Open Journal of Stomatology, 2023, 13, 414-421
https://www.scirp.org/journal/ojst
ISSN Online: 2160-8717
ISSN Print: 2160-8709

Shear Bond Strength of Different Types of Cement Used for Bonding Band and Loop Space Maintainer

Gio Lee[1], Justin Vo[1], Neamat Hassan Abubakr[2]

[1]School of Dental Medicine, University of Nevada, Las Vegas, Nevada, USA
[2]Department of Biomedical Sciences, School of Dental Medicine, University of Nevada, Las Vegas, Nevada, USA
Email: neamat.hassan@unlv.edu

How to cite this paper: Lee, G., Vo, J. and Abubakr, N.H. (2023) Shear Bond Strength of Different Types of Cement Used for Bonding Band and Loop Space Maintainer. *Open Journal of Stomatology*, **13**, 414-421.
https://doi.org/10.4236/ojst.2023.1311034

Received: October 13, 2023
Accepted: November 20, 2023
Published: November 23, 2023

Abstract

Purpose: The present study aimed to evaluate the effects of thermal aging on the shear bond strength of three different types of cement used to retain band and loop space maintainers cemented on extracted human permanent molar teeth. **Methods:** A total of 66 newly extracted permanent molars were used in this study. Eighteen teeth were used as a control and did not undergo thermal aging (six per group). All sample teeth were randomly divided into three groups: KetacCem, RelyX Luting Plus, and RelyX Unicem 2. After bonding procedures, all experimental groups undergo thermal aging. The shear bond strength of all samples was conducted using the Ultratester machine. Findings were statistically analyzed using the ANOVA and Turkey's post hoc tests. **Results:** Among the examined groups, Ketac Cem presented with the highest recorded shear bond (11.4 MPa), while RelyX Luting Plus showed the lowest (3.2 MPa). The control groups recorded the highest shear bond strength compared to all examined groups; Ketac Cem showed the highest shear bond strength (12.8 Mpa), and RelyX Luting Plus had the least recorded reading (5.4 Mpa). **Conclusion:** Within the limitation of the present study, there was a statistically significant difference between the examined groups; Ketac Cem showed a higher shear bond cement than RelyX luting Plus and RelyX Unicem.

Keywords

Shear Bond, Band and Loop Space Maintainers, Ketac Cem Cement, RelyX Plus Cement, RelyX Unicem 2 Cement

1. Introduction

Premature loss of primary dentition can have a negative impact on the developing occlusal scheme. It can result in loss of arch length, which might lead to crowding and malocclusion, and can impact erupting permanent dentition [1]. The best way to prevent this is to maintain the primary dentition until it naturally exfoliates [2] [3]. As a clinician, it is essential to monitor the developing dentition, making sure there is space management throughout. Depending upon the patient's growth, development, and age, various appliances can be utilized regarding space maintenance [4]. When maintenance of the primary dentition cannot be achieved, space maintainers can reduce or prevent these sequelae [3]. The different classifications of space maintainers include fixed (unilateral or bilateral) or semi-fixed, banded or non-banded, functional or non-functional, active or passive, and removable (unilateral or bilateral) [5]. The use of space maintainers may even obviate the consequences of the loss of arch length and the need for complex orthodontic treatment [3]. However, there can also be adverse effects of space maintainers, which include dislodgment, plaque accumulation, caries, damage or interference with successor eruption, undesirable tooth movement, inhibition of alveolar growth, soft tissue impingement, and pain [6] [7].

Proper application of space maintainers is exhibited through placement, orientation, and band cementation onto the primary or mixed dentition. Any flaws arising during this process may alter the appliance's function and longevity in the long run [8]. The longevity of fitted space maintainers depends on several factors; it was reported that band and loop space maintainers (B and L SM) failed due to cement loss, breakage, and design flaws [8] [9] [10]. In 2009, a prospective study assessing the longevity of B and L SM space maintainers reported that the decementation of the band was the most common reason for the failure of B and L SM [11]. The high rates of decementation, although their causes are not explicitly stated can further indicate the importance of the cement or luting agent being used, reflecting their success rate.

