Lingual Bracket Systems with Self Etching Primers—An In Vitro Study to Evaluate Shear Bond Strength

1Abhinay Sorake, 2Unnikrishnan Jayakrishnan, 3Ridhima Suneja, 4Subin Sam, 5Terrance Abraham, 6Anjali Jayaraj, 7Sivasuthan L Govind

ABSTRACT

Aim: To evaluate the shear bond strength of orthodontic lingual bracket systems bonded to extracted premolar teeth (Reliance self-etching primer, Clearfil Protect Bond) and self-etching primer (Clearfil SE Bond)

Materials and methods: A total of 160 extracted human first premolars were selected and divided into four groups of 10 for each bracket system to be used with four different primers. Each sample was then embedded in an acrylic block, till the coronal portion. Instron testing machine model LR LOYD 50 K was used for testing the shear bond strength.

Results: The results obtained, suggested that all the primers had clinically acceptable shear bond strength with all the bracket system considered in the study. However, there were statistically significant differences in the shear bond strength in intergroup comparisons.

Conclusion: The Reliance Self-Etching primer showed the highest bond strength with Alias lingual bracket system byOrmco, followed by clearfil protect bond, clearfil SE bond, and transbond, with the Alias lingual bracket system in the same order.

Clinical significance: This study was initiated to understand the shear bond strength of self-etching primer and its efficacy over the conventional primer, which will be of use to the clinician while selecting the primer for bonding of the bracket systems and overcome debonding of brackets encountered during the treatment progress.

Keywords: Self-etching primers, Self-ligating lingual brackets, Shear bond strength, Tooth surface demineralization.

INTRODUCTION

Over the past decade, researches have been directed towards a more patient-oriented, clinician-friendly bracket systems, to enhance the quality of treatment provided. Orthodontists are more often being approached for aesthetic needs rather than the underlying functional defects. Therefore, esthetics becomes the prime factor to address, when patient acceptance of the appliance comes into the picture. The development of lingual bracket system itself was a major leap in the treatment mechanics to provide an inconspicuous appliance and it rapidly gained popularity among the patients and clinician equally. The introduction of lingual brackets widened the options available to the clinician, as well as fulfilled the aesthetic requirements of the patients, almost completely. One of the major difficulties that the system encountered was the bonding to the tooth surface, due to the moisture-laden field of adhesion. Although different techniques have been put forward to solve this problem, indirect bonding remains the method of choice. In this study, the shear bond strength of various lingual systems was compared with four different primers, to give an insight into the adhesive
capability of the primers and the longevity of the brackets systems with these primers.

There was a rise in the practicality that was being provided to the orthodontist in terms of optimization of Laboratory process,\textsuperscript{1} chairside processes,\textsuperscript{2} computerized archwire fabrication and much more.\textsuperscript{3} Difficulties have been reported with the use of lingual bracket systems, ranging from speech dysfunction, restricted mastication, oral discomfort to oral hygiene problems.\textsuperscript{4} Almost all the problems reported, were in association with prefabricated lingual brackets.\textsuperscript{5} To overcome this, customized brackets are doing the rounds in the research tables and in the clinician’s armamentarium to provide the solution for the various problems encountered.\textsuperscript{6} Customized brackets are obtained from scanning the study models using high-resolution three-dimensional scanners. These brackets are then designed individually by computer technology and subsequently fabricated by means of rapid prototyping.\textsuperscript{7}

The bracket bases which are 0.4 mm thick are contoured to the lingual surfaces of the teeth which also permits direct (re-) bonding. Direct bonding of orthodontic attachments is a routine clinical process.\textsuperscript{8} It was Buonocore in 1955, who demonstrated the adhesion of acrylic filling materials to enamel, following acid etching by phosphoric acid. Newman in 1965, suggested that the technique might be used for orthodontic bonding.\textsuperscript{9} Among the various modalities that are being under research, phosphoric acid still seems to hold the edge in enamel surface preparation, although it is found to cause the demineralization of the most superficial layer of enamel.\textsuperscript{10}

