Original Article

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Dentistry Section

Tongue Adaptation and Airway Changes in Two Different Bracket Systems: A Randomised Clinical Trial

SOWMITHRA DEVI SARAVANAN[1], ARAVIND KUMAR SUBRAMANIYAN[2]

ABSTRACT

Introduction: Orthodontics apart from correcting the malocclusions provide an invariably indirect effects on surrounding musculature and airway by means of creating room for proper tongue posture which helps in improvement of oropharyngeal airway dimensions along with dentoalveolar corrections which in this study was experimented with two different bracket systems-MBT and Damon self-ligating systems.

Aim: To assess the adaptation of tongue and oropharyngeal airway changes following treatment with two different bracket systems.

Materials and Methods: This randomised clinical trial was conducted in the Department of Orthodontics, Saveetha Dental College and Hospital, Chennai, Tamil Nadu, India, and included 20 participants and categorised into two groups: Group 1 and group 2 included participants who underwent orthodontic treatment with Damon appliance therapy with Damon Copper NiTi (CuNiTi) wires and MBT prescription with Damon CuNiTi wires. Lateral cephalogram and intraoral scanning was done at the start of orthodontic treatment (T0) and after one year (T1). Cephalometric and occlusal model assessment to determine the adaptation of tongue and Oropharyngeal Dimensions (OD) were determined (T0-T1) using the Facad® and 3-shape software. Independent t-tests and paired t-tests were done to compare T0 and T1 for both the groups were done using Statistical Package for the Social Sciences (SPSS) software.

Results: Results of paired t-tests showed a statistically significant difference at the Interpremolar distance (IPM1) region of both groups 1 and 2 between T0 and T1 (p=0.034, p=0.011), Intercanine distance (IC) of group 2 upper (p=0.043) and IPM2 of both the groups in the upper arch (p=0.042, p=0.022). Cephalometric results showed a significant increase in all the assessed parameters within the groups between T0 and T1 (p<0.05). Oropharyngeal space did not show any difference in both the systems however comparatively increased in group 1 than in group 2.

Conclusion: Treatment with Damon and MBT prescriptions with Damon Cuniti wires showed significant alterations in adaptation of tongue and oropharyngeal space and also in bringing about arch expansion in maxilla and mandible with the greatest expansion noted for first premolar of both the groups and IC and Interpremolar (2nd premolar) width of the upper arch of both the groups.

Keywords: Arch development, Arch expansion, Damon system, MBT system, Self-ligating brackets

INTRODUCTION

Tongue is the most powerful musculature in the craniofacial region. It helps in performing various physiological actions. An unconstricted airway helps in proper ventilation and sleep quality. The genioglossus muscle originates at the inner surface of the mandibular symphysis and inserts into the tongue, genioglossus muscle is the main protruder of the tongue, and acts as an accessory respiratory muscle, resulting in advancement of the base of the tongue and dilation of the upper airway [1]. Tongue plays an important role in maintenance of equilibrium by stability of arch shape and teeth positions [2,3]. According to a study by Fatima F and Fida M tongue posture did not differ among different sagittal skeletal relationships [4]. However, tongue has been found to be important in establishing sagittal skeletal relationships [5]. Another study proved that resting pressure from the tongue in the mandibular arch did not differ in different malocclusions [6].

Various treatment modalities have been employed to improve the tongue posture and increase the airway volume. A previous study by Iwasaki T et al., concluded that expansion of maxilla assisted by rapid maxillary expansion helped in relief of nasal obstruction and improvement of tongue posture [7]. In the present study, we have used two appliance systems, Damon system and MBT system. Former is the self-ligating bracket system and the latter requires elastomeric modules or ligature wires to secure the arch wire to the bracket. Arch expansion helps to create more room for the tongue to rest and raises the tongue posture thereby improving the oropharyngeal airway [8,9].

The Damon system used in the present study presents an idea of lateral arch expansion which was put forward by Dwight Damon in 1996. CuNiTi wires along with self-ligating brackets provide an added advantage of low friction, low force and benefits arch expansion gradually. The concept of "atraumatic remodelling" of periodontal tissues has been evident with Damon appliance therapy as it helps in individual tooth movement with less force yet grouping all the teeth together ultimately resulting in faster alignment when compared to conventional bracket system [10]. The lateral arch expansion, especially at the premolar-molar region could be attributed to the wider arch form of the CuNiTi wires used than that determined by the appliance system itself [11].

