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An In Vitro Evaluation of Wear Rate of Bite Turbo Materials Commonly Used in Orthodontics

Heather D. Norton

Abstract

Objective: To assess and compare in-vitro two-body wear of three commonly used bite turbo materials.

Materials and Methods: For this study, three popular bite turbo materials were investigated) (Transbond LR, 3M; Transbond Plus Light Cure Band Adhesiv, 3M; Ultra Band-Lok, Reliance). Twelve specimens for each group of materials were fabricated and subjected to two-body wear testing. Three iterations of 50,000 cycles were completed with assessment of volumetric loss using a 3D confocal profilometer between each iteration and at the completion of wear testing.

Results: The difference in initial wear following the first iteration of 50,000 cycles was not significantly different between the three groups. At the completion of all three iterations, totaling 150,000 wear cycles, Transbond LR had significantly less wear than Ultra BandLok and Transbond Plus ($P < 0.05\%$). There was no significant difference between the wear of Ultra BandLok and Transbond Plus at the completion of 150,000 wear cycles.

Conclusion: Bite turbos are a commonly used technique to open the bite during orthodontic treatment. Treatment objectives, location, availability, cost, handling, and esthetics are all considerations when selecting a material for bite turbos. While this study elicits information regarding the wear of these bite turbo materials, there were some limitations acknowledged. Additional research on this topic is needed to assist in the clinical decision-making process.

Introduction

There are a variety of situations in orthodontics where temporary disarticulation of the teeth is beneficial. This can be achieved with removable appliances or bonded bite turbos. Some indications for this are to allow proper placement of fixed orthodontic appliances such as in deep bite patients[1], to avoid occlusal interferences that may result in debonded brackets or wear of opposing teeth, and to correct anterior crossbites.[2] Bite raising with removable appliances requires lab fabrication, patient compliance, and frequent adjustments due to tooth movements.[3] Bonded bite turbos can be conveniently placed chairside and are predictable without relying on patient compliance. Given the inherent disadvantages of removable bite plates, along with the improvement of bonding materials and methods, many orthodontists opt for bonded bite turbos as a bite opening mechanism.

Depending on the patient's occlusion and treatment objectives, bite turbos are often placed on the functional cusps of molars or the lingual aspect of central incisors[4]. Commonly used materials for bite turbos are band cements and composite resins. These materials are often already part of the orthodontists' armamentarium, have distinct coloration, and are easy and familiar to use. Studies on these materials have elicited information regarding fluoride release, solubility, compressive strength, flexural strength, and bond strength.[5-11] Much is known about the properties of these materials when utilized as intended. However, little is known about the adhesives when used to temporarily raise the bite. Due to the non-traditional utilization and placement of orthodontic cements as bite turbos, researchers have started evaluating the unique demands imposed on the material itself[12] and the effects on masticatory function[13, 14].

The purpose of this study is to compare the wear rate of commonly used bite turbo materials to provide insight on the longevity based on location and occlusal force. Supplementing the current body of knowledge regarding resin bite turbos may help clinicians improve decision making on placement and desired thickness of material.

Materials and Methods

This study is a laboratory based in vitro study carried out by the Orthodontic Department at the United States Air Force Post Graduate Dental School with association to the Uniformed Services University.

For this study, three popular bite turbo materials were investigated: 1) Transbond LR (3M, Monrovia, CA), 2) Transbond Plus Light Cure Band Adhesive(3M, Monrovia, CA), 3) Ultra Band-Lok (Reliance, Itasca, IL). Transbond LR is a composite resin with quartz and silica filler. Both Transbond Plus and Ultra Band-Lok are polyacid-modified composite resin with silica and quartz filler materials. A total sample size of 36 were assessed, 12 per group. The wear machine utilized in this study was developed at the Academic Centre for Dentistry Amsterdam (ACTA) and has been successfully used for the purpose of simulating two- and three-body wear[15-18]. A steel specimen wheel provided with the wear machine was used to standardize placement of material. Each specimen wheel contains 12 specimen compartments. All materials were placed per manufacturer's guidelines. Photoactive materials were placed and cured using the Valo cordless curing light (Ultradent, South Jordan, UT) for 6 seconds at 3200 mW/cm^2. Following photopolymerization, all samples were sanded using a grinding diamond wheel to achieve a uniform surface.

