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Comparative assessment of buccal corridor, arch width and incisor inclination in cases treated with damon and conventional bracket system

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Abstract

Background: Extractions are frequently used to treat crowding, protrusion of teeth and the soft tissue covering. The common consequences of extraction therapy were believed to be "dished-in profiles", constriction of dental arch, and increased width of the buccal corridor space, whereas non-extraction treatment results in poor stability and protrusive profile in borderline cases.

Purpose: To comparatively evaluate conventional MBT bracket system and Damon passive self-ligating system in terms of maxillary arch width, incisor position and inclination and buccal corridor area.

Materials and Methods: 20 non-extraction cases were retrospectively selected and divided into 2 groups. Group I included 10 patients (mean age, 14.33 ± 2.49 years) who had been treated with conventional bracket system while Group II included 10 patients (mean age =

15.55 ± 2.11 year) who had been treated with Damon passive self-ligating system. For each patient, pre and post treatment measurements were taken for maxillary arch width on study models, incisor position and inclination on lateral cephalograms and buccal corridor area on extraoral photographs and all these measurements were compared to see whether significant differences exist between the two groups.

Results: The results showed significant differences in maxillary arch width, incisor position and inclination and buccal corridor area after treatment in each group ($P < 0.001$). However, when these measurements were compared among the 2 groups, no significant difference was found ($P > 0.001$).

Conclusions: Irrespective of the bracket system used, in non-extraction cases, crowding is alleviated by conjunction of both transverse expansion and incisor proclination.

Keywords: Damon bracket system, conventional bracket system, arch width, buccal corridor, incisor inclination and proclination.

Introduction

The face is the most important individual factor determining the physical appearance of a person and the hard and soft tissues of oral cavity are considered fundamental in facial aesthetics.[1] Some clinicians believe that tooth extractions narrow the dental arches which results in wide buccal corridors, compromising the smile and facial aesthetics. Also, the treatment time with extraction was longer when compared to the non-extraction treatment. These problems along with the advancements in orthodontic techniques and appliances, have led to the paradigm shift from extraction to non-extraction treatment protocol.[2]

In the 1990s, Dwight Damon worked on a philosophy which stated that if a patient's face is harmonious, in most cases, a full complement of teeth can be accommodated without the need for extraction using the threshold force that must be kept low to prevent occlusion of the blood vessels in the periodontal membrane allowing the cells and the biochemical messengers to be transported to the site of bone resorption and apposition, permitting tooth movement.[3] This led to the development of Damon self-ligating system. It is believed that low orthodontic forces exerted by expanded Cu NiTi archwire used in damon appliances, do not overpower the lip musculature and thus prevents the incisors from "dumping" forward during non-extraction treatment and teeth follow the path of least resistance laterally & distally causing arch expansion.

Many studies have been carried out to compare the changes after non-extraction treatment using Damon passive self-ligating system and conventional bracket system. But interestingly there have been only few studies that support Damon's belief of greater arch width in the Damon groups than in the conventional bracket groups.[4-6] In contrast, several studies showed no difference between the two with respect to transverse arch dimensional changes and incisor position.[7, 8]. Infact some studies[4-6] even found an increase in incisor inclination after treatment using Damon appliance contrary to what was proposed by Damon. Also, there are few studies so far, that compare change in buccal corridor using Damon passive self-ligating system and conventional bracket system. Some clinician believe that buccal corridor is influenced by the anteroposterior position of maxilla, arch form, maxillary arch width, and facial pattern.[2] However, the results in the literature do not provide a clear comparison of these bracket systems in terms of arch width, incisor position and buccal corridor area.

So, the purpose of this clinical study was to evaluate and compare the maxillary arch width changes, anteroposterior change in the position and inclination of the incisors, and buccal corridor area changes in non-extraction cases treated using Damon and conventional bracket system.

