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Comparison of Treatment Time of Initial Alignment Between Self Ligating and Conventional System

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Abstract: There are various types of brackets available in orthodontics. This retrospective study investigated the difference in clinical efficiency between Damon Q self-ligating brackets (SLB) compared with MBT conventional ligating brackets (CLBs) during tooth alignment in straightwire fixed appliance therapy. Twenty patients (8 males and 12 females), aged between 12 and 25 years, were randomly divided into two groups: 9 patients received the SLB and 11 received the CLB. Upper arch impressions were taken for pre-treatment records (T0). A transpalatal arch was soldered to both maxillary first molar bands prior to extraction of the maxillary first premolars, followed by straightwire fixed appliances (0.022 × 0.028 inch). A 0.014 inch nickel titanium (NiTi) wire was used as the levelling and aligning archwire. Four monthly reviews were undertaken and impressions of the upper arch were taken at each appointment (T1, T2, T3, and T4). Displacements of the teeth were determined using Little's irregularity index (LII). Data were analysed using the Mann–Whitney U-test. In the aligning stage, the CLB group showed significantly faster alignment of the teeth compared with the SLB group at the T1–T2 interval ($P < 0.05$). However, there were no differences at T2–T3, and T3–T4 for either group ($P > 0.05$). The CLB group showed 93 per cent crowding alleviation compared with 76 per cent for the SLB after 4 months of alignment and levelling. MBT brackets aligned the teeth faster than Damon Q but only during the first month. There was no difference in efficacy between the two groups in the later 3 weeks. Alleviation of crowding was faster with CLB than with SLB.

Keywords: Conventional ligating, Initial alignment, Self-Ligating, Treatment time, Innovative

INTRODUCTION

The efficiency of treatment mechanics is necessary to ensure optimal treatment results in less clinical time and with a shorter treatment duration. Sliding mechanics in the modern straightwire fixed appliance system have considerably reduced the need for wire bending that was dominant in the standard edgewise technique. However, sliding movements along the archwire still imply friction between the archwire, bracket, and ligature surfaces, taking up part of the applied force and leaving an uncontrolled amount to act on the teeth. It is estimated that 50 per cent of applied orthodontic force is used purely to overcome the friction in the system (Roberts-Harry, 1996). Self-ligating brackets (SLB) were developed on the premise that elimination of ligature ties creates a friction-free environment, allows for better sliding mechanics, and may therefore reduce treatment time (Eberting, Straja and Tuncay, 2001). SLB were first described by Stolzenberg (1935) with his Russell Lock appliance and since then various types of SLB have been fabricated (Harradine, 2008). It is claimed that SLB fulfills the ideal properties of orthodontic ligation by providing fuller archwire engagement with low frictional force between the bracket and archwire. Furthermore, it requires less chair side assistance and allows faster archwire insertion and removal. In terms of treatment time, it was found that there was a mean reduction of 4 months in treatment and four visits during active treatment (Harradine, 2008).

The theory behind the faster treatment time may be related to the low friction that is proposed by the manufacturer. Numerous authors, with different study designs and various types of materials, archwire, and bracket slot dimensions, have shown that SLB demonstrate very low friction (Harradine, 2008). (Kapur, Sinha and Nanda, 1999) found significantly lower friction with both stainless steel and nickel titanium (NiTi) wires with SLB compared with conventional brackets. An in vivo study, (Loftus et al., 1999) found that with a simulated periodontal ligament, friction with the Damon SLB was not significantly less than with conventional brackets. However, (Thorstenson and Kusy, 2002) found that the angulation beyond the angle at which the archwire first

contacts the diagonally opposite corners of the bracket slot caused a similar rise in the resistance to sliding of both SLB and conventional ligating brackets (CLB).

It has also been claimed that SLB permits anchorage conservation (Harradine, 2008). This is due to the fact that lower forces are used for moving the teeth and thus reciprocal forces are correspondingly smaller. Lower forces per unit area lead to more anchorage preservation. The SLB system was found to align teeth at a faster rate than CLB due to the capacity of the wire to slide through the brackets of rotated teeth (Harradine, 2008). Free movement of the archwire significantly facilitates alignment of the rotated tooth and its adjacent teeth. This is because a fully secure bracket engagement permits full embrasure of the displaced teeth and therefore, full control of tooth movement can be achieved.

