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ORIGINAL RESEARCH

Comparison of Opal Self-Ligating Brackets with Manually Ligating Brackets

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ABSTRACT

This study was conducted with aim to evaluate the efficiency of the newly introduced Opal self-ligating brackets (SLB). The chairside time saved, appliance efficiency, bracket bond failures, breakages and bracket staining in the Opal SLBs were compared with the conventional standard metal manually ligating brackets (MLBs) of MBT system. Seven patients were compared in each group. Standard light curing bonding methods were used in both the group. Chairside time saving, appliance efficiency and bracket bond failures were compared among the groups whereas staining was observed with the SLBs. Appliance efficiency was evaluated by PAR scores. Results showed significant chairside time being saved in SLBs, whereas the appliance efficiency was not significant. Bond failures were found only in SLBs as well as breakages along with staining. Henceforth, we could conclude that though SLBs had advantage of saving chairside time but also had disadvantage of losing more time with bond failures.

Keywords: Self-ligating brackets, Chairside time, Appliance efficiency, Bracket staining, Plastic brackets.

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INTRODUCTION

In every field, man has tried to excel and, hence, life has never been the same. Orthodontics is no exception to this. The demand for esthetic brackets coupled with efficiency has always been strived for. Directing research toward the creation of new orthodontic brackets with improved esthetics and bonding capabilities has been one of the challenges faced. Orthodontists now have a vast number of direct bonding options because of the large number of direct bonding systems and orthodontic brackets currently available.[1] Not long ago, the only available bonded brackets were metal. Ceramic, plastic and even gold-plated brackets have been introduced. This trend toward developing different bracket materials that appeal to different patients' personalities has been continuing.

Esthetic brackets, in this particular study plastic bracket, have played and are playing a pivotal role in changing the face of a metallic smiling patient into an esthetically appealing one, all through the treatment. The introduction of these brackets in the 1970's overcame many of the esthetic limitations. Though, these brackets had a great esthetic appeal during the initial wear, this was lost due to their staining and discoloration, particularly in patients who smoke or drink dark/colored beverages.[2] Apart from this factor, bond strength along with the bracket breakages was questionable.[3,4] Although, many modifications are being made and many elements are being added to improve the properties of plastic bracket, still, a perfect plastic bracket is yet to be manufactured.

In the evolution of brackets, there has been a parallel research to help save the chairside time during the archwire changes, to improve patients comfort and the appliance's efficiency. These researches led to the evolution of new types of brackets known as the self-ligating brackets (SLB). Dr Jacob Stolzenberg was the first to introduce these brackets in the early 1930's. The mechanism of ligation in these revolutionary brackets was in stark contrast to the traditional approach of tying steel ligatures around each bracket. Treatment was considerably more comfortable, with shorter office visits and shorter overall treatment time. Perhaps because Dr Stolzenberg was ahead of his time, the concept of SLBs fell more or less into obscurity until the early 1970s.[5] In 1971, Dr Jim Wildman of Eugene, Oregon, developed the Edgelok bracket.[6] And in the process many a SLBs[5,7-10] followed suite.

Amidst these, there was introduction of another SLB – the Opal SLBs' (Ultradent, UK) which are fabricated with glass filled (nickel free) polycarbonate in year 2004. To

our knowledge, there has been no study to evaluate this type of new SLB, thus, a study was found necessary to evaluate the properties of these brackets which are both esthetic as well as self-ligating.

Our study was, therefore, aimed at evaluating the chairside time saved, patients comfort, appliance efficiency, bracket bond failures, breakages and bracket staining in the Opal SLBs and comparing them with the conventional standard metal manually ligating brackets (MLBs) of MBT system (TP Orthodontics, UK).

The aims and objectives of this study were to evaluate and compare:

1. Chairside time savings with SLB and MLB
2. Appliance efficiency in leveling and aligning of SLBs and MLBs
3. Bracket bond failures with SLBs and MLBs
4. Bracket breakages with SLBs and MLBs
5. Staining with the SLBs.