The cementation process plays a vital role in the longevity and function of B and L SM, as the cement provides stability for the space maintainer after placement on the tooth. Several reasons for the decementation of the band have been reported, with inadequate control of moisture being among these reasons [12] [13]. Different types of cement can provide different outcomes regarding longevity, shear strength, retention, and stability [7]. The present study aimed to evaluate the effects of thermal aging on the shear bond strength of three different types of cement used to retain band and loop space maintainers cemented on extracted human permanent molar teeth.

2. Materials and Methods

2.1. Tooth Selection

A total of 66 recently extracted sound permanent human molars were used in this study. Eighteen of the teeth were used as a control and did not undergo thermal aging (six per group). The extracted teeth were cleaned on the buccal, lingual, and interproximal surfaces of the sterilized teeth-making sure unnecessary excess is removed. A diagnodent was used to ensure that the teeth selected for the experiment were caries free. The remaining 48 teeth were randomly divided into three experimental groups in accordance with a double blind randomized study (**Table 1**).

All teeth were stored in artificial saliva (Pickering Laboratories-Mountain View, CA). The space maintainer bands (Denovo-Colorado, USA) were fit and contoured and sized around each individual tooth according to the material shown in **Table 2**.

2.2. Cementation and Thermal Aging Procedure

The space maintainer bands were cemented onto the teeth based on their respective groups as shown in **Table 1**. The examined cementing agents were manipulated according to the manufacturer's instructions. During the cementation process, excess cement was removed before the cement had set. The teeth for groups A-C were then placed in the thermocycler (SD Mechatronik, Germany). The thermocycler water baths were set to 5˚C and 55˚C for 20 seconds. The readings were taken after 20,000 thermocycles (two estimated clinical years) [14]. The thermal aging process was done in order to mimic conditions similar to that of the patient's oral environment. This was done by alternating between five degrees celsius and fifty-five degrees celsius in the thermocycler. 10,000 cycles is equivalent to one year in a patient's oral environment undergoing similar temperature changes associated with the patient's diet; *i.e.* hot food and cold beverages. The samples were then removed from the thermocycler and mounted vertically in self-curing acrylic, in a way that the crown and space maintainer band was exposed. The mounted samples were then stored in distilled water until the shear bond of the cemented samples were examined using an UltraTester™ Bond Strength Testing Machine (Ultradent machine, Utah, USA). The values were then recorded in the respective tables and statistical analyses was conducted utilizing the ANOVA test and Turkey's post hoc tests.

3. Results

Two sample teeth from the Ketac control groups were lost (fracture during mounting), leaving the Ketac control group with four teeth remaining. The highest recorded shear bond in the control groups belonged to the Ketac Cem, with a mean shear bond value of 12.8 MPa followed by the Unicem 2 with a mean shear bond value of 9.5 MPa. The lowest recorded shear bond value for the control group was RelyX luting Plus with an average shear bond value of 5.4 MPa (**Figure 1**).

The recorded shear bond values in the experimental group from highest to lowest were as followed, Ketac Cem with a mean shear bond value of 11.4 MPa , Unicem 2 with a mean shear bond value of 7.4 MPa, and RelyX luting with a mean shear bond value of 3.2 MPa (**Figure 1**).

Table 1. Allocated research groups.

Group A (16)	Bands cemented with Ketac Cem Aplicap placed in thermocycler
Group B (16)	Bands cemented with RelyX Luting Plus Automix placed in thermocycler
Group C (16)	Bands cemented with RelyX Unicem 2 Automix placed in thermocycler
Group D (6)	Bands cemented with Ketac Cem Aplicap-Control
Group E (6)	Bands cemented with RelyX Luting Plus Automix-Control
Group F (6)	Bands cemented with RelyX Unicem 2 Automix-Control

Table 2. List of the examined cements.