Some SLB is functionally narrower than conventional brackets. This leads to a wider interbracket span and thus, a longer segment of wire connects the brackets. When the force exerted is proportional to the third power of the length, the deflection of the archwire will be reduced. Hence, lower forces and a longer range of action with any given archwire during the alignment phase (Harradine, 2008). SLB requires less time during archwire changes by eliminating the use of any type of ligation. This results in faster archwire ligation and archwire removal, as well as lessening the need for chair side assistance. (Voudouris, 1997) reported a 4-fold reduction in archwire time change with SLB. In other words, clinical time used to ligate and remove archwires can be 80 per cent shorter.

Several published prospective clinical trials comparing SLB and CLB have shown differences in the effectiveness of SLB systems but no difference in perceived discomfort experienced by the patients (Scott et al., 2008). Comparison between Smart-Clip SLB and CLB in the reduction of crowding over the first 20 weeks of treatment showed no difference between the two bracket types (Miles, 2007). A similar study by (Celikoglu et al., 2015) that compared Damon 2 and conventional brackets found no difference in the clinical ability to align the teeth. Our department is passionate about research we have published numerous high quality articles in this domain over the past years ((Kavitha et al., 2014) , (Praveen et al., 2001),(Devi and Gnanavel, 2014), (Putchala et al., 2013), (Vijayakumar et al., 2010), (Lekha et al., 2014a, 2014b) (Danda, 2010) (Danda, 2010) (Parthasarathy et al., 2016) (Gopalakannan, Senthilvelan and Ranganathan, 2012), (Rajendran et al., 2019), (Govindaraju, Neelakantan and Gutmann, 2017), (P. Neelakantan et al., 2015), (PradeepKumar et al., 2016), (Sajan et al., 2011), (Lekha et al., 2014a), (Neelakantan, Grotra and Sharma, 2013), (Patil et al., 2017), (Jeevanandan and Govindaraju, 2018), (Abdul Wahab et al., 2017), (Eapen, Baig and Avinash, 2017), (Menon et al., 2018), (Wahab et al., 2018), (Vishnu Prasad et al., 2018), (Uthrakumar et al., 2010), (Ashok, Ajith and Sivanesan, 2017), (Prasanna Neelakantan et al., 2015). The purpose of this study was to compare the efficacy of Damon Q SLB with MBT CLB in alignment of the upper anterior teeth during fixed appliance therapy.

MATERIALS AND METHODOLOGY

The reference population for this study consisted of patients who reported to the department of orthodontics in a private dental college in Chennai. Twenty patients (08 males and 12 females) (Figure 1), between 12 and 25 years of age (mean 18.7 years) who met the inclusion criteria, were invited to participate and were randomly allocated to be treated using either SLB or CLB. The nature of the study was explained to all patients and/or their parents and consent forms were obtained.

Inclusion criteria

1. Healthy systemic condition/no systemic illness, as reported by patients.
2. No use of any form of anti-inflammatory drugs preceding the beginning of study.
3. Good oral hygiene and periodontal health with periodontal pockets of less than or equal to 4 mm, full mouth plaque score less than or equal to 20 per cent, and full-mouth bleeding score less than or equal to 20 per cent (within 15 seconds after pocket depth probing).
4. Cooperative and motivated.
5. In the permanent dentition with all teeth present at least to the first molars.
6. Class I or Class II division 1 incisor relationship with an overjet less than or equal to 6.0 mm (an upper tooth which was in crossbite was accepted provided the orthodontic bracket could be bonded to the tooth and no additional space opening mechanics were needed to align the tooth).
7. Extraction of at least both upper first premolars to relieve moderate to severe crowding and/or to reduce the overjet.
8. Patients who needed at least upper fixed appliance treatment to retract the maxillary canines. 9. No radiographic bone loss was observed on the dental pantomography image.

Exclusion criteria

1. Previous upper removable orthodontic treatment.
2. Patients who required surgery to correct skeletal discrepancies.
3. Patients with hyperdontia, hypodontia, or syndromic diseases (e.g. cleft lip and palate).
4. Uncooperative patients.

All patients underwent a routine orthodontic assessment and were treated by one clinician under supervision of the principal investigator. Prior to the start of treatment, full-mouth scaling and prophylaxis were undertaken and the subjects were instructed correct oral hygiene practice. A transpalatal arch was constructed with suitable molar bands and cemented to the maxillary first molars. Upper alginate impressions were taken as the baseline impression (T0) just before bonding of either of the bracket systems. A 3 shape scanner was used to record the impression of the jaws as well and for further measurements.

