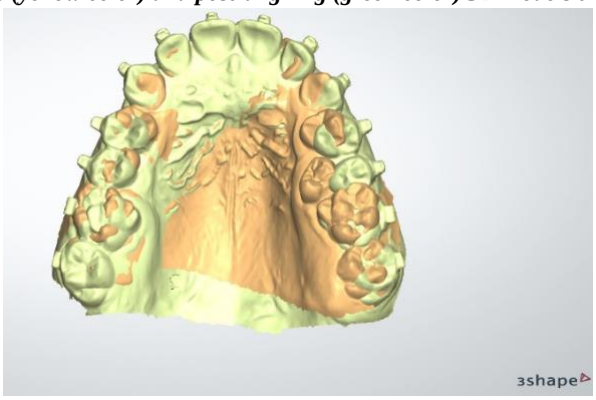

Fig 2: Superimposition of pre (yellow color) and post-aligning (green color) 3D models treated with Damon prescription.

Parameters assessed

To assess and compare the differences in transverse dimensions between T0 and T1 the following parameters were used.

1. Inter-canine width (ICW) (from cusp tip of C1 to cusp tip of C2).
2. Inter-premolar width (IPW) (Buccal cusp tips of first premolar to buccal cusp tips of first premolar on contralateral side).
3. Intermolar width (IMW) (Buccal cusp tips of first molar to buccal cusp tips of first molar on contralateral side).
4. Arch length (From mesial pit of first molar to mesial pit of first molar on contralateral side).

The primary outcome analyzer (HN) was blinded to the groups the 3D model intraoral scans were allotted to. Three readings were recorded, of which the mean reading was taken for final analysis. The readings were repeated after a two week interval to assess intra-observer reliability.

Statistical analysis

The recorded data was subjected to statistical analysis using SPSS V17 Statistics software version 20.0 for Windows. Descriptive statistics was first performed, and the mean, standard deviation and standard error were calculated. The data was tested for normality using the Shapiro-Wilk test. One way ANOVA and Tukey HSD post hoc tests were employed to determine the statistical difference in pre and post ICW, IPW and IMW in all three groups. The probability value (*p* value) was set at 0.05 for statistical significance. Kappa statistics was performed to determine the intra-observer reliability. Any conflict was resolved by discussion with the second author (NB).

RESULTS

Kappa statistics performed to determine the intra-operator reliability showed a value of 0.78, which suggests substantial agreement between the readings.

The descriptive statistics and One-way ANOVA test for the pre and post measurement values in ICW, IPW and IMW for inter-group comparisons are enlisted in Table 1 and Table 2. In our study, the maximum increase in IPW measurements (4.56 mm) and ICW measurements (3.51 mm) was observed in Group 2.

Lowest differences in ICW measurements (2.471 mm) and IPW measurements (3.308 mm) between T0 and T1 stages were observed in Group 3 i.e.. the Ceramic group. Group 1 presented the highest measurements in IMW measurements (2.458 mm) and arch length measurements (3.961 mm).

There was no statistical difference between three groups in terms of inter-canine width, inter-premolar width, intermolar width, arch length.

Table 1: Descriptive statistics and Intra-group comparisons of all three groups.

Parameter		**N**	**Group 1**		**Group 2**		**Group 3**		**Sig (p value)**
			Mean	SD	Mean	SD	Mean	SD	
Inter-canine width	Pre ICW	10	34.720	2.069	34.525	3.2247	33.478	2.7649	.556
	Post ICW	10	36.896	2.122	38.031	2.7445	35.949	2.4064	.180
Inter premolar width	Pre IPW	10	41.821	3.038	40.761	3.1261	40.748	1.3017	.601
	Post IPW	10	44.821	2.112	45.319	2.5280	44.056	1.5717	.414
Inter molar width	Pre IMW	10	50.852	3.727	51.102	3.5647	50.295	2.6034	.859
	Post IMW	10	53.310	2.579	53.100	3.6221	52.329	3.0536	.762
Arch Length	Pre-Arch Length	10	70.643	5.148	70.639	5.5529	66.197	5.2751	.118
	Post Arch Length	10	74.604	5.528	72.879	6.9212	70.060	4.6116	.224

Table 2: Inter-group comparisons with One way ANOVA test for mean differences in ICW, IPW, IMW and Arch length values.