Material and method

A total of 20 non-extraction cases were retrospectively selected from the records of department of Orthodontics and Dentofacial Orthopaedics of the Institute. Ethical approval was obtained from the university institutional review board. The patients were selected according to the following inclusion criteria: permanent dentition, mild to moderate crowding, comparable smile width before and after treatment and availability of pre and post-orthodontic treatment records. The patients were excluded if there was any congenitally missing or supernumerary teeth prior to orthodontic treatment, facial asymmetry, treated orthodontically with tooth stripping or with the use of adjunctive appliances such as quad helix, functional appliances and rapid palatal expander.

Group I included 10 patients (mean age, 14.33 ± 2.49 years) who had been treated with conventional bracket system (022 slot 3M Unitek Gemini, Monrovia, USA). Group II included 10 patients (mean age = 15.55 ± 2.11 year) who had been treated with Damon Clear (022 slot passive self-ligating appliance system, San Diego, Calif). All these patients had been treated by non-extraction treatment protocol with the aim to provide an ideal occlusion according to Andrew's six keys and Roth's guidelines. No other appliances for expansion had been used. In group I, after leveling and alignment, 0.019 X 0.025-inch stainless steel broad arch form was used as opposed to group II, wherein 0.018 X 0.025-inch CuNiTi arch wires followed by 0.019 X 0.025-inch stainless steel in Damon arch form had been used without any customization.

Method of analysis

For each group, pre-treatment and post treatment measurements were taken for arch width on dental cast, incisor inclination and position on lateral cephalogram (Allengers Smart PAN 2K150330009-D9) and buccal corridor area on frontal view photograph using Photoshop CC. All the measurements were taken by 1 examiner. The intra-examiner reproducibility of the measurements was assessed by replication of the measurements at 4 weeks interval by the same examiner. Reliability was calculated by intraclass correlation coefficient and 99% confidence intervals for each clinical parameter.

Study model

A digimatic caliper (Mitutoyo, ABSOLUTE); CD-6" CSX was used to measure the following transverse maxillary dimensions on the pretreatment and posttreatment models (Figure 1):

(1) Inter canine width, the distance between the maxillary right and left canine cusp tips.

(2) Inter1stpremolar width, the distance between the buccal cusp tips of the maxillary right and left first premolars.

(3) Inter2ndpremolar width, the distance between the buccal cusp tips of the maxillary right and left second premolars.

(4) Intermolar width, the distance between the Mesiobuccal cusp tips of the maxillary right and left first molars.

Figure 1: Arch dimension measurements on dental study casts: I, inter canine width; II, inter first premolar width; III, inter second premolar width; IV, intermolar width.

Lateral cephalogram

Both pre and post-treatment lateral cephalogram of each subject were studied for 2 linear parameters namely, upper central incisor to NA plane (U1 to NA), lower central incisor to NB plane (L1 to NB) and 4 angular parameters namely, upper incisor to SN plane (U1 to SN), upper incisor to NA plane (U1 to NA), lower incisor to NB plane (L1 to NB), lower incisor to mandibular plane (L1 to Go-Gn) (Table 1) (Figure 2).

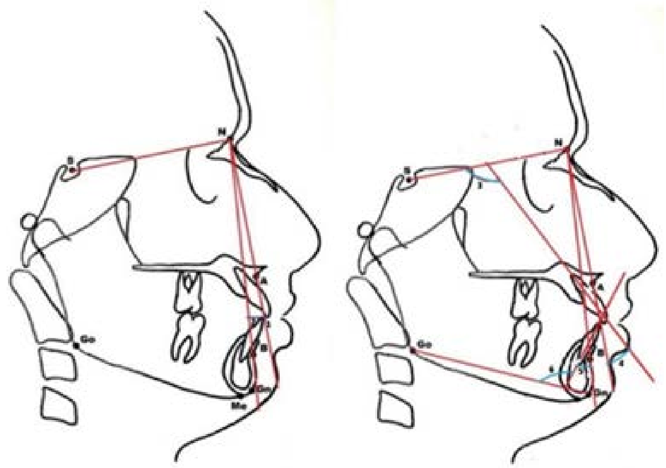

Figure 2: Lateral cephalometric linear and angular parameters: 1, U1 to NA (mm); 2, L1 to NB (mm); 3, U1 to SN (^{o}); 4, U1 to NA (^{o}); 5, L1 to NB (^{o}); 6, L1 to Go-Gn (^{o}).