Either Damom Q or MBT brackets were bonded on the buccal surfaces of all teeth in both arches with Transbond™ XT (3M Unitek) composite resin according to the manufacturers' recommendation. A 0.014 inch dimension circular cross-sectional NiTi archwire was used as the initial aligning archwire and was cinched back (Figure 1). A laceback stainless steel wire (0.010 inch) was tied lightly from the canine to the molar tooth in every quadrant to prevent deflection of the NiTi archwire during mastication. The patients were recalled at monthly intervals for 4 months and an upper impression was taken at each visit (T1, T2, T3, and T4). The same 0.014 inch round NiTi archwire was used to align the teeth throughout this period, unless there was a need for a replacement, but the wire diameter was kept the same. The overbite, overjet, and molar relationship of each patient and their oral hygiene practice were closely monitored throughout these review appointments. The progress of the study is shown in Figure 2.

Outcome measurements

Little's irregularity index (LII; Little, 1975) was used to assess the overall changes in alignment (Figure 3). All measurements were made on the study models taken at T0 and during alignment and levelling (T1, T2, T3, and T4). These measurements were carried out using electronic digital callipers with an accuracy of 0.01 ± 0.02 mm. Assessment of the effect of the brackets on tooth movement was determined by subtracting the current reading from the previous reading. Calibration was performed using a set of 14 study models from the Orthodontic Department archive with measurements obtained by RMAW as gold standard.

Statistical analysis

The Statistical Package for Social Sciences (SPSS) software was used to analyse the data, using the Mann–Whitney U-test for the LII score at all stages of alignment due to non-parametric distribution of the data. Z statistics and P values were used to test the significance of the results. $P < 0.05$ indicated statistical significance.

RESULTS AND DISCUSSION

A total of 20 patients were recruited into the study which consisted of 12 females and 8 males (Figure.1), 11 in the CLB, and 9 in the SLB groups (Figure 2).Patient allocation with gender distribution, types of malocclusion, mean age, and mean pre-treatment LLI are shown in Table 1. Intra- and inter-examiner reproducibility and reliability assessments showed good agreement, with intraclass correlation coefficient values of 0.996 and 0.995. Descriptive statistics showed no difference between the groups in crowding pre-treatment.

Comparison of the difference in the rate of tooth alignment (LII scores) changes during treatment for the two bracket groups are shown in Table 2. There was a marginally statistically significant difference in the rate of tooth movement at T1–T2 between CLB and SLB ($P < 0.05$; Table 2).

Association between gender and type of brackets was done using chi square test and was found not to be statistically significant, p value=0.7 ($p>0.05$) with chi square value of 0.73. Conventional ligating brackets and Self ligating brackets were used for initial alignment of the anterior teeth in both males and females..(Figure 3)

Comparison of the difference in overall tooth alignment for the LII score between T0 and T4 showed faster changes for the CLB compared with SLB over the 4 month alignment and levelling phase (Figure.4). The average percentage alleviation of crowding was higher with CLB (98 per cent) compared with in SLB (67 per cent; Table 3).

Previously our team had conducted numerous clinical trials (Sivamurthy and Sundari, 2016) (Samantha et al., 2017) (Krishnan, Pandian and Kumar S, 2015) (Vikram et al., 2017) (Kamisetty, 2015; Vikram et al., 2017) (Viswanath et al., 2015) (Felicita, 2017b) and lab animal studies (Rubika, Sumathi Felicita and Sivambiga, 2015) (Jain, Kumar and Manjula, 2014) (Pandian, Krishnan and Kumar, 2018) (Ramesh Kumar et al., 2011) (Felicita, 2017a) and in-vitro studies (Felicita, Chandrasekar and Shanthasundari, 2012) (Dinesh et al., 2013) (Felicita and Sumathi Felicita, 2018). The results of this study showed that CLBs aligned teeth at a statistically faster rate than SLBs but only during T1–T2. There was no statistically significant difference between the CLB and SLB during T2–T3 and T3–T4. This finding is in accordance with previous investigations that compared CLB and SmartClip brackets (Miles, 2007) and Damon 2 SLBs (Website, no date). In an in vivo study, (Miles, 2007) compared the effectiveness of SmartClip brackets and Victory conventional twin brackets for initial alignment of the mandibular arch. Fifty-eight patients were recruited and alternately assigned to either one bracket group. LII was used to determine the differences in alignment and measurements were taken before treatment, 10 weeks after initial archwire placement, and then at 20 weeks. A 0.014 inch Damon Cu–NiTi was used as the initial wire and was later changed to 0.016 × 0.025 inch Damon Cu–NiTi. The author found that at the end of the 20 weeks period, the

SmartClip bracket was no more effective in reducing irregularity than a conventional twin bracket ligated with elastomeric modules or stainless steel ligatures with both wire tested.