MATERIALS AND METHODS

All cases were selected from the Department of Orthodontics and Dentofacial Orthopedics, PMNM Dental College, Bagalkot, Karnataka. Out of the 20 cases, 6 cases (3 in each group) were excluded from the study for discontinuation of treatment by the patients. This reduced the overall number to 14 cases (7 in each group).

Two groups of patients were compared. The first group (SLB) consisted of 10 cases treated with Opal SLBs (Ultradent products, USA; Fig. 1A). The second group (MLB) also consisted of 10 patients treated with manually ligating metal brackets (Nu-Edge, TP Orthodontics, USA; Fig. 1B). In both the groups' 0.022 × 0.028" slot was used.

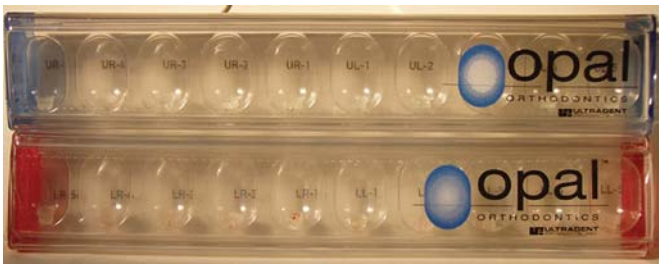


Fig. 1A: Opal self-ligating brackets (Ultradent products, USA)

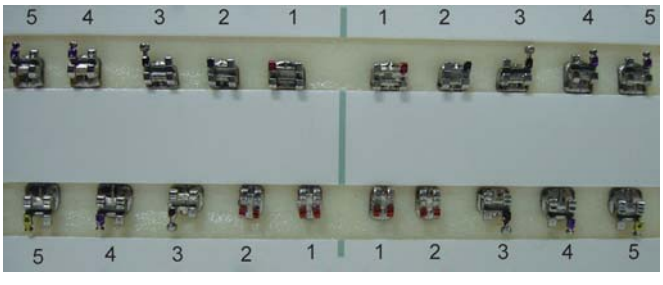


Fig. 1B: Manually ligating brackets (Nu-Edge, TP Orthodontics, USA)

Criteria for Patient Selection

All cases selected met the following selection criteria:

1. Age of 15 to 25 years.
2. A minimum score of 10 on peer assessment rating (PAR).
3. No history of trauma to the orofacial region.
4. No history of orthognathic surgery and/or previous orthodontic treatment.
5. No known congenital craniofacial anomaly.
6. Treatment plan required no extractions.

Methods

Bonding Procedure

Prior to bonding of the brackets, all cases were advised for oral prophylaxis. Later, labial surfaces of all the teeth to be bonded were polished with pumice paste.

Conventional brackets (MLBs): The area at the bracket placement was etched with 37% o-phosphoric acid (Ortho Source, USA) for 30 seconds and then washed away with water. After washing the etchant, the enamel surface was completely dried with moisture free air. A layer of Python sealant (TP Orthodontics, USA) was applied onto the tooth and light cured for 10 seconds. Python adhesive paste (TP Orthodontics, USA; Fig. 2) was applied to the base of the bracket and pressed firmly onto the tooth. Excess adhesive paste was removed from around the base of the bracket, and the adhesive was light cured (Cromalux 75, Mega-Physik Dental, Germany) on each interproximal side for 10 seconds.

Opal SLBs: The bonding was done as per the manufacturer's manual with material provided by the manufacturer (Ultradent products, USA). The material included the Opal ultra etch – an etchant, Opal prime – a primer and Opal bond – a light cure composite material (Figs 3A to C). The

Fig. 2: Orthosource phosphoric acid etchant (37%), python sealant and light cure composite paste

Figs 3A to C: (A) Opal bond, (B) Opal prime and (C) Opal ultra etch

labial surfaces were treated with the etching agent, Opal ultra etch for 30 seconds. Enamel surface was then rinsed thoroughly for 5 seconds with firm air/water spray. Care was taken to remove all moisture from tooth surface prior to bonding. A thin layer of Opal prime was applied to the tooth surface and to the bracket base (without curing). A thin coat of Opal bond was later applied to the bracket base. The bracket was then firmly positioned on tooth surface and excess of bonding material was removed from around the bracket. The adhesive was light cured (Cromalux 75, Mega-Physik Dental, Germany) on each interproximal side for 10 seconds.