Table 1: Landmarks and planes used and variable measured.

S. No.	Landmarks	Name	Description
	Point A	Subspinale	The deepest mid-point on the pre-maxilla between the anterior nasal spine and prosthion.
	Point B	Supramental	The most posterior point in the concavity between infradentale and pogonion.
	S	Sella	Geometric center of pituitary fossa located by visual inspection.
	N	Nasion	The intersection of the inter-nasal suture with the nasofrontal suture in the midsagittal plane.
	Go	Gonion	A point on the curvature of the angle of the mandible located by bisecting the angle formed by lines tangent to the posterior ramus and the inferior border of the mandible.
	Gn	Gnathion	A point located by taking the midpoint between the anterior (pogonion) and inferior (men ton) points of the bony chin.
	Me	Men ton	The lowest point on the symphyseal shadow of the mandible seen on a lateral cephalogram.
Cephalometric Planes			

	S-N	SN plane	The plane between the points N (nasion) and S (Sella).
	Go-Gn	Mandibular plane	The plane between the points Go (gonion) and Gn (gnathion).
	N-A	NA plane	The plane between the point N (nasion) and point A.
	N-B	NB plane	The plane between the point N (nasion) and point B.
Variables Description			
Linear Measurements			
	U1 to NA	Distance of upper incisor from NA plane	Distance between incisal edge of the upper central incisor to NA plane.
	L1 to NB	Distance of upper incisor from NA plane	Distance between incisal edge of the lower central incisor to NB plane.
Angular Measurements			
	U1 to SN	Inclination of upper incisor to SN plane	Angle formed by intersection of the long axis of upper central incisor and SN plane.
	U1 to NA	Axial inclination of upper incisor	Angle formed by intersection of the long axis of upper central incisor and NA plane.
	L1 to NB	Axial inclination of lower incisor	Angle formed by intersection of the long axis of lower central incisor and NB plane.
	L1 to Go-Gn	Inclination of lower incisor to mandibular plane	Angle formed by intersection of the long axis of lower central incisor and mandibular plane.

Extra oral photograph

Each patient's pretreatment and posttreatment frontal view photographs that had been taken in the standard location in the orthodontic department with ambient lighting is collected from the records. For all the photographs, patients had been asked for a relaxed smile with their head in a natural head position. Each photograph was maximized to fill the computer screen (15.6-inch Dell P47F monitor; Dell), in photoshop CC. The magnetic lasso tool was used for buccal corridor area measurements. The area was recorded as the number of pixels (Figure 3a and 3b). Ratios were calculated according to the methods of Hulsey[9], Johnson and Smith[10], and Ritter et al[1]. Area ratios were determined as;

- BCC: TSA- total area of right and left buccal corridor in relation to canine / total smile area x 100 [%].
- BCL: TSA- total area of right and left buccal corridor in relation to last visible maxillary tooth / total smile area x 100 [%].

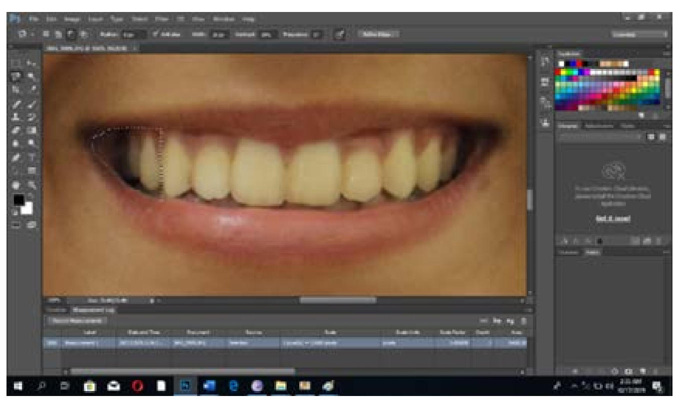

Figure 3a: Right side buccal corridor area in pixels measured from canine.