Parameter	N/ group	Group	Mean Difference (pre-post)	Sig (p value)
ICW	10	Group 1	2.176	0.273
		Group 2	3.506	
		Group 3	2.471	
IPW	10	Group 1	3.030	0.198
		Group 2	4.558	
		Group 3	3.308	
IMW	10	Group 1	2.458	0.717
		Group 2	1.998	
		Group 3	2.034	
Arch Length	10	Group 1	3.961	0.464
		Group 2	2.240	
		Group 3	3.863	

DISCUSSION

This study was aimed at determining the difference in transverse dimensions of maxillary arch using different bracket and archwire combinations, by superimposing the pre-treatment and post-leveling and aligning 3D maxillary intraoral model scans.

The results of the study indicate that a non-extraction treatment plan, utilizing all the three treatment modalities was effective in achieving adequate inter-occlusal expansion to alleviate mild to moderate crowding. Maximum increase in ICW, IPW dimensions were seen in Group 2- Passive self-ligating Damon Q brackets with broad archwires. Not only was it statistically significant (p value= 0.048 and p= 0.044, respectively), but it was also clinically significant to alleviate maxillary crowding.

In Group 1 with MBT prescription with conventional nitinol archwires, the intra-group comparisons revealed no significant change (p value = 0.180). In Group 3 with ceramic MBT brackets with HANT archwires, the intra-group comparisons revealed no significant difference (p value = 0.414). However, in Group 2- Damon self-ligating bracket with broad archwires, intra-group comparisons revealed significant differences in inter-canine and inter-premolar widths (p value= 0.048 and p value= 0.044, respectively). There was no statistically significant difference in terms of arch expansion between the three groups, suggesting a similar amount of arch dimension changes and alignment efficiency in all three bracket-archwire combinations.

The results of our study are in agreement with the study by Gianelly et al. who reported an increase in the IPW and IMW of non-extraction cases in the range of 0.81-2.10 mm. [14] This study measured the ICW, IPW and IMW on dental casts of randomly selected extraction versus non-extraction cases to determine if there was narrowing of the posterior dental arches in the extraction group. Weinberg et al reported the greatest expansion at the second premolar region (1.8 mm) and least at the canines (0.9 mm). [15] Our study reported maximum expansion at the first premolar region, similar to the findings in the study by Askari et al. [16]

The ceramic group showed the least increase in ICW, IPW and IMW dimensions. This could be correlated to the fact that ceramic brackets had significantly higher frictional resistance than stainless steel brackets for most wire size-alloy combinations, regardless of slot size. [17-18]

Tipping of teeth would also have compensated to alleviate the crowding; however, 3D intraoral scan models are not sufficient to make this claim. Correlation of these findings with CBCT measurements would have been more accurate and precise. In order to differentiate increases in arch width and alleviation of crowding due to bodily versus tipping movements, evaluation of apical displacement must be made. Root angulation changes measured with the CBCT readings would be more precise. Mah et al. emphasized the need for CBCT evaluation in this regard. [19] A larger sample size with a prospective study design would allow us for more accurate and fair results.

CONCLUSION

Our study aimed to assess the maxillary arch transverse dimension changes among the above-mentioned groups at ICW, IPW, IMW regions. Keeping in mind the limitations of the study, the following conclusions can be made:

1. Significant difference in inter-canine and inter-premolar width in Group 2 (passive self-ligating system with broad arch forms).
2. Maximum increase was seen in the inter-premolar dimension at the first premolar region amongst all the groups.
3. Although the difference between groups was not statistically significant, it was appreciated clinically in relieving upper anterior crowding.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

REFERENCES

1. Pattisapu JV, Gegg CA, Olavarria G, Johnson KK, Ruiz RL, Costello BJ. Craniosynostosis: diagnosis and surgical management. Atlas Oral Maxillofac Surg Clin North Am. 2010 Sep;18(2):77–91.