On the other hand, a conventional bracket system although not self-ligated it does help in arch expansion. Williams MAR and Stone ERM studied the dental arch dimensions in conventional and Damon system and concluded that both the appliance system equally provided expansion in the premolar region and found no significant difference, also he claims that conventional bracket system with full slot wires overpowers the muscular force thus unwanted proclination cannot be prevented whereas in Damon, the lip musculature helps in alignment of teeth [12]. Another study by Eslami et al., found no difference between conventional and Damon system in terms of changes in incisor position and dental arch dimensions [13].

Thus this study was undertaken to evaluate the positional changes of tongue and airway improvement from the two appliance prescriptions, as no previous research has studied the tongue and airway changes in MBT prescription using Damon CuNiTi wires. This will allow us to determine, if the wider CuNiTi wires that were employed in this trial with both Damon and MBT prescriptions and the ligation system

are responsible for the arch expansion that happens with Damon therapy. The null hypothesis of the study is that no difference exists between conventional and Damon bracket systems.

MATERIALS AND METHODS

This study was conducted as a randomised clinical trial in the Department of Orthodontics, Saveetha Dental College and Hospital, Chennai, Tamil Nadu, India and was approved by the Institutional Scientific Review Board of Saveetha University with an approval number of IHEC/SDC/ORTHO-2001/21/638. The study participant recruitment was done in November-December 2021 and study was completed by December-January 2022.

Sample size calculation: It was done using G*Power 3.1.9.4 software (Germany) with a significance of 5% (0.05) and a power of 90% obtaining a sample size of 20 with 10 participants in each group. The authors had obtained appropriate written and video consent from all the participants included in the study according to recent Helsinki declaration guidelines 2013.

Inclusion criteria:

- Participants with no missing teeth (except for third molars)
- More than 18 years of age
- Crowding ranging from 3-6 mm and greater than 6 mm
- Class 1 skeletal base with an ANB relationship of+2.67°±0.127°
- Ovoid arch forms with Angle's Class I dental relationships
- Non extraction treatment
- Normal vertical proportions mandibular plane angles ranging from 26°-32°
- Mandibular incisor positions ranged from 88°-97° to the mandibular plane
- The maxillary incisor positions to the Sella-nasion plane ranged from 105°-112°.

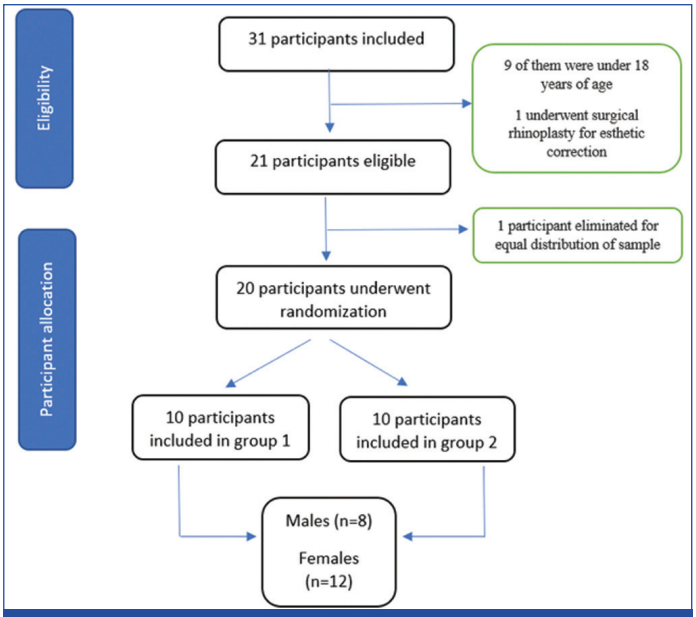
Exclusion criteria:

- No history of oral and maxillofacial surgeries
- No history of nasal or pharyngeal obstruction and related surgeries
- No residual growth evident (CVMI 6)
- No sign of ankyloglossia.