Opal bracket cap opening: A gentle insertion of Opal key bracket opening instrument (Fig. 4) into the space between bracket base and closed bracket cap and rotation of the instrument handle lifts opens the cap. For closing the bracket cap, after taking a rest of the thumb on the cingulum of the tooth for which the bracket is to be closed, a gentle force with index finger was placed on the cap of the bracket till the archwire was secured in the bracket.

Fig. 4: Opal key

Various parameters were evaluated as below:

1. *Chairside time evaluation*: Only one operator operated, having no prior experience in the usage of both the bracket systems. In both the groups, the time required to remove and replace the archwire in either the maxillary and mandibular arch from the right second premolar to the left second premolar was noted. The time recorded was solely related to the removal or replacement of the ligature tie and did not involve manipulation of the archwire. Time taken for engagement of the archwire into the molar buccal tubes and archwires cinching was not taken into consideration.
   For the sake of standardization, 0.016" × 0.022" NiTi and stainless steel archwires were used. Intentionally, the initial aligning wire (round NiTi and stainless steel wires) was not noted in the study, to avoid the time discrepancy in cases of rotations, blocked out teeth, etc. The time was recorded using a stopwatch which was recorded by a trained staff. The operator announced the start and completion of upper and lower archwire removal and placement and the time taken was noted. This time data was divided by the number of the brackets present to calculate the average time taken for each bracket.
2. *Appliance efficiency (in leveling and aligning)*: The PAR scores were included as a matching criterion in this study for two reasons. Firstly, this score has a relationship with treatment complexity and secondly, this measure can be used to record the severity of malocclusion at any stage of treatment and thus provide a measure of quality of treatment.[25,26]

   These scores were measured using PAR ruler (Fig. 5; Ortho Care, UK). The PAR score was calculated prior to the start of treatment and about 120 days after the start of treatment on the study models of each patient (Figs 6 and 7). The differences between the scores were used to evaluate the efficiency of both the groups.
3. *Bracket bond failures:* Number of bracket bond failures in both the groups was noted. Bond failures at the time of archwire placement (which could have been due to excessive force levels generated by usage of stiffer wire being forcefully ligated into a malposed tooth's bracket) and due to occlusal prematurities were not counted.
4. *Breakage of the brackets:* Breakages in the bracket wings, cap was evaluated in comparison with the ligating metal brackets.
5. *Staining of the SLBs:* The change in the color of the brackets was evaluated only in SLB group (Fig. 8).

Fig. 5: PAR ruler (Ortho Care, UK)

Fig. 6A: Pretreatment records of an MLB patient

Fig. 6B: Records of an MLB patient after 120 days

Fig. 7A: Pretreatment records of an SLB patient

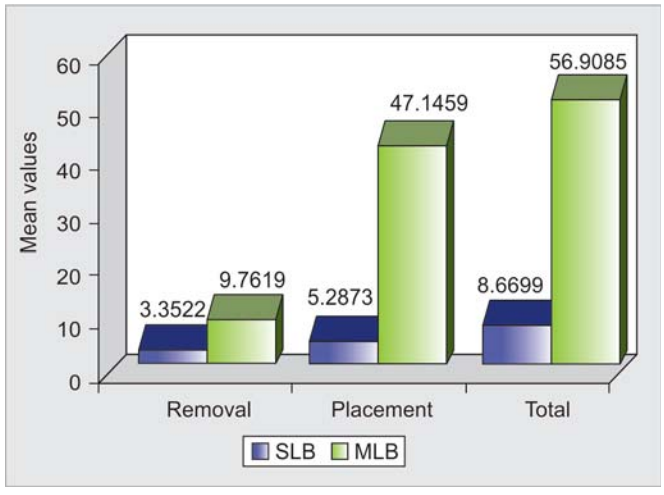
Fig. 7B: Records of an SLB patient after 120 days

RESULTS

A total of 7 patients were examined in both the groups (SLB and MLB), for comparing the chairside time saved by the operator, comparing the appliance efficiency (or performance) of SLBs with that of MLBs using PAR scores, comparing the bracket bond failures in both the groups, comparing the breakages with the wings and cap of the brackets and observe changes in the color of the brackets for staining.