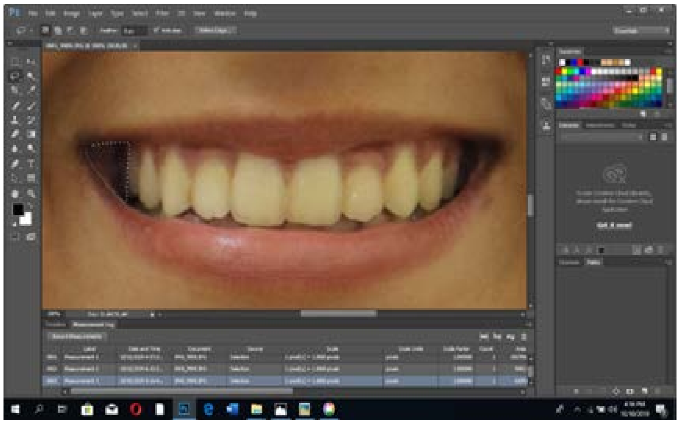

Figure 3b: Right side buccal corridor area in pixels measured from last visible teeth.

Statistical analysis

SPSS software version 22 was used for the statistical analysis. For intragroup comparison, paired t-test was used to evaluate the statistical significance of the mean differences between the pre-treatment and post-treatment measurements. For intergroup comparison, unpaired t-test was used to find significant difference in between the groups. A P-value of less than 0.05 was considered statistically significant.

Results

The mean age in Group I was 14.33 ± 2.49 years and Mean age in Group II was 15.55 ± 2.11years. Upper arch crowding in Group I was 4.65 ± 1.92 mm and in Group II was 5.60 ± 2.47 mm, Lower arch crowding in Group I was 4.50± 1.72 mm and in Group II was 4.70 ± 2.64 mm.

Arch width changes

With respect to maxillary arch width in Group I, significant expansion was seen in all regions being greatest in inter1stpremolar width (+3.95 ± 0.69mm), followed by inter2ndpremolar width (+3.93 ± 1.12mm), inter canine width (+2.69 ± 0.49mm) and was least in intermolar width (+1.33 ± 0.42mm) area (Table 2). In Group II significant expansion was seen in all regions being greatest in inter2ndpremolar width (+4.73 ± 1.33mm), followed by inter1stpremolar width (+4.37 ± 1.63mm), inter canine width (+3.10 ± 1.94mm) and intermolar (+1.87 ± 1.27mm) area (Table 3). In intergroup comparison, there was statistically insignificant difference between Group I and Group II with respect to the changes in arch width though expansion found in the maxillary transverse dimensions were greater in Group II (Table 4).

Table 2: Intragroup comparision of pre and post treatment measurements using paired t-test in Group I.

Variables	Treatment Changes				t-value	p-value
	Pre-treatment		Post-treatment			
	Mean	S.D.	Mean	S.D.		
For arch width measurements (mm)						
Inter canine width	32.48	1.96	35.17	1.89	17.179	<0.001*
Inter 1st Premolar width	38.19	1.95	42.14	1.98	18.209	<0.001*
Inter 2 nd Premolar width	42.51	2.42	46.44	2.27	11.11	<0.001*
Intermolar width	48.56	2.18	49.89	2.12	9.95	<0.001*
For incisor position and inclination measurements						
U1 to SN degree	102.50	9.13	111.30	7.92	7.903	<0.001*
U1 to NA (angular) degree	24.25	6.32	31.50	7.00	7.521	<0.001*
U1 to NA (linear) mm	4.10	2.28	5.80	2.25	10.371	<0.001*