\section*{AIMS AND OBJECTIVES}

The aim of the present study was:
\begin{itemize}
  \item To evaluate the shear bond strength of Orthodontic Lingual Bracket systems bonded to extracted premolar teeth with self-etch primer, Reliance Self Etching Primer, Clearfil Protect Bond, Clearfil SE Bond and Transbond.
  \item To compare the mean bond strength values of various primers with the different lingual bracket systems used.
\end{itemize}

\section*{MATERIALS AND METHODS}

Total 160 freshly extracted human first premolars were collected and stored in a solution of 0.1\% (weight/volume) thymol solution, for 15 days to prevent dehydration and bacterial growth.

\section*{Inclusion Criteria}
\begin{itemize}
  \item Freshly extracted first premolar teeth
  \item Intact enamel surface
  \item No evident caries
  \item No visible cracks
  \item The teeth were fixed in acrylic self-cure blocks such that the roots were completely embedded in acrylic up to the cementoenamel junction, to simulate the clinical crown height.
\end{itemize}

\section*{Distribution of Sample}

Teeth were divided into four groups of 40 samples each. Each group was then subdivided into four subgroups based on the different orthodontic lingual bracket system used with 10 samples each.
\begin{itemize}
  \item \textit{Group I (TP)}: Transbond Plus (3M Unitek, Monrovia, Calif) (Fifth generation) (Fig. 1A)
  \item \textit{Group II (SE)}: Clearfil SE Bond (Kuraray, Osaka, Japan) (Fifth generation) (Fig. 1B)
  \item \textit{Group III (CP)}: Clearfil Protect Bond (Kuraray, Osaka, Japan) (Sixth generation) (Fig. 1C)
  \item \textit{Group IV (RSEP)}: Reliance Self etching Primer (Reliance Orthodontics) (Sixth generation) (Fig. 2)
\end{itemize}

\section*{Bracket Systems Used}
\begin{itemize}
  \item 7th Generation (Ormco) (Fig. 3A)
  \item STb (Fig. 3B)
  \item Incognito (Fig. 3C)
  \item Alias (Ormco) (Fig. 3D)
\end{itemize}

\section*{Light Curing Unit}

3M Curing light 2500 (3M Dental Products) with an intensity of 480 nm was used for polymerization for 20 seconds. Each bracket was cured for 4 seconds of gingival, 4 seconds from occlusal, 4 seconds from mesial, 4 seconds from distal and 4 seconds interproximally.

\section*{Adhesive}

Transbond XT was used for bonding all the four groups.

\section*{Incubation}

The samples were stored in deionized water at 37°C for 24 hours before debonding.

The Instron Universal testing machine (Model No. LR LOYD 50K-UK) was used to carry out the test for shear bond strength.

\section*{Bonding Procedures}

The lingual surface of all teeth was pumiced and thoroughly rinsed with distilled water. The tooth surfaces were dried and isolated to avoid contamination of the treatment area.

Primer liquid was dispensed into the mixing dish, immediately before application and was applied gently...
and dried with mild airflow. The required amount of the bond was dispensed into a mixing dish and applied to the primed area. After applying bond, a uniform bond film was created using a gentle oil-free airflow; it was light-cured for 10 seconds with curing light. Bracket with adhesive was placed on the tooth surface and firmly pressed in place and was light-cured for 20 seconds with visible light curing unit.

**Bond Strength Testing**

The shear bond strength of bonded specimens was tested after 24 hrs of bonding in an Instron testing machine model LP50K with a crosshead speed of 0.5 mm/min.

The acrylic block mounted with specimen was secured to the lower grip of the machine (fixed head) and a custom-made grip was placed in the upper grip (movable head) connected to the load level and the blade was positioned in such a way that it touched the bracket.

