An in Vitro Assessment of the Retentive Property of Orthodontic Molar Bands Cemented With HY Agent-Containing Glass Ionomer Cement

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KEYWORDS

Shofu HY bond GIC, Voco Meron, retentive property, luting cement

ABSTRACT

Introduction: In orthodontic treatments, glass ionomer cements (GICs) are the most extensively used adhesive materials. Through an acid-base reaction with enamel and dentin, they function as chelating agents, creating a chemical bond with stainless steel bands. It has been reported that glass ionomer cement (GIC) containing HY agents along with a complex of zinc fluoride, strontium fluoride, and tannic acid offers enhanced retentive strength. This combination contributes to reduced solubility, promotes remineralization, and improves acid resistance. In this in vitro study, Shofu HY Bond glass ionomer cement (HY GIC) was utilized to compare and evaluate the retentive strength of molar bands cemented with it against Voco Meron (VM GIC), a conventional glass ionomer cement.

Materials and Methods: The long axis of fifty extracted maxillary first molars was aligned at 90 degrees to the acrylic resin blocks. Of these teeth, twenty-five were bonded using HY-GIC (group 1), while the remaining twenty-five were bonded with Meron GIC (group 2). The retentive properties of both types of glass ionomer cement were evaluated using universal testing equipment. An independent t-test was employed to compare the retentive strength between the two groups.

Results: The average retentive strength of bands bonded with HY-GIC was measured at 14.65 ± 1.37 MPa, while bands using Meron GIC had a strength of 10.75 ± 1.10 MPa. The difference between these two values was statistically significant.

Conclusion: There was a significant difference in the retentive strength between the 2 groups with Shofu HY bond GIC being superior.

1. Introduction

In orthodontics, stable attachments are essential for effective tooth movement, and molar bands are commonly used on posterior teeth to achieve this [1]. Despite the rise of composite resin and acid-etch bonding techniques, metal bands remain prevalent, particularly on molars [2]. This is largely due to the higher failure rates of molar tubes, which are more prone to detachment under masticatory forces [3,4]. Molar bands provide greater durability and are better suited for supporting external appliances like headgear [5]. Their strength reduces the risk of bond failure, minimizing treatment delays and improving the overall success of the treatment [6].

Historically, zinc phosphate and polycarboxylate cement were the primary choices for band placement due to their ability to create mechanical bonds that improved retention [7]. Their limitations, like high viscosity, fast setting time, and significant solubility in saliva, posed challenges in clinical use [8,9]. These drawbacks led to its gradual replacement by glass ionomer cement (GIC), which provided superior handling and enhanced durability. Glass ionomer cement (GIC), to a large extent, is used as a luting agent for the cementation of molar bands in orthodontic treatment [10]. Given the location of molar bands on posterior teeth, they are subjected to significant shear and tensile forces due to chewing and potential trauma. The adhesive strength of the cement used must be sufficient to withstand these forces, preventing premature detachment [11,12].

Various GICs are commercially available, and their clinical efficacy is influenced by the specific components. Consequently, this study sought to assess the in vitro retention strength of two different commercially available GICs. In this study, HY-Bond Glasionomer CX-SMART (Shofu) and Meron (Voco) glass ionomer cement were utilized for band cementation. HY-Bond GIC is uniquely formulated with a patented HY-agent, which includes a complex of tannic acid, strontium fluoride, and zinc fluoride, along with fluoro-aluminosilicate glass and an acrylic acid-tricarboxylic acid copolymer solution. In contrast, Voco Meron GIC comprises polyacrylic acid, fluoro-silicate, and parabens as its main components. Since bond strength between orthodontic bands and teeth is crucial for treatment success, it is essential to evaluate the retentive properties of different GIC formulations. Therefore, this research aims to analyze and compare the retentive strength of orthodontic bands cemented with Shofu HY-Bond GIC and Voco Meron, a conventional GIC. The null hypothesis for the study was that there would be no difference in average retentive strength between the two materials used.

2. Materials and Methodology

Study Design

Fifty extracted human maxillary first permanent molars were utilised in the study. The inclusion criteria were that the selected teeth had undamaged buccal and lingual enamel with no signs of cracks, demineralization, or evident cavities. No chemicals were used for their preservation post-extraction. The extracted teeth were ultrasonically scaled and polished using non-fluoridated pumice paste and a bristle brush to remove any plaque, calculus, or stains. The samples were subsequently stored in distilled water at room temperature until they were required for testing.

The tooth roots were then embedded in cylindrical moulds using chemically activated acrylic resin, and each tooth was aligned with the help of a surveyor to ensure that the buccal surface was perpendicular to the base of the mould. Subsequently, the first molar bands for buccal tubes, made from standard stainless steel and clinically adapted, were fabricated to fit the crowns of the teeth. Then the embedded teeth were randomly assigned into two groups of twenty-five before band cementation was performed.

Banding Procedure

The bands of the two groups, each containing a sample size of 25, were cemented together using glass ionomer cement prepared according to the manufacturer’s guidelines.