L1 to Mandibular plane degree	88.70	5.10	95.90	4.43	8.565	<0.001*
L1 to NB (angular) degree	20.50	5.13	26.90	4.48	8.727	<0.001*
L1 to NB (linear) mm	4.50	2.50	7.10	2.81	14.697	<0.001*
For buccal corridor measurements						
BCC: TSA	25.26	4.92	24.83	4.83	7.839	<0.001*
BCL: TSA	10.25	1.67	8.26	1.87	9.072	<0.001*

*The difference between pre and post treatment measurements was statistically significant.

Table 3: Intragroup comparision of pre and post treatment measurements using paired t-test in Group II.

Variables	Treatment Changes				t-value	p-value
	Pre-treatement		Post-treatment			
	Mean	S.D.	Mean	S.D.		
For arch width measurements (mm)						
Inter canine width	31.75	2.52	34.86	1.84	7.356	<0.001*
Inter 1st Premolar width	38.17	3.44	42.54	2.55	8.453	<0.001*
Inter 2 nd Premolar width	42.36	4.30	47.09	2.85	7.709	<0.001*
Intermolar width	48.33	3.54	50.20	3.23	4.664	<0.001*
For incisor position and inclination measurements						
U1 to SN degree	101.70	6.57	109.00	5.93	4.689	<0.001*
U1 to NA (angular) degree	23.70	5.25	30.10	4.23	7.945	<0.001*
U1 to NA (linear) mm	4.75	1.99	6.35	1.76	5.779	<0.001*
L1 to Mandibular plane degree	91.30	7.87	97.60	6.06	9.438	<0.001*
L1 to NB (angular) degree	22.60	6.97	28.40	7.23	6.708	<0.001*
L1 to NB (linear) mm	3.90	1.87	5.85	2.29	6.263	<0.001*
For buccal corridor measurements						
BCC: TSA	26.14	3.02	25.51	3.21	3.992	<0.001*
BCL: TSA	10.75	1.79	8.65	2.03	6.574	<0.001*

*The difference between pre and post treatment measurements was statistically significant.

Table 4: Intergroup comparision of treatment changes between Groups I and II using unpaired t-test.

Variables	Treatment Changes				t-value	p-value
	Group I		Group II			
	Mean	S.D.	Mean	S.D.		
For arch width measurements (mm)						
Inter canine width	2.69	0.49	3.10	1.33	0.762	0.456#
Inter 1st Premolar width	3.95	0.69	4.37	1.63	0.744	0.466#
Inter 2 nd Premolar width	3.93	1.12	4.73	1.94	1.170	0.257#

Intermolar width	1.33	0.42	1.87	1.27	1.186	0.251#
For incisor position and inclination measurements						
U1 to SN degree	8.80	3.52	7.30	4.92	0.784	0.443#
U1 to NA (angular) degree	7.25	3.05	6.40	2.55	0.677	0.507#
U1 to NA (linear) mm	1.70	0.82	1.60	0.88	0.2629	0.7956#
L1 to Mandibular plane degree	7.20	2.66	6.30	2.11	0.838	0.413#
L1 to NB (angular) degree	6.40	2.32	5.80	2.15	0.828	0.418#
L1 to NB (linear) mm	2.60	0.52	1.95	0.98	1.849	0.081#
For buccal corridor measurements						
BCC: TSA	0.43	0.17	0.63	0.50	1.180	0.253#
BCL: TSA	1.99	0.45	2.10	1.07	0.2997	0.767#