The crosshead speed was adjusted to 0.5 mm/min and the force at which the bracket debonded was recorded. The bond strength was calculated in Mega Pascals by using the following formula.

Shear Bond strength in MPa = Force in Newton / Surface area of the bracket in mm²
Statistical Analysis (Table 1 and Graph 1)

The single step, multiple comparison procedure, and statistical test, Tukey test was used in conjunction with an ANOVA (post-hoc analysis), to find means that are significantly different from each other. F-test was used to compare the statistical models. These statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) version 17.0 software.

RESULTS (Table 2)

- Reliance Self Etching Primer gave superior results with all the bracket systems under the study.
- Alias self-ligating lingual brackets displayed an increased shear bond strength with all the primers that were considered in the study.
- The mean bond strength among 4 groups was found to be highly significant. Maximum bond strength was found in Reliance Self Etching Primer used along with Alias self-ligating lingual Bracket system and minimum bond strength was observed with...
ligation, a design of anterior brackets for a better quality of ligation, and design of all brackets that would provide adequate tip control. This was overcome by the design of premolar and molar brackets, with occlusal tie wings projecting mesially and distally instead of labiolingually. These tie wings change the direction of the ligature pull 90°, thereby helping in effectively seating the archwire in the bottom of the slot. Anterior brackets use this same design feature to enhance the quality of their ligation. The occlusal tie wings have mesial and distal undercuts that parallel the bottom of the slot. They also change the direction of the pull of the ligature to seat the archwire into the bottom of the slot.

The bond strength plays a crucial role in the properties expressed by the bracket system, as they provide stability to the bracket base. The treatment results were found to be significantly higher in mechanisms involving better adhesive properties. Various evolutions, in terms of adhesives used in the bonding procedures, have provided the platform for an improved direct bonding technique in Orthodontic clinical setup.

The introduction of lingual appliances flocked the patients to the dental office for invisible braces. This was an exciting development in the field of orthodontics but demanded rigorous attention to technique, a requirement that every practitioner could not handle without special training. The lingual appliances have several clear-cut advantages over the labial appliances from the patient’s point of view:

- Facial surfaces of the teeth are not damaged from bonding, debonding, adhesive removal or from the plaque retained areas around the braces,

| Class       | N  | Mean   | Std. Deviation | Minimum | Maximum |
|-------------|----|--------|----------------|---------|---------|
| Transbond   | 10 | 11.214 | 0.105          | 11.11   | 11.33   |
| Clearfil SE Bond | 10 | 11.390 | 0.065          | 11.29   | 11.47   |
| Clearfil Protect Bond | 10 | 11.548 | 0.054          | 11.47   | 11.60   |
| Re| 10 | 12.856 | 0.079          | 12.76   | 12.96   |
| Transbond   | 10 | 12.046 | 0.133          | 11.90   | 12.22   |
| Clearfil SE Bond | 10 | 12.740 | 0.046          | 12.67   | 12.80   |
| Clearfil Protect Bond | 10 | 15.324 | 0.143          | 15.10   | 15.50   |
| Re| 10 | 13.258 | 0.083          | 13.16   | 13.37   |
| Transbond   | 10 | 10.644 | 0.062          | 10.58   | 10.72   |
| Clearfil SE Bond | 10 | 11.908 | 0.052          | 11.84   | 11.98   |
| Clearfil Protect Bond | 10 | 12.708 | 0.084          | 12.61   | 12.81   |
| Re| 10 | 15.416 | 0.101          | 15.32   | 15.57   |
| Transbond   | 10 | 12.576 | 0.104          | 12.43   | 12.72   |
| Clearfil SE Bond | 10 | 14.160 | 0.051          | 14.08   | 14.22   |
| Clearfil Protect Bond | 10 | 14.258 | 0.124          | 14.07   | 14.40   |
| Re| 10 | 16.376 | 0.070          | 16.30   | 16.45   |