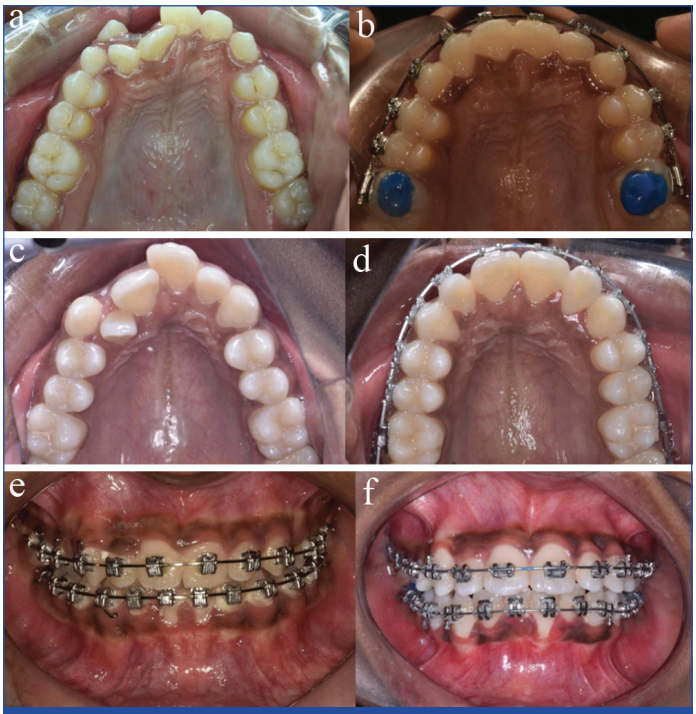
Study Procedure

Randomisation of participants was done by placing concealed envelopes which had letters D (Damon bracket system) or C (conventional bracket system) placed in a black box. Participants were asked to pick one envelope from the black box and were allocated to the groups accordingly with the Damon group being group 1 and the conventional group being group 2. The second investigator allocating the participants into two groups was blinded. The blinding of the clinician (primary investigator) who provides treatment to the participants with either of the bracket systems could not be blinded. Initially, 31 participants were randomly selected and checked for eligibility to take part in the study. Of the 31 participants, nine of them were under 18 years of age and 1 underwent surgical rhinoplasty for esthetic correction. A total of 21 participants were eligible for the study. To get an equal distribution of participants in both the groups' one eligible participant was excluded from the study thus giving a total recruitment of 20 participants with 10 participants randomly distributed into two groups [Table/Fig-1].

All the participants were treated by a single clinician being the primary investigator of the study to avoid any bias. The selected participants of the study were given the brackets both in the upper and lower arch respective of their groups. For group 1 Damon appliance system and for group 2 conventional system 3M Unitek APC with MBT 0.022 prescription was used. Both the groups were given the following sequence of Damon CuNiTi wires: 0.013,



[Table/Fig-1]: Consolidated Standards Of Reporting Trials (CONSORT) flowchart depicting participant allocation.

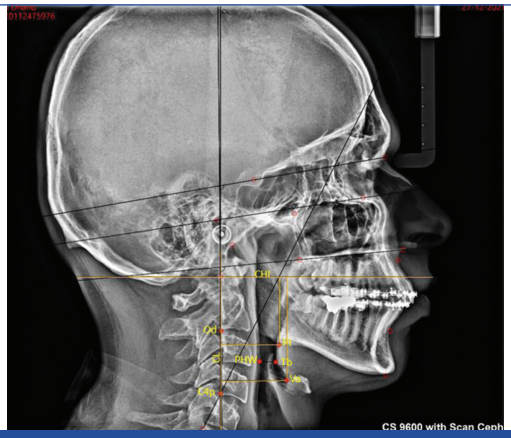


[Table/Fig-2]: a,b) Shows the maxillary arch form at T0 and T1 of a participant belonging to group 1 (Damon brackets with Damon CuNiTi wires); c,d) Shows the maxillary arch form at T0 and T1 of a participant belonging to group 2 (conventional brackets with damon cuniti wires); e,f) Shows group 1 and 2 with their respective brackets and wires.

0.014x0.025, 0.018x0.025 and a stainless steel wire of dimension 0.019x0.025 [Table/Fig-2]. For group 2 ligature wires were used to secure the wire to the bracket. The participants were taken lateral cephalograms and intraoral scans at the end of one year, by the time which the patients should have completed the leveling and aligning stage of orthodontic treatment. All the 20 participants were taken for a lateral cephalogram using CS 9600 machine and intraoral scans using 3-shape intraoral scanners before the bracket placement. Cephalometric landmarks were marked and reference lines were digitally traced on the cephalogram using FACAD software by the primary investigator to avoid error in marking the landmarks. Landmarks and reference lines were marked manually in the FACAD software and not by auto generation of landmarks, a built-in feature of the software. Description of landmarks and reference lines used in evaluating the positional changes of tongue and airway dimensions are mentioned in [Table/Fig-3,4] [14]. For evaluating the occlusal parameters all the participants were taken intraoral scans with TRIOS 3-shape intraoral scanners at the start of treatment (T0) and