Specimens were soaked in a salivary simulant (Biotene, GSK, Richardson, TX) for 24 hours immediately before testing. Two-body wear testing was performed within a bath of distilled water against a stainless steel antagonist wheel at a force of 750 g and frequency of 1 Hz. The initial iteration consisted of 50,000 cycles followed by assessment of volumetric loss (μm) with a non-contact optical profilometer (3D Laser-Scanning Confocal Profilometer, Keyence, Itasca, IL). An additional 50,000 cycles were completed two more times with assessment of volumetric loss following each iteration, resulting in a total of 150,000 cycles per sample. Data collected with the profilometer were converted to wear area per length (μm^2/μm) for equivalent comparison across samples. At the conclusion, the data was assessed and analyzed using a one-way repeated analysis of variance (ANOVA) and Tukey's post hoc test. Significance was set to $p<0.05$. Statistical analyses will be performed using SAS version 9.4 (Statistical Analysis Software, Cary, NC).

Results

Mean values and standard deviations are shown in Figures 1-3. A 1-way ANOVA showed significant differences ($p < 0.05$) and materials were grouped into significantly different groups using the Tukey post-hoc analysis. An example of the profilometer scans for one specimen at each timepoint is shown in Figure 4, and the measurement of wear shown in Figure 5.

After the initial wear of 50,000 cycles, there was no significant difference in the amount of wear between the three materials. After 100,000 cycles and 150,000 cycles, Transbond LR had significantly less wear than Ultra Band Lok and Transbond Plus. Of note, the rate of wear was not linear; less wear is observed between subsequent wear cycles. Additionally, Transbond LR had less average wear at 150,000 cycles than 100,000 cycles. After further scrutinization, this was likely due to a variation in where the measurements were taken within the sample. The limitations discussed below may also have contributed to this flaw.

Discussion

The materials used in this study are not typically subjected to occlusal forces. Thus, there is limited research available regarding the rate of wear of these materials. This study compared the wear of three orthodontic materials against a stainless steel antagonist. The null hypothesis was rejected as there was shown to be differences in material wear amongst the different materials. Considering the composition of each materials sheds light on the expected hardness and susceptibility to abrasion. The highly filled composite resin (Transbond™ LR, 75–85 wt% filler)[7] showed less overall wear than the polyacid-modified composite resin materials with less filler content (Transbond™ Plus Band Adhesive, 65–75wt% filler and Ultra Band-Lok, 50–75wt% filler). This has also been shown in a previous wear study using similar materials[1]. The composition of Transbond Plus and Ultra Band-Lok contain similar filler content and showed similar amounts of wear in this study. The rate of wear can assist the orthodontist in selecting a bite turbo material and determining the amount of material that may be needed to achieve the treatment goals. While this study did not evaluate the wear against enamel, this is another important consideration when selecting a bite turbo material. A previous study showed no significant difference in opposing enamel wear between Transbond LR and Transbond Plus.[1]

This study assessed two-body wear using the ACTA wear machine. This does not take into consideration the factors that can influence the amount, frequency, and types of forces experienced by a bite turbo in vivo. The force level used in this study was only a fraction of actual occlusal forces. The intent of this study was not to replicate physiologic force, but to standardize force, frequency, and environment between samples. However, future in vitro studies to evaluate three-body wear could elucidate further information on the wear of these materials in the presence of a third media.

Another study using the ACTA wear machine reported that 220,000 wear cycles was equivalent to two years of intraoral wear.[15] That would mean that 150,000 cycles would represent approximately 16 months of intraoral wear. If bite opening is desired for a short period of time, such as in correcting an anterior crossbite, the wear rate may not be as strong of a factor in material selection, as all three materials wore similarly in the initial iteration of wear cycles.