DISCUSSION

The basic foundation of lingual appliance design is opening of the archwire slots to the occlusal aspect rather than to the lingual aspect. The occlusal approach makes arch wire insertion, seating, and removal easier than arch wire insertion with lingually opening slots. The first 1 mm of the molar tube opens to the occlusal aspect which provides direct guidance for insertion of the archwire occlusal to the archwire plane. As the ends of the archwire are inserted into the tubes, the rest of the archwire moves gingivally directly into the occlusal opening of the bracket slots. But the lingually opening slots require insertion of the archwire distally beyond anterior brackets, constriction of the archwire lingually to engage premolars lots, and then bringing of the archwire mesially, to fully engage the anterior brackets. This explains the reason for the difficulty in placement and removal of stiffer archwires in linguoally opening archwire slot. This also provides an additional benefit, that the archwire will not pull out of the slot with space-closing mechanics. This eliminates the special time-consuming ligation techniques (double-over ties) necessary for lingually opening slots.

The occlusal design approach did have potential problems that had to be solved: specifically, a design of premolar and molar brackets that would provide effective ligation, a design of anterior brackets for a better quality of ligation, and design of all brackets that would provide adequate tip control. This was overcome by the design of premolar and molar brackets, with occlusal tie wings projecting mesially and distally instead of labiolingually. These tie wings change the direction of the ligature pull 90°, thereby helping in effectively seating the archwire in the bottom of the slot. Anterior brackets use this same design feature to enhance the quality of their ligation. The occlusal tie wings have mesial and distal undercuts that parallel the bottom of the slot. They also change the direction of the pull of the ligature to seat the archwire into the bottom of the slot.

The bond strength plays a crucial role in the properties expressed by the bracket system, as they provide stability to the bracket base. The treatment results were found to be significantly higher in mechanisms involving better adhesive properties. Various evolutions, in terms of adhesives used in the bonding procedures, have provided the platform for an improved direct bonding technique in Orthodontic clinical setup.
Lingual Bracket Systems with Self Etching Primers—An In Vitro Study to Evaluate Shear Bond Strength

The bonding of Lingual Bracket Systems itself is a challenge due to the difficulty in obtaining a moisture free environment and difficulty in maintenance of oral hygiene. Intact enamel surface of the tooth was taken as a criteria for this study, in order to derive a more comprehensive idea of the shear bond strength and to provide uniformity among the samples collected.

Results of the Present Study

- Among the primers used, the Reliance Self Etching Primer exhibited better shear bond strength with all the bracket systems considered in the study.
- With the recent advances in the bracket systems, the Alias Self ligating Lingual Brackets were found to exhibit higher shear bond strength amongst various lingual bracket systems considered in the study.
- Reliance Self Etching Primer showed superior qualities among the tested materials and proved to be cost effective.
Some studies have put forward the conclusion that the surface quality of the bonding surface has an impact on the shear bond strength. Various authors have reported that the surface treatment techniques of the bases of lingual brackets have enhanced the adhesive capability and thereby the shear bond strength of the brackets. This study mainly deals with the self-etching primers influencing the shear bond strength and being an in vitro study, has its own limitations in the clinical scenario. The results impart an understanding of the strength of various primers and the lingual bracket systems. More research in this regard, on a clinical basis, will prove to be more effective and will overcome this limitation of the study.

CONCLUSION

This study could clearly identify the evolution of various primers and the bracket system in a single study. The primers gave a constant increase in properties from early to latest inventions in the field. The improvement in the lingual bracket systems also provided worthy contributions to the exhibition of superior properties by the appliances. The Reliance Self Etch Primer used along with the Alias Self Ligating Lingual Brackets provided the higher shear bond strength amongst the samples considered in the study. This study also strengthens the results that primers provide a better bracket-adhesive interface and self-etching primers are better in that aspect. The evolution of various primers and the bracket system can be easily identified in a single study.