The results of various parameters are presented as follows:

1. *Chairside time saving:* The mean and standard deviation (SD) were calculated in both the groups. Table 1 and Graph 1 show the summary of the mean and SD of the time required for removal, placement and the total time taken for archwire changes at the chairside. An unpaired Student's t-test was done to compare and detect any statistically significant differences between both the groups for the mean and SD at 0.1% level of significance (Table 2).
   i. *Removal of archwire:* Time taken for the removal of archwire in SLB (mean: 3.3522 ± 0.3465) was 2.9 times faster compared with MLB (mean: 9.7619



Graph 1: Comparison of mean values of both the groups with respect to chairside time saving in removal, placement and its total for each bracket

Table 1: Mean and SD values of chairside time saving during archwire changes in both the groups

Time	*Summary*	*SLB*	*MLB*	*No. of folds of difference in means*
Removal	Means	3.3522	9.7619	2.9120
	SD	0.3465	0.8345	
Placement	Means	5.2873	47.1459	8.9168
	SD	0.3871	4.4173	
Total	Means	8.6699	56.9085	6.5639
	SD	0.6337	3.8199	

Table 2: Comparison of the groups with respect to chairside time saving in removal, placement and its total time taken for archwire changes

Time	*Groups*	*Mean*	*SD*	*Unpaired t-value*	*p-value*	*Significance*
Removal	SLB	3.3522	0.3465	–18.7683	0.0000	HS
	MLB	9.7619	0.8345			
Placement	SLB	5.2873	0.3871	–24.9754	0.0000	HS
	MLB	47.1459	4.4173			
Total	SLB	8.6699	0.6337	–32.9603	0.0000	HS
	MLB	56.9085	3.8199			

p-value < 0.05—S (Significant); p-value < 0.01—HS (Highly significant)

± 0.8345) which was statistically highly significant (t = –18.7683 and p = 0.0000).

ii. *Placement of archwire:* Time taken for the placement of archwire in SLB (mean: 5.2873 0.3871) was 8.9 times faster than MLB (mean: 47.1459 ± 4.4173). This was statistically highly significant (t = –24.9754 and p = 0.0000).

iii. *Total time taken (for removal and placement of archwire)*: The total time taken for the archwire removal and placement in SLB group (mean: 8.6699 ± 0.6337) was 6.5 times lesser compared with MLB group (mean: 8.6699 ± 0.6337) which was statistically highly significant (t = –32.9603 and p = 0.0000).

2. *Appliance efficiency (in leveling and aligning)*: The mean and SD were calculated in both the groups for the pre [mean: 22.8571 ± 7.0102(SLB) and 19.0000 ± 5.0662 (MLB)] and posttreatment [mean: 9.4286 ± 4.1173 (SLB) and 8.0000 ± 2.4495 (MLB)] percentage reductions in PAR scores after a period of 120 days of the leveling and aligning stage. Paired Student's t-test was used at 0.01% level to determine statistical significance of percentage reductions in PAR scores in the SLB (Table 3 and Graph 2) and MLB (Table 4 and Graph 3) group.

A high statistically significant reduction was noted between the pre- and posttreatment percentage reductions in both the groups [t = 7.58 (SLB) and 6.99 (MLB) and p = 0.0003 (SLB) and 0.0004 (MLB)].

An unpaired Student's t-test was done to find the statistical significant difference between the groups (Table 5 and Graph 4). The pretreatment (t = 1.1799 and p = 0.2609), posttreatment (t = 0.7889 and p = 0.4455) as well as the percentage reduction in PAR scores (t = 1.0251 and p = 0.3255) of SLB and MLB groups at 5% level revealed no statistically significant difference between both the groups.

3. *Bracket bond failures*: No statistical analysis could be performed for this parameter since there were no bond failures in MLB group, as against 22 bracket bond failures in SLB group (Table 6). This proves that the SLB group had very high incidence of bond failures.