Effort was made to standardize the protocol to ensure a uniform environment for each sample wheel, yet limitations were acknowledged. Throughout the study, there was an unanticipated amount of wear of the stainless steel antagonist wheels, resulting in a smoother surface texture as the study progressed. It would have been more ideal to have three separate stainless steel antagonists paired with each specimen wheel that stayed consistent throughout the study. Additionally, it would have been prudent to measure the amount of force applied to each specimen during wear testing to ensure standardization. These are a few factors that could have contributed to some of the outliers that were identified and omitted from the data.

Conclusions

This study evaluated two-body wear of three commonly used bite turbo materials. Transbond LR exhibited less wear than Ultra Bandlok and Transbond Plus at the completion of 150,000 wear cycles. While this study elicits information regarding the wear of these bite turbo materials, there were some limitations acknowledged. Additional research on this topic is needed to further assist in the clinical decision-making process.

References

1. Feagin, K., et al., *In vitro comparison of wear of three orthodontic bite materials and opposing enamel.* Int Orthod, 2021.
2. Kravitz, N.D., *Interceptive Orthodontics with Resin Turbos for Pseudo-Class III Malocclusions.* Case Rep Dent, 2019. 2019: p. 1909063.
3. Kravitz, N.D., et al., *Resin bite turbos.* J Clin Orthod, 2018. 52(9): p. 456-461.
4. Kravitz, N., et al., *Resin bite turbos.* J Clin Orthod, 2018. 52(9): p. 456-461.
5. Aksakalli, S., et al., *Physical properties of different orthodontic cements.* J Orofac Orthop, 2015. 76(4): p. 328-37.
6. Lund, R.G., et al., *Band cementation materials: solubility and fluoride release.* Oral Health Prev Dent, 2008. 6(4): p. 323-9.
7. Gillgrass, T.J., et al., *Fluoride release, microbial inhibition and microleakage pattern of two orthodontic band cements.* J Dent, 1999. 27(6): p. 455-61.
8. Caves, G.R., et al., *Fluoride release from orthodontic band cements-a comparison of two in vitro models.* J Dent, 2003. 31(1): p. 19-24.
9. Ashcraft, D.B., R.N. Staley, and J.R. Jakobsen, *Fluoride release and shear bond strengths of three light-cured glass ionomer cements.* Am J Orthod Dentofacial Orthop, 1997. 111(3): p. 260-5.

10. Millett, D.T., et al., *In vitro comparison of orthodontic band cements.* Am J Orthod Dentofacial Orthop, 2003. 123(1): p. 15-20.
11. Aguiar, D.A., et al., *Evaluation of mechanical properties of five cements for orthodontic band cementation.* Braz Oral Res, 2013. 27(2): p. 136-41.
12. Kilinc, D.D. and G. Sayar, *Comparison of shear bond strength of three different adhesives used as temporary bite raiser in daily orthodontic practice.* Int Orthod, 2018. 16(3): p. 440-449.
13. Changsiripun, C. and D. Pativetpinyo, *Masticatory function after bite-raising with light-cured orthodontic band cement in healthy adults.* Angle Orthod, 2019.
14. Pativetpinyo, D., W. Supronsinchai, and C. Changsiripun, *Immediate effects of temporary bite-raising with light-cured orthodontic band cement on the electromyographic response of masticatory muscles.* J Appl Oral Sci, 2018. 26: p. e20170214.
15. Benetti, A.R., et al., *Assessment of wear facets produced by the ACTA wear machine.* J Dent, 2016. 45: p. 19-25.
16. Pelka, M., et al., *Comparison of two- and three-body wear of glass-ionomers and composites.* Eur J Oral Sci, 1996. 104(2 (Pt 1)): p. 132-7.
17. Reyes-Sevilla M, K.R., Werner A, Kleverlaan CJ, Lobbezoo F. , *Comparison of wear between occlusal splint materials and resin composite materials.* . J Oral Rehabil, 2018(45): p. 539–544.
18. Bonifacio, C.C., A. Werner, and C.J. Kleverlaan, *Coating glass-ionomer cements with a nanofilled resin.* Acta Odontol Scand, 2012. 70(6): p. 471-7.

Figure Legends

Fig. 1. Graph comparison of average wear of all materials at each timepoint.

Fig. 2. Graph comparison of average wear for each material regardless of timepoint.

Fig. 3. Graph comparison of wear amongst each material at three different time points.