In the study of Miles et al. (2006), 60 patients were recruited in this split-mouth in vivo study. One side of the lower arch was bonded with 0.022 inch slot Damon 2 SLBs and the other side with 0.022 inch slot Victory CLBs. Similarly, the LII was scored for both sides at baseline, at 10 weeks, and at the 20 weeks archwire change. The same archwires as used by Miles (2005) study utilized. They found that at both archwire changes, the Victory CLBs had a lower LII score than the Damon 2 bracket (0.2 mm). Although this finding was not clinically significant, it showed that the Damon 2 SLB were no better than CLB during the initial alignment stage of orthodontic treatment.

(Pandis, Eliades and Bourauel, 2009) investigated in vitro the duration of mandibular crowding alleviation with SLB (Damon 2) compared with conventional appliances (Microarch) and the accompanying dental effects. They recruited 54 patients with no spaces in the mandibular permanent dentition and with a LII score greater than 2. All patients were treated non-extraction and the time for alignment was estimated in days. Lateral cephalometric radiographs were used to assess mandibular incisor position pre- and post-alignment stages. Measurements of the intercanine and intermolar widths were also performed on dental casts to determine the changes associated with correction. They observed that, in general, there was no difference in the time needed to correct mandibular crowding either with Damon 2 or with conventional brackets (Microarch) during the initial aligning and levelling stage. However, the Damon 2 brackets aligned the teeth 2.7 times faster than the other bracket type in a moderately crowded (irregularity index less than 5) mandibular arch. For greater crowding with a LII score of more than 5, they found that for every irregularity index unit, treatment was prolonged by an additional 20 per cent regardless of bracket type. In addition, they found a statistically greater intermolar width increase in the Damon 2 group. Proclination of the incisors was observed but there was no difference for this parameter between either bracket type. In that study, crowding alleviation showed a higher percentage with CLB (98 per cent) compared with SLB (67 per cent).

Although Miles et al. (2006) found that there was no difference in bracket efficiency between SLB and CLB during the initial aligning and levelling stage, the result in the present study at T2 can be explained by the fact that better archwire engagement was possible with CLB. Although no figure-of-eight configuration was used during treatment, full archwire engagement with maximum contact of the archwire with the bracket slot were easily achieved when placing the elastomeric modules on the bracket wings as compared with SLB. Movement of the teeth was facilitated by the friction between the archwire-slot-module interfaces so that the teeth could be aligned by the preformed NiTi archwires at a faster rate.

The teeth of a number of patients were rotated to a moderate degree. Despite the fact that orthodontic brackets were bonded to these teeth, elastomeric modules were not fully engaged at both the mesial and the distal wings. The modules were placed sufficiently to hold the archwire to the bracket to avoid dislodgement of the bracket from the tooth surface. At T1 and T2, the rotated teeth were slowly aligned and subsequently full ligation of the modules to the bracket wings was carried resulting in full engagement of the archwire within the bracket slot, which in turn facilitated tooth movement.

Despite the fact that the Damon bracket was successfully bonded on the rotated tooth surfaces, closure of the metal slot could not be carried out due to excessive bending of the archwire at T1. This resulted in no engagement of the archwire within the bracket slot. In this case, a 0.010 inch stainless steel ligature archwire was used to secure the NiTi archwire to the bracket. Failure of archwire engagement within the slot significantly affected the rate of tooth movement in terms of relieving crowded arches. However, as the rotated teeth slowly aligned as treatment progressed, the aligning archwire was able to be fully inserted within the bracket slot during the subsequent visits.

For the purpose of comparison in alignment and levelling, a 0.014 inch NiTi archwire was used throughout the aligning phase despite the larger bracket slot dimension of the passive Damon Q SLB used in the present study. Miles et al. (2006) postulated that the presence of ‘play’ between the smaller archwire dimension and the slot when the 0.014 inch archwire was fitted within the 0.028 inch slot depth Damon 2 bracket (0.0275 + 0.0010-in/−0.0000 in slot tolerance, data from Ormco) would allow 8.5 degree of rotational play compared with a theoretically fully engaged archwire in conventional twin bracket. Scott et al. (2008) found no difference in initial alignment between the Damon 3 and conventional brackets with respect to discomfort.