Pt	The most posterior point on the contour of tongue
Va (Vallecula)	The deepest point of the vallecula
Tb	Intersection point between the lower border of the mandible and contour of the tongue (The posterior border of the dorsum of the tongue closest to the pharyngeal wall).
Od (odontoid)	The most posterior-superior point of the second cervical vertebrae
C4p	The most posterior-inferior point of the 4th cervical vertebrae
CL (Cervical line)	Line connecting Od and C4p
CHL (Cervical Horizontal Line)	A line drawn perpendicular from Od to CL
PHW (Posterior pharyngeal Wall)	A line drawn along the posterior pharyngeal wall
Pt-CL	Determines the position of tongue in the horizontal plane. Increase in Pt-CL distance denotes more forwardly postured tongue. A perpendicular line drawn from Pt and cervical line
Pt-CHL	Determines the position of tongue in vertical plane. Increase in Pt-CHL distance denotes that tongue is positioned upwards. Line drawn perpendicular to CHL from point Pt
Va-CL	Determines the position of tongue in horizontal plane. Increase in Va-CL distance denotes more forwardly postured tongue. A perpendicular line drawn from point Va to cervical line
Va-CHL	Indicates position of tongue in vertical plane. Increase in Va-CHL distance denotes that tongue is positioned upwards and decrease in Va-CHL distance denotes tongue is placed downwards. Perpendicular line drawn from Va to CHL
PHW-Tb (OD-Oropharyngeal Dimension)	The distance between the Tb point and the posterior pharyngeal wall to evaluate the oropharyngeal dimensions for airway assessment
Intercanine width (IC)	The distance between the cusp tips of right and left canines.
Interpremolar width 1 (IPM1)	The distance between buccal cusp tips of the first premolars.
Interpremolar width 2 (IPM2)	The distance between buccal cusp tips of the second premolars.
Intermolar width (IM1)	The distance between the mesiolingual cusp tips of the first molars.

[Table/Fig-3]: Landmarks and reference lines used in evaluating oropharyngeal airway dimensions and positional changes of tongue in horizontal and vertical planes [14].

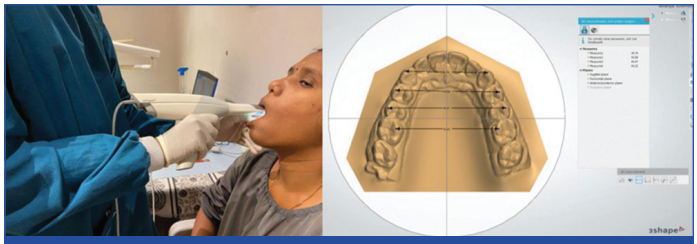


[Table/Fig-4]: Solid red points and yellow lines show the markings and reference planes for assessing the tongue position in horizontal and vertical dimensions.

one year after treatment (T1) [Table/Fig-5a,b]. The measurements to determine the IC, IPM1, IPM2, Intermolar (IM) were done using the 3-shape digital system software. The intraoral scans were taken at T0 and T1 by a single investigator to avoid bias.

STATISTICAL ANALYSIS

The differences in cephalometric and occlusal parameters were entered in excel spreadsheet and was imported to version 23.0 SPSS software. Descriptive statistics to record the mean IC, IPM1, IPM2, IM was done. The intergroup and intragroup differences between



[Table/Fig-5]: a) Intraoral scanning with TRIOS 3-shape scanner; b) occlusal parameters (IC, IPM1, IPM2, IM1) evaluated using digital models in 3-shape software.

T0 and T1 of both the groups were subjected to independent t-tests and paired t-tests at a significance level of $p<0.05$.

RESULTS

Of the 20 participants included in the study, 8 of them were males and 12 of them were females and all of them were 28±4 years of age. Paired t-test done to evaluate the intragroup changes for adaptation of tongue using lateral cephalogram shows a statistically significant difference between T0 and T1 that was noted for both the groups except for OD (PHW-Tb) ($p<0.05$) [Table/Fig-6]. This shows both the groups perform equally well in improving the position of tongue and regardless of the bracket system used. However, no difference in terms of oropharyngeal airway was noted within the groups ($p<0.05$).