Fig. 4. Profilometer scan of one sample.

Fig. 5. Measurement of wear area for the scanned sample.

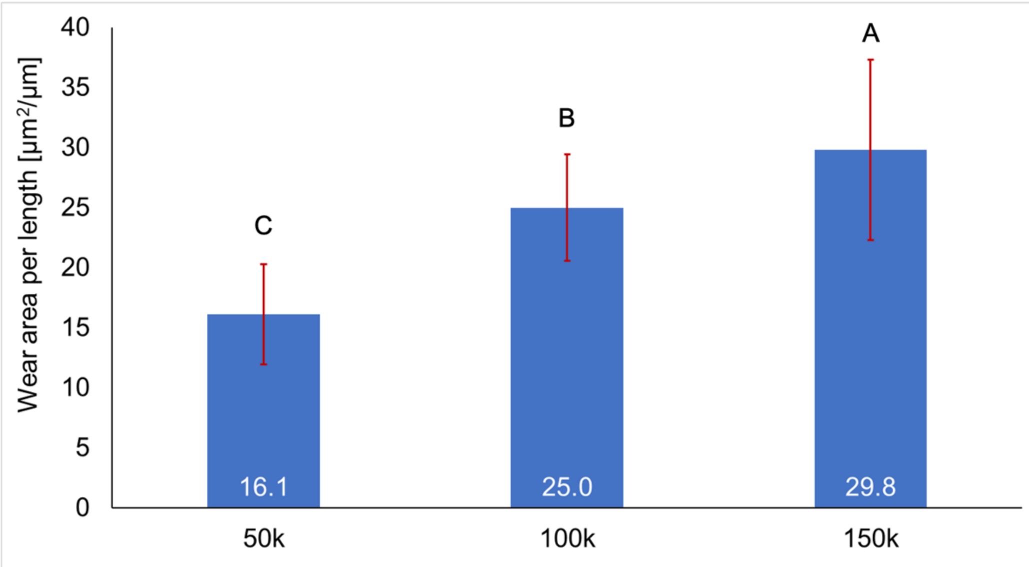

Figure 1: Comparison of average wear of all materials at each timepoint. Cycles with the same letter are not significantly different (p>0.05).

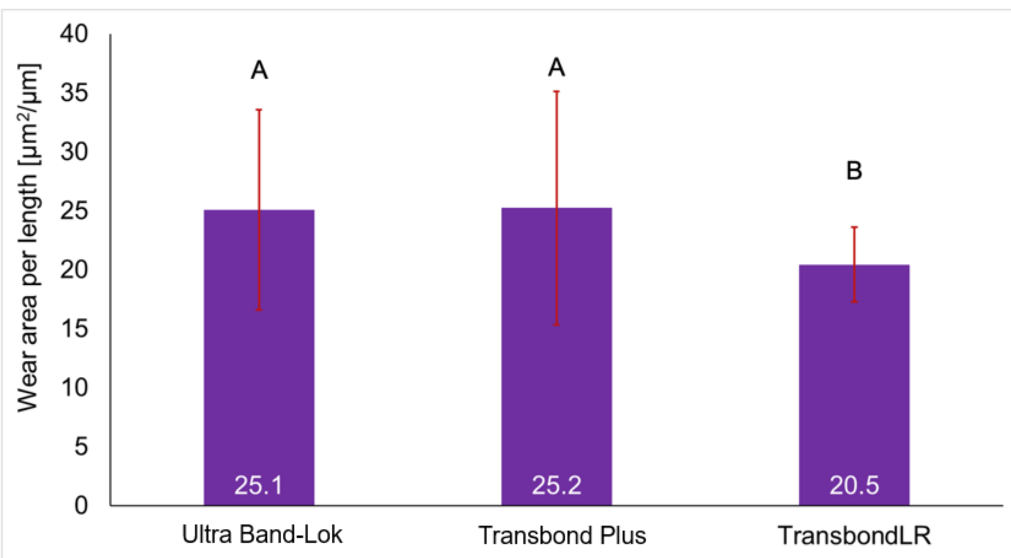

Figure 2: Comparison of average wear for each material regardless of timepoint. Materials with the same letter are not significantly different (p>0.05).