Group 1: HY-Bond Glasionomer CX-SMART (Shofu; Tokyo, Japan)

Group 2: Meron luting GIC (Voco, Germany)

A level scoop of powder was measured with the provided measuring spoon and placed on the mixing pad, followed by the addition of one drop of liquid. The powder was then gently incorporated into the liquid by folding it, with the mixing process continuing for fifteen seconds to ensure proper consistency. Following the loading of each orthodontic band into the band, the teeth were manually seated onto the band using a stainless steel band seater. After each band was correctly positioned on the molar crown and securely pressed into place, the excess cement was carefully removed.

After the GIC had been completely set, the samples were artificially aged by a thermocycling process consisting of 4000 cycles that alternated between 5 and 55 with a dwelling time of 40s. A universal testing machine was employed to assess the retentive strength of specimens from both groups following thermocycling, operating at a crosshead speed of 1 mm/min. Each tooth was mounted on a custom jig specifically designed for this testing, which was then securely attached to the holding device and affixed to the load cell at the base of the universal testing apparatus. The arrowheads of the holding mechanism were configured to fully encompass both the lingual sheath and buccal tube of each molar band, ensuring a secure grip. This configuration ensured that all debonding forces were applied parallel to the long axis of the tooth, ensuring consistency and accuracy during testing. The testing process continued until the band was completely separated from the tooth, enabling a precise measurement of the retentive strength of the cemented bands. The bond strength values in megapascals (MPa) were obtained by dividing the greatest force measured (in Newtons) during debonding by the band surface area (in square millimeters) using the stress-strain curve for each specimen.

3. Statistical Analysis

Before the retentive strength was statistically evaluated, the cumulative frequency (normalized by the sample size) was calculated using the Shapiro-Wilk test. Each group's retentive strength was calculated using descriptive statistics, which included the mean, standard deviation, and minimum and maximum values. The statistical difference between the means of the two groups was evaluated using an independent sample t-test.

4. Results

The average retentive strength of bands cemented with HY-Bond GIC was recorded at 14.65 ± 1.37 MPa, whereas the Meron luting GIC demonstrated an average retentive strength of 10.75 ± 1.10 MPa. An independent sample t-test indicated no statistically significant difference in retentive strength between the two glass ionomer cements, with a p-value of 0.01.

Table 1: Descriptive statistics (in megapascals) of the retentive strength of experimental groups

	Number of samples	Mean	Std. deviation
Group A	25	14.65	1.37
Group B	25	10.75	1.10

5. Discussion

Glass ionomer cement (GIC), introduced by Wilson and Kent in 1971, brought significant advancements to dental materials by offering several key benefits [13]. These included low solubility in oral fluids, which made it resistant to degradation in the mouth and increased compressive and tensile strength, providing it with the ability to withstand the forces of mastication. The primary factor contributing to cement failure between the band and crown is the shear bond loads directed occlusally [14]. Despite this, there has been limited research on the clinical effectiveness of glass ionomer cements (GICs) that incorporate HY agents.

This in vitro study aimed to compare the retentive strength of orthodontic bands bonded with Shofu HY Bond GIC, which contains HY agents, against conventional Voco Meron GIC. The findings indicated a statistically significant difference in retentive strength between the two types of GICs, with the Shofu HY Bond showing a mean retentive strength of 14.65 ± 1.37 MPa and Voco Meron demonstrating 10.75 ± 1.10 MPa.

Previous in vitro research has examined the retentive strength of conventional glass ionomer cement (GIC) compared to GICs that contain HY agents. In a study conducted by Farret et al [15]. (2012), the mechanical properties of various glass ionomer cements used for orthodontic applications were evaluated. The study included two conventional GICs, Ketac Cem Easy Mix (3M-ESPE) and Meron (Voco), along with a resin-modified glass ionomer known as Multi-Cure Glass Ionomer (3M-Unitek). The findings indicated that the Multi-Cure Glass Ionomer exhibited significantly higher diametral tensile strength ($p < 0.01$) and compressive strength compared to the conventional GICs ($p = 0.08$). The study concluded that the resin-modified glass ionomer cement demonstrated superior mechanical properties relative to conventional GICs.

Yamaga et al. conducted an in vitro study to evaluate the adhesive properties of glass ionomer cement (GIC) that incorporated different ratios of a tannin-fluoride preparation (HY agent) when applied to dentin [16]. Their findings indicated that adding a 1.5% HY agent to the GIC resulted in improved bond strength on the first day. However, over time, bond strength decreased for all mixtures, with no significant differences noted between the cement that contained the agent and those that did not. Additionally, there were no notable differences among the various mixtures containing different amounts of the HY agent. Previous research comparing the retentive strength of conventional GIC and GIC with HY agents found minimal differences, suggesting that both can be suitable for clinical applications.

6. Limitations

The study was conducted in vitro using extracted teeth, which may not accurately reflect the conditions found in the oral environment. Since fixed orthodontic treatment typically spans a longer period, it is essential to assess the solubility properties of glass ionomer cement.

7. Conclusion

Both conventional glass ionomer cement and those containing the HY agent demonstrated sufficient retentive strength to effectively prevent debonding, though the HY agent had a superior retentive strength.

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