Parameters		Mean	SD	p-value
MBT PT-CL	T0	28.6	1.71	0.046
	T1	30.34	1.83	
Damon PT-CL	T0	28.31	1.6	0.006
	T1	29.54	2.02	
MBT VA-CL	T0	30.26	1.81	0.001
	T1	31.82	2.44	
Damon VA-CL	T0	29.41	1.67	0.051
	T1	30.34	1.99	
MBT PT-CHL	T0	30.18	2.63	0.038
	T1	31.13	3.2	
Damon PT-CHL	T0	27.31	2.72	0.043
	T1	27.7	2.67	
MBT VA-CHL	T0	30.7	2.77	0.029
	T1	34.31	2.23	
Damon VA-CHL	T0	30.15	4.95	0.003
	T1	30.8	5.18	
OD MBT	T0	13.53	0.91	0.065
	T1	13.55	0.93	
OD Damon	T0	14.32	0.77	0.079
	T1	14.55	0.79	

[Table/Fig-6]: Paired t-test showing differences between T0 and T1 for the cephalometric parameters assessed ($p<0.05$).

[Table/Fig-3] shows the mean IC, IPM1, IPM2, IM in regard to both the groups but the increase was statistically not significant ($p<0.05$) [Table/Fig-7]. Mean increase in IPM1 and IPM2 at T1 was noted for both the groups however it was greater with group 1 than for group 2 especially for IPM1. Minimal increase in IM width for both the groups was noted at T1 [Table/Fig-7]. Statistically significant differences between T0 and T1 were noted for IPM1 (upper and lower arch) of both the groups and IPM2 showed a significant increase only in the upper arch ($p<0.05$) [Table/Fig-7]. Inter-group comparison between the groups did not show any statistically significant difference except for Od, which favoured Damon group ($p<0.05$) [Table/Fig-8,9].

DISCUSSION

The study focuses on alteration of tongue position with two different appliance systems which can be greatly altered with skeletal

		Upper						Lower					
		MBT			Damon			MBT			Damon		
		Mean	SD	T0-T1	Mean	SD	T0-T1	Mean	SD	T0-T1	Mean	SD	T0-T1
IC	T0	31.18	1.22	**0.062**	29.31	1.96	**0.043**	33.64	0.61	**0.068**	28.31	1.43	**0.231**
	T1	31.65	1.43		29.95	2.01		33.65	1.1		28.33	1.52	
IPM1	T0	44.65	1.23	**0.034**	40.59	2.47	**0.011**	48.63	2.96	**0.043**	46.93	2.3	**0.039**
	T1	44.99	1.45		41.13	2.05		48.71	3.14		47.22	1.39	
IPM2	T0	43.96	2.84	**0.042**	40.52	3.21	**0.022**	47.66	3.23	**0.072**	45.68	2.34	**0.064**
	T1	44.25	2.13		41.21	2.67		47.83	3.75		46.31	2.06	
IM1	T0	46.23	1.99	**0.121**	41.66	2.32	**0.063**	49.98	1.13	**0.136**	47.62	2.01	**0.196**
	T1	46.25	2.34		41.82	2.41		50.01	1.25		47.73	1.45	

[Table/Fig-7]: Descriptive statistics showing mean and SD of IC, IM, IPM1, IPM2 as measured in digital models and paired t-test showing difference in significance between T0 and T1 for the occlusal parameters (p<0.05).

	T0			T1		
Parameters	MBT	Damon	p-value	MBT	Damon	p-value
Pt-CL	28.6	28.31	0.056	30.34	29.54	0.084
Va-CL	30.26	29.41	0.126	31.82	30.34	0.195
Pt-CHL	30.18	27.31	0.185	31.13	27.7	1.314
Va-CHL	30.7	30.15	2.154	34.31	30.8	1.784
Od	13.17	13.4	0.59	13.89	14.23	**0.001**

[Table/Fig-8]: Independent t-test showing intergroup comparison of cephalometric parameters assessed in the study for both the groups at T0 and T1 (p<0.05)

	Upper						Lower					
	T0			T1			T0			T1		
Parameters	MBT	Damon	p-value	MBT	Damon	p-value	MBT	Damon	p-value	MBT	Damon	p-value
IC	31.18	29.31	0.653	31.65	29.95	0.238	33.64	28.31	0.639	34.01	28.53	0.691
IPM1	46.23	41.66	0.589	47.11	42.12	0.431	49.98	47.62	0.112	50.01	47.73	0.468
IPM2	44.65	40.59	0.381	44.99	41.13	0.688	48.63	46.93	0.231	48.71	47.22	0.336
IM1	43.96	40.52	0.465	44.25	41.21	0.579	47.66	45.68	0.665	47.93	46.01	0.758

[Table/Fig-9]: Independent t-test showing intergroup comparison of occlusal parameters measured in the study (p<0.05).

relationships, malocclusion, muscular imbalances [4,5,11]. The airway changes induced by orthodontic movements affect the room for the tongue, thereby affecting the position of the hyoid bone and causing a subsequent change in the dimensions of the posterior airway [14].