4. *Breakage of bracket:* No statistical analysis could be performed here too since any bracket breakages were noted in the MLB group. However, single cap breakage was noted in SLB group, which is of significance (Table 6).

Table 3: Comparison of pre- and posttreatment scores of PAR in SLB group

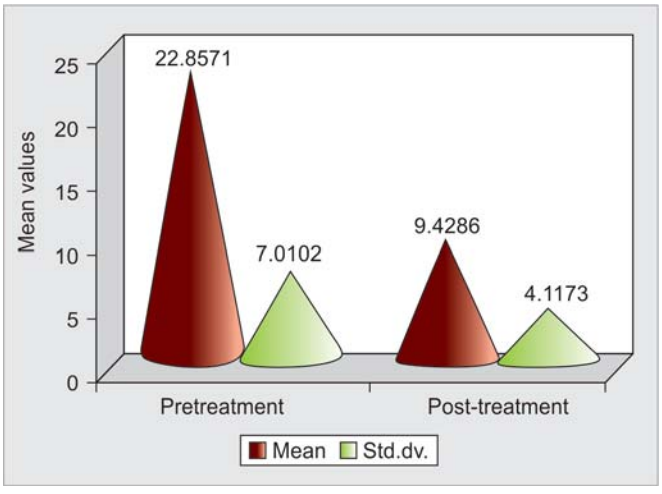
Treatment	*Mean*	*SD*	*Mean diff.*	*SD diff.*	*Paired t-value*	*p-value*	*Significance*
Pre	22.8571	7.0102	13.4286	4.6853	7.5829	0.0003	HS
Post	9.4286	4.1173					

p-value >0.05—NS (Nonsignificant); p-value <0.05—S (Significant); p-value <0.01—HS (Highly significant)

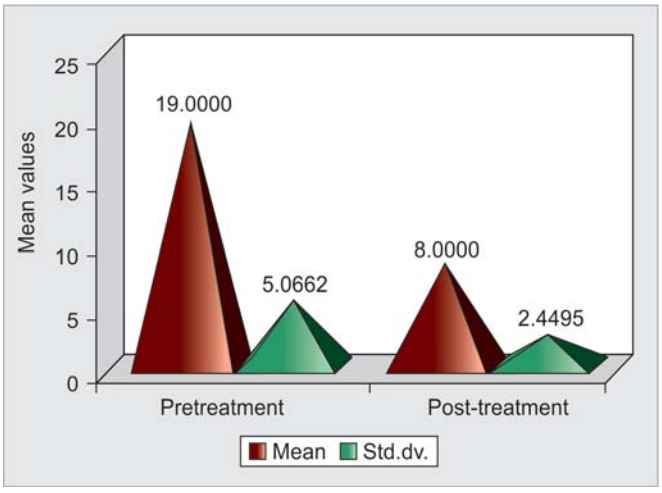
Table 4: Comparison of pre- and post-treatment scores of PAR in MLB group

Treatment	*Mean*	*SD*	*Mean diff.*	*SD diff.*	*Paired t-value*	p-*value*	*Significance*
Pre	19.0000	5.0662	11.0000	4.1633	6.9904	0.0004	HS
Post	8.0000	2.4495					

p-value >0.05—NS (Nonsignificant); p-value <0.05—S (Significant); p-value <0.01—HS (Highly significant)



Graph 2: Comparison of means and SD values in pre- and post-treatment PAR scores in SLB group

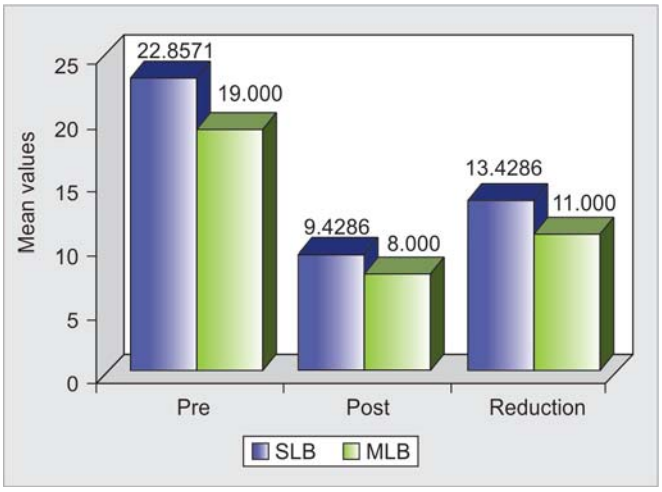


Graph 3: Comparison of mean and SD values in pre- and post-treatment PAR scores in MLB group