#The difference between groups I and II was statistically not significant

Incisor position and inclination changes

When group I was analysed, results showed that maxillary and mandibular incisors were proclined as indicated by the measurements U1 to SN (8.80 ± 3.52), U1 to NA angular (7.25 ± 3.05), L1 to mandibular plane (7.20 ± 2.66) and L1 to NB angular (6.40 ± 2.32). The maxillary and mandibular incisors were also advanced anteriorly as indicated by U1 to NA linear (1.70 ± 0.82) and L1 to NB linear (2.60 ± 0.52) (Table 2). In Group II, results showed that maxillary and mandibular incisors were proclined as indicated by the measurements U1 to SN (7.30 ± 4.92), U1 to NA angular (6.40 ± 2.55), L1 to mandibular plane (6.30 ± 2.11) and L1 to NB angular (5.80 ± 2.15). The maxillary and mandibular incisors were also advanced Antero posteriorly as indicated by U1 to NA linear (1.60 ± 0.88) and L1 to NB linear (1.95 ± 0.98) (Table 3). In intergroup comparison, there was statistically insignificant difference between Group I and Group II, though pro clination and protrusion found in the maxillary and mandibular incisor were greater in Group I than Group II (Table 4).

Buccal corridor area changes

post-treatment changes with respect to buccal corridor in Group I viz. BCC: TSA (-0.432 ± 0.17), BCL: TSA- (-1.99 ± 0.45) (Table 2). In Group II the treatment changes in buccal corridor viz. BCC: TSA (-0.63 ± 0.50), BCL: TSA- (-2.10 ± 1.07) (Table 3). Buccal corridor area were significantly reduced from pre-treatment to post-treatment in both Group I and Group II. In intergroup comparison, the reduction were comparable and there were no significant difference between Group I and Group II (Table 4).

Discussion

There has been a major concern in choosing between the extraction and non-extraction treatment modality as it affects the soft tissue profile as well as the hard tissues in the oral cavity. Few orthodontists also think that extraction leads to broader buccal corridor due the the narrowing of the arches which does not look esthetic. With the advent of various treatment philosophies and systems, there has been a shift from extraction to non-extraction treatment modality. One of the many systems is Damon passive self-ligating bracket system that claims that light forces do not prevail over the muscles, instead, the arch aligns by taking the path of least resistance leading to posterior expansion. The muscles present around the oral cavity, like the orbicularis oris and the mentalis muscle results in a lip bumper effect minimizing the movement of the incisors labially. This system also claimed to produce no changes in the inter canine width.[11]

So, to asses all these claims, we aimed a study that contained 20 non-extraction cases consisting of 2 groups- Group I consisted of non-extraction cases which had been treated with conventional bracket system and Group II consisted of non-extraction cases which had been treated with Damon bracket system. These cases had permanent dentition with mild to moderate crowding. The subjects who had passed the pubertal growth spurt according to the CVMI were preferred to eliminate the effects of growth on hard and soft tissues and crowding. Mean age of 14.33 ± 2.49 years was taken in Group I and mean age = 15.55 ± 2.11 year was taken in Group II.

Pre and post treatment measurements were taken in respect to arch width changes, incisor position and inclination changes and buccal corridor changes. To reduce any magnification errors in the cephalometric measurements, it was made sure that all the radiographs were taken from the same machine with the same settings.

Evaluation of arch width

Intragroup comparison of the treatment changes in arch width in both the groups showed that inter canine width, inter1st premolar width, inter2nd premolar width and intermolar width, all were significantly increased from pre-treatment to post-treatment. This is very well in accordance with many studies that have consistently shown that alleviation of crowding during non-extraction treatment always occurs by buccal segment expansion and incisor proclination , if no other appliance (like headgear or lip bumper) are used[5, 11-13] and irrespective of the appliance system used during the treatment.[14]