The limitations of this study are with regard to the system recommended by the manufacturer of the SLB. The study protocols were relatively strict to avoid bias to either type of brackets. Therefore, the recommended system for Damon Q SLB could not be applied. Furthermore, measurement of crowding using LII only measured the contact point displacement of the six anterior teeth, which did not represent true tooth movement. Arch length was not measured prior to or after alignment to detect whether alignment was due to mesial distal movement or proclination of the teeth.

CONCLUSION

The results of this study indicate that in general, SLB are not superior to CLB in terms of tooth alignment during the aligning and levelling stage, although the alignment of incisor teeth during the first month was at a significantly faster rate. Furthermore, CLB showed 93 percent of crowding alleviation compared with 76 percent for SLB after 4 months of alignment and levelling.

Author Contribution

Both the authors have equal contribution.

Conflict of Interest

There is no conflict of interest.

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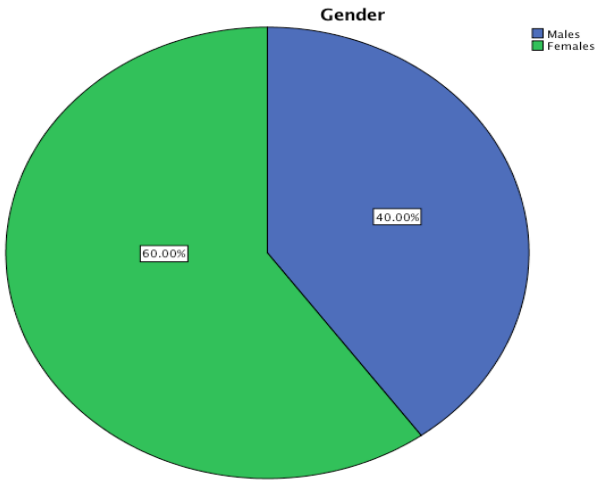

Fig.1: Pie chart depicting the gender distribution of study population. 60% were females and 40% were males.

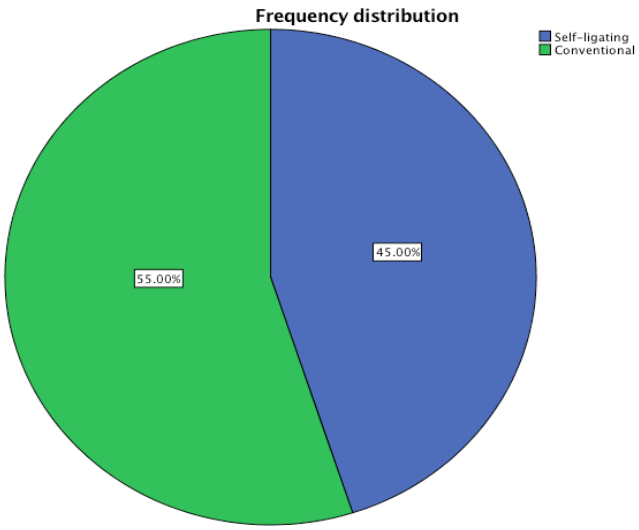

Fig.2: Pie Chart depicting frequency distribution of the type of bracket. 55% of study population conventional ligating brackets were used and 45% self ligating brackets.

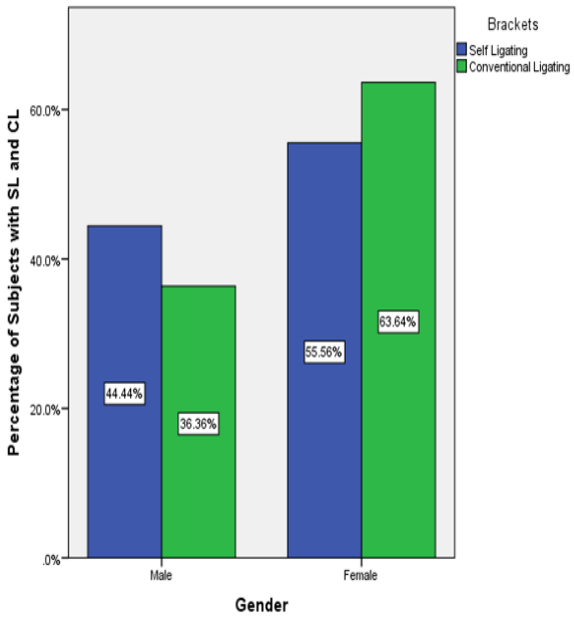

Figure 3. Bar graph showing the association between gender and the type of brackets used. X axis shows the gender distribution and the Y axis shows the percentage of subjects using SL and CL brackets. Association between gender and type of brackets was done using chi square test and was not significant. Conventional ligating brackets and self ligating brackets were used for initial alignment of the anterior teeth in both males and females. p value=0.7 (p>0.05 statistically not significant).