2. Meyer AH, Woods MG, Manton DJ. Maxillary arch width and buccal corridor changes with orthodontic

treatment. Part 1: differences between premolar extraction and non-extraction treatment outcomes. Am J Orthod Dentofacial Orthop. 2014 Feb;145(2):207–16.

3. Gurgel J de A, Pinzan-Vercelino CRM, Leon-Salazar V. Maxillary and mandibular dentoalveolar expansion with an auxiliary beta-titanium arch. Am J Orthod Dentofacial Orthop. 2017 Oct;152(4):543–52.

4. Mathur P, Tandon R, Chandra P, Dhingra R, Singh P. Self-ligating brackets: from past to present. IP Indian J Orthod Dentofac Res. 2021 Oct 28;7(3):216–22.

5. Damon DH. The Damon low-friction bracket: a biologically compatible straight-wire system. J Clin Orthod. 1998 Nov [cited 2022 Oct 18];32(11).

6. Miles PG, Weyant RJ, Rustveld L. A clinical trial of Damon 2 vs conventional twin brackets during initial alignment. Angle Orthod. 2006 May;76(3):480–5.

7. 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 Aug;132(2):208–15.

8. Turnbull NR, Birnie DJ. Treatment efficiency of conventional vs self-ligating brackets: effects of archwire size and material. Am J Orthod Dentofacial Orthop. 2007 Mar;131(3):395–9.

9. Nam HJ, Flores-Mir C, Major PW, Heo G, Kim J, Lagravère MO. Dental and skeletal changes associated with the Damon system philosophical approach. Int Orthod. 2019 Dec;17(4):621–33.

10. Shook C, Kim S (Michelle), Burnheimer J. Maxillary arch width and buccal corridor changes with Damon and conventional brackets: A retrospective analysis. Angle Orthod. 2015 Sep 23;86(4):655–60.

11. Gatto E, Matarese G, Di Bella G, Nucera R, Borsellino C, Cordasco G. Load-deflection characteristics of super elastic and thermal nickel-titanium wires. Eur J Orthod. 2013 Feb;35(1):115–23.

12. Eslami N, Sharifi F, Nasseri A, Jahanbin A. Comparison of changes in incisors inclination and dental arch dimensions in Damon and MBT systems using Dolphin software. Iran J Orthod. 2021 May 11;15(1).

13. Pazera C, Gkantidis N. Palatal rugae positional changes during orthodontic treatment of growing patients. Orthod Craniofac Res. 2021 Aug;24(3):351–9.

14. Gianelly AA. Arch width after extraction and non-extraction treatment. Am J Orthod Dentofacial Orthop. 2003 Jan;123(1):25–8.

15. Weinberg M, Sadowsky C. Resolution of mandibular arch crowding in growing patients with Class I

malocclusions treated non extraction. Am J Orthod Dentofacial Orthop. 1996 Oct;110(4):359–64.

16. Robert Williams MA, Maureen Stone ER. CBCT assessment of dental and skeletal changes using the Damon versus conventional (MBT) system. Dentistry (Sunnyvale). 2015;5(10).

17. Angolkar PV, Kapila S, Duncanson MG Jr, Nanda RS. Evaluation of friction between ceramic brackets and orthodontic wires of four alloys. Am J Orthod Dentofacial Orthop. 1990 Dec;98(6):499–506.

18. Frictional resistance of ceramic and stainless steel orthodontic brackets. Am J Orthod Dentofacial Orthop. 1990 Nov 1;98(5):398–403.

19. Mah JK, Huang JC, Choo H. Practical applications of cone-beam computed tomography in orthodontics. J Am Dent Assoc. 2010 Oct;141 Suppl 3:7S – 13S.

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