In intergroup comparison, there was statistically insignificant difference between Group I and Group II with respect to the changes in arch width viz. inter canine, inter1 premolar, inter2nd premolar and intermolar region. Even though expansion found in the maxillary transverse dimensions were greater in Group II, it was not statistically significant to be of any clinical importance. These results are similar to those found in some other studies[14, 15], which also reported a non-significant difference in arch expansion between self-ligating and conventional bracket system. Contrary to this ,Vajaria R et al[11] and Pandis et al[5, 15] found greater intermolar arch width increases in Damon group then in the conventional group. This can be because of the different wire sequence and arch form used in different bracket system groups in these studies. Damon Cu NiTi wire used in Damon bracket system has a broad arch form, particularly in the buccal segments and could have contributed to increased amount of expansion reported with this bracket system. In our study, we tried to eliminate this confounding effect of different arch forms to some extent by using broad arch forms for both the groups, and this explains the non-significant difference for arch width changes between both the groups in our study. These all leads us to conclude that, in non-extraction treatment, amount of arch expansion is not much affected by the bracket system used but mainly by the arch form and material of the arch wire used during the treatment.

Evaluation of Incisor position and inclination

In both the groups, treatment changes in upper and lower incisor position and inclination showed that U1 to SN, U1 to NA, L1 to Mandibular plane and L1 to NB were significantly increased from pre-treatment to post-treatment, indicating proclined and forwardly placed upper and lower incisors in both the groups post treatment. Similar result where obtained in various other studies[5, 11] again indicating that if distalisation of arches are not planned, then relieving of crowding in non-extraction treatment not only occurs by transverse dimensional changes but also by incisor proclination and advancement.

In intergroup comparison, there was statistically insignificant difference between Group I and Group II, though proclination and protrusion found in the maxillary and mandibular incisor were greater in Group I than Group II. Vajaria R et al[11], in their study using the Damon vs conventional edgewise system have also reported similar results as our study. Both the bracket systems significantly proclined the incisors from pretreatment to post treatment time. Thus , the notion that Damon system has lip bumper effect which minimizes the anterior movement of incisors[16] , is not supported by our study.

Evaluation of Buccal corridor area

Buccal corridor is one of the appraisal points in dynamic appearance of face during conversation and smile. In present study , buccal corridor is measured as area ratio instead of the linear ratios to measure the actual area of buccal corridor space.[17] In our study it was found that buccal corridor area ratios both in respect to canine and last visible maxillary tooth were significantly reduced from pre-treatment to post-treatment in both Group I and Group II. This result is in concordance with what has been stated by James A McNamara[18] that an increase in arch width eliminate or reduces the buccal corridors and is attributed to the post treatment increase in arch width seen in both the groups in our study. Results obtained in our study are also in accordance with the results of some former studies.[17-21] post-treatment evaluation of both the group had revealed that, buccal corridor area were greatly reduced in relation to the last visible maxillary teeth (BCL: TSA) than canine (BCC: TSA). This can be associated with the highest amount of expansion seen in the first premolar and second premolar area in our study which is usually the last visible tooth associated with smile.

In intergroup comparison, even though the buccal corridor areas were reduced in both the groups but, the reduction were comparable and there were no significant difference in between Group I and Group II. Shook C. et al[8] conducted a similar study as ours using the Damon vs conventional bracket system and had reported a non-significant difference in buccal corridor area ratio changes during the treatment, same as our study.

Thus it can be said that in our study significant arch width changes during the treatment would have caused a clinically relevant effect on buccal corridor area.

Limitations

Limitations of this study can be attributed mainly to its retrospective nature, since retrospective data might introduce selection and detection bias. Other limitations of this retrospective study would involve information about treatment that was limited to what was available in the patient records. More studies with large sample size are needed to identify the strength and limitation of Damon system that can be a valuable tool in patient selection for practice.

Conclusion

The present study concluded that

1. Bracket system used for treatment had no significant effect on any transverse dimensional changes, incisal position and inclination and on buccal corridor.

2. In non-extraction cases where distalisation of arches are not part of treatment plan, in such cases crowding is always relieved by a combination of transverse

expansion and incisor proclination regardless of bracket system used.

3. In non-extraction treatment, amount of expansion achieved is related more to the arch form and material of the arch wire used, than the bracket system used during treatment.

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