Table 1: The table shows the distribution of patient gender, malocclusion, age, and pre-treatment Little's irregularity index (LII). The table shows that the mean age of subjects that used Damon Q brackets was 19.5+/-3.9 years and in the MBT group it was 21.9+/-3.6 years. The mean pre-treatment LII was 11.3+/-3.9 in the Damon group and 11.7+/-4.1 in the MBT group.

Type of bracket	Male	Female	Mean age	Mean pre-treatment LII
Damon Q	4	6	19.5 ± 3.9	11.3 ± 3.9
MBT	4	6	21.9 ± 3.6	11.7 ± 4.1

Table 2: Comparison between the MBT conventional ligating bracket and the Damon Q self-ligating bracket groups in the Little irregularity index scores at the four treatment intervals: T0 = pre-treatment and at the first (T1), second (T2), third (T3), and fourth (T4) reviews using the Mann-Whitney U-test. IQR, interquartile range. There was marginally a statistical significance in the LII score at the T1-T2 time interval.

Brackets types	Damon Q	MBT	Z Statistic	P Value
T0–T1 median	1.76 (2.97)	4.73 (2.36)	−1.698	0.082
T1–T2 median	2.03 (2.82)	5.17 (2.06)	−1.938	*
T2–T3 median	0.91 (1.26)	1.42 (1.13)	−0.966	0.313
T3–T4 median	0.93 (0.59)	1.04 (2.26)	−0.248	0.776

*P<0.05

Table 3: Little's irregularity index scores between before alignment (T0), after alignment (T4), and percentage of improvement for MBT conventional ligating and Damon Q self-ligating brackets during the levelling and aligning stage. The mean LII scores between T0 and T4 in both the MBT and Damon Q groups were 11.9+/-4.7 and 8.4+/-4.3 respectively. The mean improvement percentage in the MBT group was 95.4+/-8.2% and in the Damon Q group was 66.3+/-11.6%.

Bracket types	n	Mean T0 (mm)	Mean T4 (mm)	Mean T0-T4 (mm)	Mean % improvement
Damon Q	9	12.1 ± 4.4	3.3 ± 1.4	8.4± 4.3	66.3 ± 11.6
MBT	11	12.4 ± 4.5	1.4 ± 0.9	11.9 ± 4.7	95.4 ± 8.2

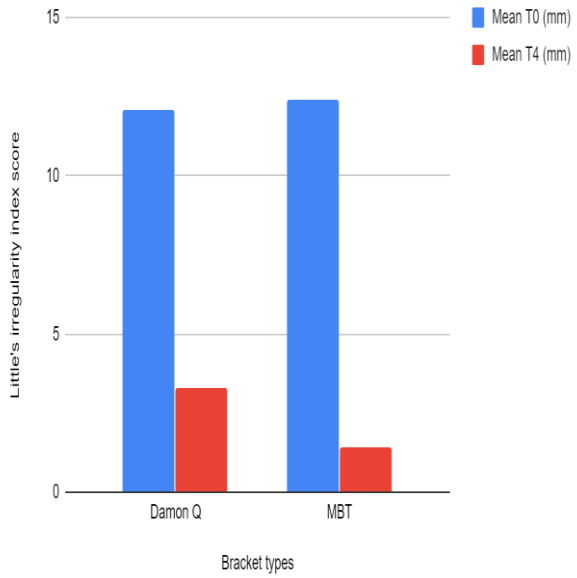

Fig.4: Bar chart representing Little's irregularity index scores between the time period before alignment (T0) and after alignment (T4). The X-axis represents the different bracket types - Damon Q and MBT. The Y-axis represents the mean of LII scores. The mean LII score of the MBT bracket at T0 was 12.4 ± 4.5 and T4 was 1.4 ± 0.9. The mean LII score of the Damon Q bracket was 12.1 ± 4.4 and the T4 was 3.3 ± 1.4. Hence, it was inferred that comparison of the difference in overall tooth alignment for the LII score between T0 and T4 showed faster changes for the CLB compared with SLB over the 4 month alignment and levelling phase.