Group	Cement	Composition	Batch Number	Manufacturer
A	Ketac Cem Aplicap Cement	Glass powder, pigments, polycarboxylic acid, tartaric acid, water, conservation agents	7613175	3M Deutschland GmbH, Neuss, Germany
B	RelyX Luting Plus Automix Cement	Paste A: Fluoroaluminosilicate (FAS) glass. Proprietary reducing agent, HEMA, water, opacifying agent Paste B: Methacrylated polycarboxylic acid, BisGMA, HEMA, water, potassium persulfate, zirconia silica filler	NE74370	3M ESPE, Dental product, St. Paul, MN, USA
C	RelyX Unicem 2 Automix Cement	Base paste: Methacrylate monomers containing phosphoric acid groups, methacrylate monomers, silanated fillers, initiator components, stabilizers, rheological additives Catalyst paste: Methacrylate monomers, alkaline (basic) fillers, silanated fillers, initiator components, stabilizers, pigments, rheological additives	5272460	3M Deutschland GmbH, Neuss, Germany

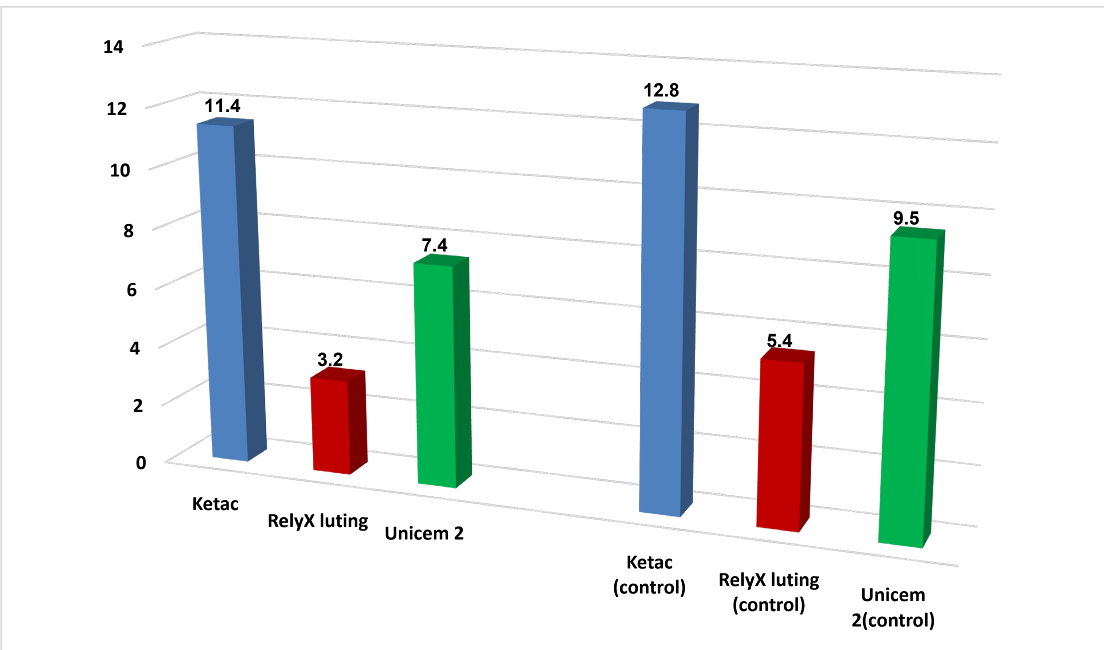

Figure 1. Mean shear bond values for both experimental and control groups in MPa.

Thermocycling has an effect on the shear bond strength of the material. Ketac Control has a 1.1 MPa shear bond strength mean value higher than experimental Ketac sample. Unicem Control has a 2.1 MPa shear bond strength mean value higher than experimental Unicem experimental. The highest difference in mean values was shown between RelyX Luting control and experimental RelyX Luting, which was 2.2 MPa (**Figure 1**).

The descriptive data as shown in **Table 3** shows the descriptive values of all examined materials. The standard deviation ranged from 0.9275 MPa to 2.8683 MPa. Experimental Ketac presented with the highest standard of deviation of 2.8683 MPa (**Table 3**).

The ANOVA analysis of shear bond strength as shown in **Table 4** indicates the significance of 0.00 between all experimental groups.