Table 5: Comparison of SLB and MLB with respect PAR scores in pre- and post-treatment

Treatment	*Group*	*Mean*	*SD*	*Unpaired t-value*	p-*value*	*Significance*
Pre	SLB	22.8571	7.0102	1.1799	0.2609	NS
	MLB	19.0000	5.0662			
Post	SLB	9.4286	4.1173	0.7889	0.4455	NS
	MLB	8.0000	2.4495			
Reduction	SLB	13.4286	4.6853	1.0251	0.3255	NS
	MLB	11.0000	4.1633			

p-*v*alue >0.05—NS; p-*v*alue <0.05—S; p-*v*alue <0.01—HS



Graph 4: Comparison of mean values of PAR scores in both the groups for pre-, post-treatment and in the reduction of PAR scores

Table 6: Some of the other/miscellaneous problems encountered in treatment with Opal SLBs during the study but were not encountered in MLBs

S. no	*Problems encountered (no. of patients)*	*No. of times*
1.	Brackets bond failures	22 (6)
2.	Cap breakage	1 (1)
3.	Cap would not open	12 (6)
4.	Cap inadvertently opened between visits	9 (5)
5.	Inability to place elastomeric chains for space closure between anteriors	

There was color change from translucent white to opalescent yellow in all the SLBs. Figure 8 illustrates one such bracket after 120 days of treatment.

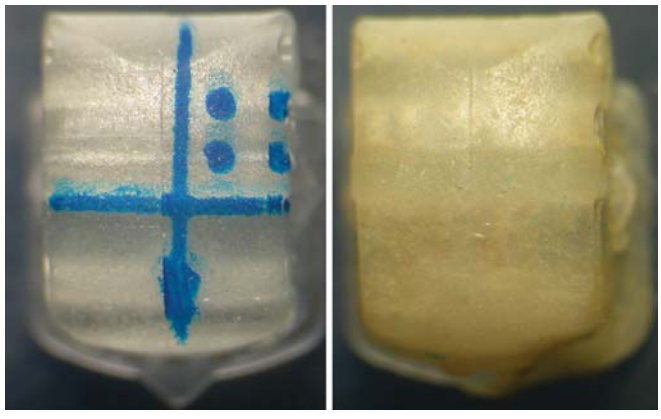


Fig. 8: Opal SLBs, prior to usage (left), after 120 days of treatment (right)

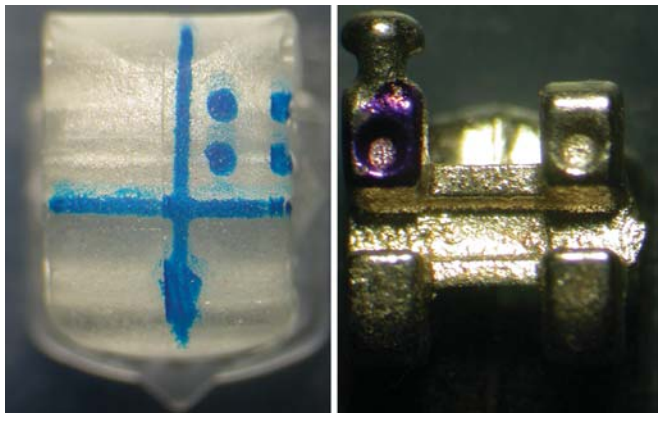


Fig. 9: Front view of SLB (left) and MLB (right)