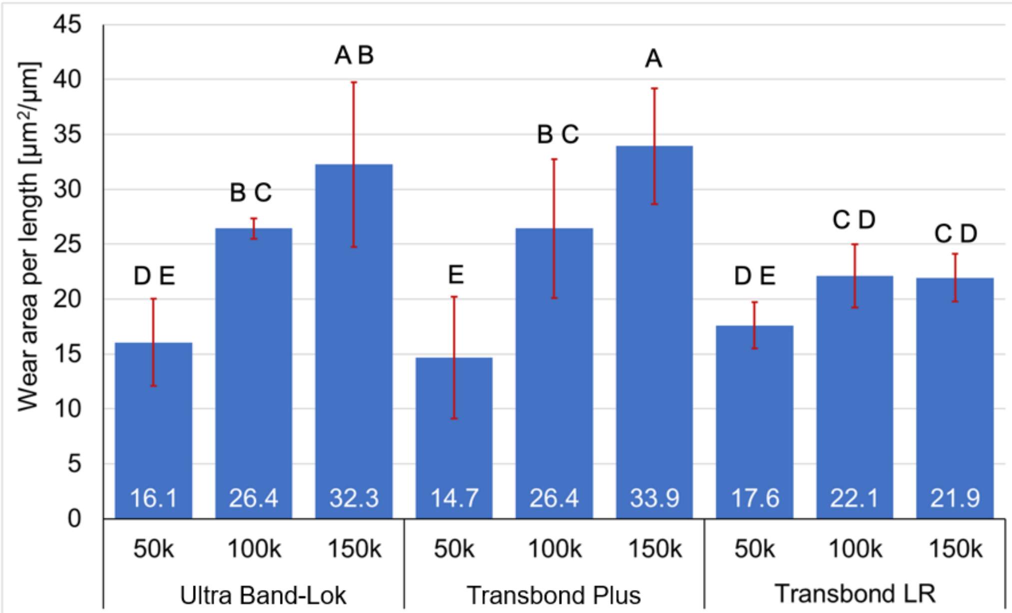

Figure 3: Comparison of wear amongst each material at three different time points. Materials with the same letter are not significantly different (p>0.05).

Figure 4: Profilometer scan of one sample.

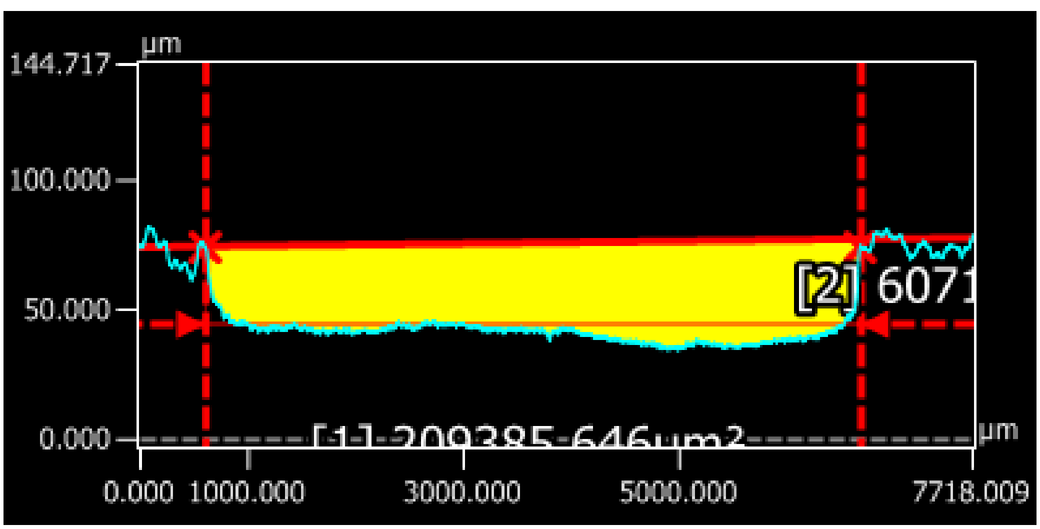

Figure 5: Measurement of wear area for the scanned sample