The comparison shown in **Table 5** shows that the mean significant difference between Ketac, RelyX luting and Unicem2 was 0.000 (less than 0.005).

4. Discussion

Several appliances could be used as space maintainers; B and L SM is the most common type of space maintainer due to its economical and chair-side time application. Despite their unique combination of favorable properties, B and L SM have several drawbacks, such as cement failures and breakage of the solder [3] [4] [11] [15] [16]. One of the widely used types of cement for band cementation is Glass ionomer cements due to its chemical adhesive properties and the fluoride release property. These properties made Glass ionomer one of the favorite bonding agents for space maintainers [17] [18]. The average shear bond values of experimental Ketac Cem Aplicap were 11.4 MPa for the experimental group and 12.8 MPa for the Ketac control group. These groups both showed the highest values in shear bond strength compared to their respective groups, reflecting their strength, retention, and stability. The present study's finding comes in agreement with previous studies which indicated that Ketac-Cem was superior in its shear bond strength and survival rate [17] [18]. The recorded mean shear bond value relative to the RelyX Luting and the Unicem2 only further justifies its use in pediatric dentistry to cement band and loop space maintainers.

Table 3. Descriptive values for shear bond strength of the examined materials.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Ketac	16	11.42	2.8683	0.7171	9.890	12.947	6.6	16.1
RelyX	16	3.22	0.9275	0.2319	2.725	3.713	1.8	6.0
Unicem 2	16	7.39	2.1728	0.5432	6.230	8.545	2.5	10.3

Table 4. ANOVA analysis of shear bond strength between and within experimental groups.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	537.970	2	268.985	58.439	0.000
Within Groups	207.126	45	4.603		

Table 5. Multiple comparisons between the examined groups.

(I) Grouping	(J) Grouping	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Ketac	RelyX	8.2000*	0.7585	0.000	6.362	10.038
	Unicem 2	4.0313*	0.7585	0.000	2.193	5.870
RelyX	Ketac	−8.2000*	0.7585	0.000	−10.038	−6.362
	Unicem 2	−4.1688*	0.7585	0.000	−6.007	−2.330
Unicem 2	Ketac	−4.0313*	0.7585	0.000	−5.870	−2.193
	RelyX	4.1688*	0.7585	0.000	2.330	6.007

*The mean difference is significant at the 0.05 level.

In this study, the mean shear bond for the B and L SM bands cemented RelyX Luting, and the Unicem2 was significantly lower than the shear bond reading obtained from the Ketac Cem samples. The reading of the present investigation agrees with the finding of Cantekin *et al.*, which indicated that glass ionomer cement showed higher retentive strength than resin base bonding cement [19]. Other studies compared the failure rates of band cementation, and their findings come in agreement with the present study finding; all studies agreed that the failure rate and retentive strength of glass ionomer, namely Ketac Cem were better than Resin Modified glass Ionomer, Compomer and resin-based luting cements [19] [20] [21] [22].

The temperature changes in the oral cavity directly affect on the bond strength. Thermocycling is the most commonly used or applied artificial aging. Theromcycling dramatically decreased the shear bond strength of all tested materials; this could be due to the fluctuations in temperature, varying from hot to cold, resulting in thermodynamic stresses B and L SM. As a result of thermocycling, the decrease of shear bond has been previously reported and proven to be a variable dependent upon shear bond strength [23] [24] [25]. Further research is needed to validate the long-term behavior of the different bonding cement using different types of space maintainers when tested in a various testing conditions including the masticatory forces.

5. Conclusion

Within the limitation of the present study, there was statistical significance between the examined groups, and Ketac Cem showed a higher shear bond cement than both RelyX luting Plus and RelyX Unicem. The present study provides evidence that thermal aging affects the shear bond strength.

Clinical Relevance

The survival of space maintainers depend mainly on the type of used bonding agent.

Authors' Contributions

GL, JV and NHA planned and performed the study; GL and NHA performed literature review. GL, NHA drafted the manuscript, GL, JV and NHA carried out the statistical analyses and interpretation of data. GL and NHA critically revised the manuscript for intellectual content. All the authors have read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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