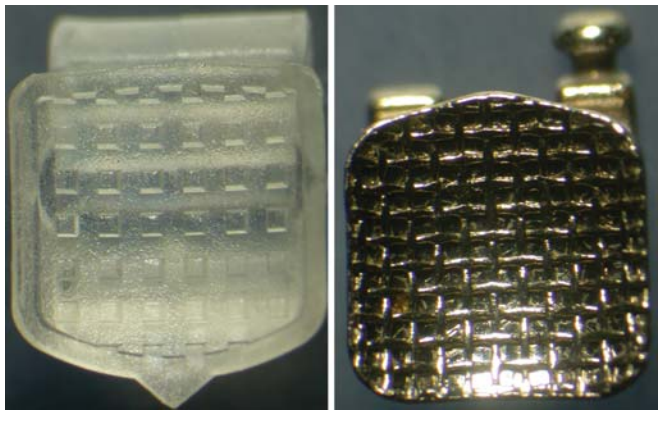


Fig. 10: Bracket bases of SLB (left) and MLB (right)

DISCUSSION

Introduction of SLBs in 1935 by Dr Jacob Stolzenberg left many practitioners unfamiliar with the advantages of these revolutionary brackets. The mechanism of ligation in these revolutionary brackets was in stark contrast to the traditional approach of tying steel ligatures around each bracket.[5] Treatment with these brackets was considerably more comfortable to the patient as well as for the orthodontist as the former enjoyed shorter office visits, lesser percutaneous injuries and the latter had the advantages of reduced chair time, faster archwire removal and ligation, shorter treatment time and precise tooth translation. But, the concept of SLBs fell more or less into obscurity until the early 1970s, which gave rebirth to these types of brackets system.

In 1970's, there was introduction of plastic brackets which changed the face of a metallic smiling patient into an esthetically appealing one, all through the treatment. They had their advantages of being esthetic brackets and attracted the adult patients for treatment. But were criticized for their discoloration, lower bond strength, lack of rigidity and bracket wing breakages.

The Opal SLBs' (Ultradent, UK), fabricated with glass filled (nickel free) polycarbonate material were launched in 2004. This introduction of the self-ligation in plastic brackets should logically have the advantages of both the types in a single bracket.

In the past, there have been many studies on SLBs[2,5-10,13,15,19-21,28] and on plastic brackets[1,3,4,11,12,14,16-18,22,23] separately. But our extensive literature review did not find any studies which evaluated this type of brackets. Thus, a study was undertaken to evaluate this type of new SLB.

The present study was aimed at evaluating and comparing the chairside time saved, appliance efficiency, bond failure, breakages and bracket staining in the Opal SLBs and comparing them with the conventional standard metal manually ligating PEA brackets (MLBs; TP Orthodontics, UK).

A total of 14 patients were examined in both the groups (7 with SLBs and 7 with MLBs). All the cases were operated by single operator, who had no prior practical experience with usage of both the bracket systems. The various parameters were compared in both the groups (except for the staining of the brackets which was noted only in the SLB group).

To our knowledge, there have not been any studies done in past which have compared the plastic SLBs and metal MLBs. So, in some of the following sections we have compared our results with the studies which have evaluated metal SLBs and metal MLBs.

Following parameters were evaluated:

1. *Chairside time saving*: The mean and SD of the time required for removal, placement and the total time taken by each bracket for archwire changes at the chairside are shown in Table 1 and Graph 1.

   The SLBs have a distinct advantage over MLBs considering the chairside time saving for archwire changes. The time needed to place a 0.016 × 0.022" archwire into SLB was nearly 9 (8.92) folds less when compared to the MLBs. SLBs required only 1/3rd the time taken by MLBs for the removal of archwire. While the time taken for the whole procedure (i.e. for removal and placement) was 6.5 times less with SLBs.

   An unpaired Student's t-test confirmed a statistically high significant (p = 0.0001) time saving in SLB group (Table 2).

   These findings are in agreement with studies done by Hanson,[7] Damon,[9] Maijer and Smith,[13] Shivapuja and Berger,[15] Berger and Byloff,[19] and Harradine.[21,28]
2. *Appliance efficiency (in leveling and aligning)*: Statistically highly significant reduction p = 0.0003 (SLB) and 0.0004 (MLB) in the PAR scores for the treatment changes was observed in both the groups. Table 3 and Graph 2 (SLB), Table 4 and Graph 3 (MLB). One hundred and twenty days of treatment (Figs 6 and 7) had brought about significant reduction in PAR scores.