The results of the study show a statistically significant difference (p<0.05) between pre (T0) and post (T1) one year of orthodontic treatment with two different appliance systems, indicating both the appliance systems are equally effective in improving the tongue position for all the parameters evaluated for tongue position in horizontal and vertical dimensions except for Od-MBT and Od-Damon. This shows an improved tongue position to a more forward direction which will eventually adapt to this newer position. However, the oropharyngeal airway did not show much of a difference between T0 and T1. This shows the extent of arch expansion to gain room for the tongue is not sufficient enough to increase the airway. The results are similar to a study conducted by Ozdemir F et al., in which he had evaluated the oropharyngeal airway changes with a fixed functional appliance and found even with mandibular repositioning with fixed functional appliances the airway does not improve in young adults [14].

The effect of the two appliance systems used in the present study to gain room for tongue is much less compared to that achieved by a fixed functional therapy [14]. Hence, it is not surprising to note insignificant differences in oropharyngeal airway dimension. The results of intergroup comparison of T0 and T1 for both groups did not show any significant difference for all the cephalometric parameters studied except for the Od dimensions which was significant statistically favouring Damon group. A similar study by Bruno da Silva V on Cone Beam Computed Tomography (CBCT) assessment of airway changes in Damon group of patients did not find any improvement in Od, which is in contrast to the results of the present study [15]. The observable statistical significant difference is small that it cannot be generalised to the results that the Damon group does actually help in improving the Od.

Significant difference was noted for IC in group 1 only in the upper and not in the lower arch. This could be attributable to variable cortical bone thickness in maxilla and mandible [16]. Both the groups showed greatest expansion in the region of 1st premolars which is similar to the results of the study by Williams MAR and Stone ERM [12]. Least expansion was noted in the first molar region in both the groups and in the second premolar region, especially in the lower arch which might be attributable to cortical bone thickness which is greater in the posterior region of maxilla and mandible [17]. However, compared to group 2, the Damon group showed greatest expansion for almost all the occlusal parameters although a statistically significant difference was observed only for IC, IPM1, IPM2 of upper arch and IPM1 of lower arch. This shows the Damon group (group 1) is comparatively more effective in expansion of arches than the conventional bracket system (Group 2) even though a statistical difference was not obtained. Also, results from the study depicts a major contribution to the arch expansion is majorly by the wider arch form CuNiTi wires as both the groups were employed the same wires and significant difference was noted among the groups for T0 and T1 and partly by the type of bracket (Damon group showed increase in arch width when compared to MBT group), as no statistical difference is appreciated between the two groups.

Limitation(s)

Difference in gender distribution, different brands of brackets used could influence the results of the study.

CONCLUSION(S)

Within the limitations of the study, the results of the study showed arch width increased in both the groups, with the Damon group being more effective than conventional group, thus rejecting the null hypothesis. The greatest expansion was observed in the IPM1 region of both groups with a statistically significant difference between T0 and T1. Statistically significant difference was also observed for IC of

Group-2 upper and IPM2 of both the groups in the upper arch. The Od improved comparatively in Damon group. Further research with larger sample size is required in future, to provide stable results.

Acknowledgement

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Authors' contributions: The study design, manuscript correction, and formatting were done by Dr. AK; study execution, data collection, data analysis, and manuscript preparation were done by Dr. SD; and data analysis was rechecked by Dr. AK. All authors have made substantial contributions to the present study, and all have reviewed the final paper prior to its submission. Finally, all authors have given approval for publication.

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PARTICULARS OF CONTRIBUTORS:
1. Postgraduate, Department of Orthodontics, Saveetha Dental College and Hospital, Chennai, Tamil Nadu, India.
2. Dean and Head, Professor, Department of Orthodontics, Saveetha Dental College and Hospital, Chennai, Tamil Nadu, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Sowmithra Devi Saravanan,
A-1008, Radiance Royale Apartment, Poonamalle High Road,
Velappanc Havadi, Chennai, Tamil Nadu-600056, India.
E-mail: 152008001.sdc@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Oct 25, 2022
- Manual Googling: Dec 28, 2022
- iThenticate Software: Jan 13, 2023 (10%)

ETYMOLOGY: Author Origin

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- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

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