The primers gave a constant increase in properties from early to latest inventions in the field. The improvement in the lingual bracket systems also provided worthy contributions to the exhibition of superior properties by the appliances. Most the studies have concluded that there is a significant difference in the shear bond strength when the surface characteristics of the bracket systems changes. There are reports of improvement in the bond strength when primers are used at the bracket-adhesive interface.

The clinical significance of this study is aimed at identifying the difference in shear bond strength of various primers that are available at present and thereby guide the clinician in reducing the failure rate of bonding.

There is still research going on in the field to improve the strength of the materials and to provide a near flawless material with improved bond strength, to avoid any inter appointment debonding of the brackets. More research in this aspect might prove to be beneficial to the patient and the clinician so that the quality of care is never compromised. It is found that the lingual brackets have the same capacity to align the teeth, just as the labial brackets. The designing of the appliance system, with a precise understanding of the technique and proper use of the materials, yielded the best results.

REFERENCES

1. Fillion D 1997 Improving patient comfort with lingual brackets. Journal of Clinical Orthodontics 31:689-694.
2. Wiechmann D 2000a Lingual orthodontics (part 3): intraoral sandblasting and indirect bonding. Journal of Orofacial Orthopedics 61:280-291.
3. Wiechmann D 2000b Lingual orthodontics (part 4): economic lingual treatment (ECO-lingual therapy). Journal of Orofacial Orthopedics 61:359-370.
4. Fukawa R. Lingual orthodontics in the new era treatment according to criteria for occlusion and aesthetics. Int Orthod. 2009 Dec;7(4):370-402.
5. Siures K.P. Lingual and esthetic orthodontics. Br Dent J. 2011 Dec 23;211(12):614.
6. Richard D, George, Sunil Hirani. Fully Customised Lingual Appliances: How Lingual Orthodontics became a viable treatment option. Journal of Orthodontics, 2013;40: S8-S13.
7. Miyawaki S, Yasuhara M, Koh Y. Discomfort caused by bonded lingual orthodontic appliances in adult patients as examined by retrospective questionnaire. Am J Orthod Dentofacial Orthop 1999;115:83-88.
8. Wiechmann D, Rummel V, Thalheim A, Simon JS, Wiechmann L. Customized brackets and archwires for lingual orthodontic treatment. American Journal of Orthodontics and Dentofacial Orthopedics 2003;124:593-599.
9. Ostby AW, Bishara SE, Denehy GE, Laffoon JJ, Warren JJ. Effect of self-etching pH on the shear bond strength of orthodontic brackets. Am J Orthod Dentofacial Orthop 2008;134(2):203-208.
10. Buyukyilmaz T, Usumez S, Karaman AI. Effect of self-etching primers on bond strength – Are they reliable? Angle Orthod 2003;73(1):64-70.
11. Cehreli ZC, Keck D, Kocadereli I. Effect of self-etching primer and adhesive formulations on the shear bond strength of orthodontic brackets. Am J Orthod Dentofacial Orthop 2005;127(5):573-579.
12. Zachrisson BU. Bonding in orthodontics. In: Graber LW, Vanarsdall RL Jr, Vig KW, eds. Orthodontics: Current Principles and Techniques. 6th ed. St. Louis: Mosby;1994.
13. Shin-Hye Chunga, Soha Chob, Kyungsun Kimc et al. Anti-microbial and physical characteristics of orthodontic primers containing antimicrobial agents. Angle Orthod. 2017; 87:307-312.
14. Cehreli ZC, Keck D, Kocadereli I. Effect of self-etching primer and adhesive formulations on the shear bond strength of orthodontic brackets. Am J Orthod Dentofacial Orthop 2005;127(5):573-579.
15. Ashokkar S, Shetty P, Deshpande R, Jadhav P. Evaluation of the shear bond strength of lingual brackets manufactured by three different processes using two different adhesive primers: An in vitro study. J Indian Orthod Soc 2016; 50:240-245.