   There was no statistically significant difference between the groups when pre- (p = 0.2609), posttreatment (p = 0.4455) and percentage reductions (p = 0.3255) in PAR scores were considered.

   Our findings are in agreement with Dobrin[27] who has shown that conventional plastic brackets have poor efficiency due to their deformation. But they are not in concurrence with the studies by Damon,[9,10] Eberting, Straja and Tuncay[20] and Harradine.[21] However, these studies (a) compared metal SLBs and conventional ligating bracket, and (b) evaluated the treatment changes at the end of complete treatment.

   The efficiency of metal SLBs is better than the plastic SLBs as the latter could fail on three fronts (a) rigidity,[27] (b) wear resistance of the tab on the cap which secures the wire into slot and (c) secure locking of the cap into its right place.
3. *Bracket bond failures*: Statistical analysis could not be performed on this parameter as there were no bond failures in MLB group, as against 22 bracket bond failures in SLB group (Table 6). All the bracket failures were at the bracket and resin interface. This demonstrates that the plastic SLBs have very low bond strength due to poor adhesion between the bracket and the bonding agent provided.

   This is in accordance with various studies on the bond strength of plastic brackets.[3,4,14,16-18,22,23]

   The poor strength is probably due to (a) inability of the primer to bond chemically with the base and (b) poor design of the bracket base which does not provide sufficient mechanical locking for the adhesive.
4. *Breakage of bracket*: Again, no statistical analysis could be performed, since no bracket breakage was noted in the MLB group. Single cap breakage was noted in SLB group, which could be of significance as this is 1 in 138 brackets used (Table 6).

   The inferior fracture resistances of plastic brackets[11,12,24] could have lead for single cap breakage.
5. *Staining of the brackets*: There was a color change from translucent white to opalescent yellow in all the SLBs.

Figure 8 illustrates one such bracket after 120 days of treatment. The change in the color of the plastic brackets has also been noted by Profitt[2] and Newman.

This might be due to poor wear resistance of plastic bracket materials as demonstrated by Zinelis.[24] Another rationale could be that even after the cap is closed there is some space between the slot and the cap. The food debris and other staining elements trapped in this space.

Some of the Other/Miscellaneous Problems Encountered in Treatment with Opal SLBs during the Study but were not Encountered in MLBs

Table 6 lists the technical shortcomings of SLBs.

Opening of the Cap of Bracket

In cases with marked degree of mesiolingual rotation, opening of the cap was a problem. This was noted in 12 instances. This was due to interference of the Opal key with the tooth of opposite quadrant in the same arch, while opening the cap.

Inadvertently Opening of Cap of Bracket between Visits

The inadvertent opening of the cap between visits was noted in 9 instances. All cases had reported within 24 hours and care was taken for reclosure of the brackets. This is could be of huge significance as cap opening between visits could have detrimental effects varying between nil and a major loss of control of that tooth movement.

Inability to Place Elastomeric Chains

Whenever, there was spacing between the anteriors which needed engagement of elastomeric chain, SLBs did not permit its use. This was due to the larger size and unavailability of undercuts/wings of the bracket. But elastomeric thread could be used for the same purpose.

CONCLUSION

The following conclusions were drawn from the study:

1. SLBs were 6.5 times quicker than the MLBs during the archwire changes, thus saving considerable chairside time.
2. Treatment outcome after 120 days, in both groups was almost the same.
3. The SLBs had many bracket bond failures while MLBs had none.
4. SLBs had other shortcomings such as bracket breakage, staining, cap opening, etc.

CLINICAL SIGNIFICANCE

This study found that SLBs were better than MLBs on saving chairside time and esthetics. But these advantages were overwhelmed by frequent bond failures, breakages, cap opening between appointments, etc. Therefore, in our opinion, the opal self-ligating brackets have more disadvantages than advantages. One should remember that this was a short-term study done on a smaller sample.

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