Exploring the fracture resistance of retentive pin-retained e.max press onlays in molars

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Retentive titanium dentinal pins have been combined with indirect restorations. Application of pins has been used with lithium disilicate, an indirect pressed ceramic restorative material, termed e.max. The objective of this study was to investigate the fracture resistance of pin-retained versus non-pin-retained indirect e.max press restorations. Ten human extracted teeth were used for the control and ten for the test group. Titanium dentinal pins were placed and e.max press restorations were fabricated, by a commercial laboratory, and then cemented. Fracture resistance was assessed. Data was collected and results were obtained. Fracture resistance of both groups indicated no significant difference in values. An observation from testing illuminated that pin-reinforced e.max benefited from a controlled fracture, which minimized tooth damage. The data suggests that pin-reinforced indirect e.max restorations offer no appreciable difference in fracture resistance. Further testing would be required to expand upon the sample size, explore other strength vectors and consider a clinical investigation.

Introduction

The loss of tooth structure, from disease or biomechanical stress, requires the replacement of tooth structure through dental restoration techniques. This may occur either directly or indirectly. Extensive tooth restorations typically require indirect restorations; [i] Indirect dental restorations benefit from excellent form, function, esthetics, and strength, however, the retention of indirect restorations can prove problematic; [ii] This is primarily due to variable technique-sensitive chemical bond of the restorative material with the tooth; [iii] The type of restoration used largely depends on the magnitude of tooth destruction and dictates unique preparation design characteristics; [iv] With the increasing demand in esthetics, use of ceramics has become more prevalent in restorative dentistry; [v] E.max, a ceramic and metal-free restorative material, has been demonstrated to be an extremely strong, dependable restoration with ideal esthetics; [vi] It is a highly bio-compatible glass ceramic composite of lithium disilicate; [vii] E.max is also among the most durable dental materials on the market. Previous studies have concluded that e.max poses no health risk to dental patients and has little potential to cause irritation or sensitizing reactions, when compared to composite or gold restorations.

Although the primary retention of an indirect restoration is based on bond strength, secondary elements can be introduced to further increase surface area and retentive strength, such as pins; [viii] Traditionally, retentive pins were employed to offer significant retention to direct restorations when minimal tooth structure remained; [ix] Effective utilization of pins required proper application of biomechanical principles in each clinical case; [x] Adequate dentin, to support the pin, remains an important factor in the evaluation of the clinical success of retentive restorations; [xi] The type of pin used also determines the success rate of the restoration. Among the two pins types, titanium retentive pins have been found to be highly biocompatible with minimal corrosive activity; [xii]

Due to the sensitivity of indirect restoration bonding and resultant retention, an investigation on whether the use of titanium retentive pins would offer an increase in fracture resistance seemed fitting. If there was a significant increase in fracture resistance between the restorative material and the tooth, pin-reinforced e.max press restorations could justify further investigation. In addition, with advances in 3D intraoral imaging and CAD/CAM, a digital workflow would provide a simple and predictable clinical alternative.

Materials and methods

Human extracted molar teeth were used for this investigation. They were sorted and randomized. A total of 20 extracted molar teeth were used. The control group contained ten molar teeth. Each tooth was prepared for a four surface onlay restoration which did not incorporate pins. The test group included ten molar teeth. Each tooth was prepared for a four surface onlay restoration which did not incorporate pins. Each four surface e.max onlay restoration preparation had either the buccal or lingual wall remaining intact (Fig. 1) following standard pin-retained amalgam guidelines; [xiii] Titanium pins with a diameter of 0.6 mm were used (Stabiklo, Fairfax Dental Inc). Two pins were placed in each tooth at the appropriate line angles, pin 1 was placed on the mesial side whereas pin 2 was placed on the distal side of each molar tooth (Fig. 2). Pins were inserted to a 2 mm depth. The prepared tooth was fixed in a buccolingual and mesiodistal fashion to verify pin placement (Fig. 3). Tooth specimens were sealed in a moisture controlled container and shipped to a dental laboratory (DentUSA) for restoration fabrication with e.max press (Ivoclar Vivadent). Standard Schulich Dentistry protocols were followed. The prepared tooth was fixed with ortho resin (Fig. 7) (acrylic resin, DENTIFY Caukl in the stabilization ring (Fig. 8). A universal loading machine (Instron laboratory testing unit ITW) was utilized to apply an axial load to the tooth until the tooth fractured (Fig. 9). The machine applied pressure at a maximum crosshead speed of 0.5 mm/min. Tooth fracture was assessed visually and measured in Newtons for all the specimens.

Control Group (N) Test Group (N)
3016 2679
2277 2436
2121 1605
3079 2606
2510 1716
2258 2927
3120 3060
2396 1575
2859 3118
2222 2385

Table 2: Fracture resistance values for samples (Newtons)

Fracture resistance of both groups remained; [xvi] Effective utilization of pins required proper application of biomechanical principles in each clinical case; [xvii] Adequate dentin, to support the pin, remains an important factor in the evaluation of the clinical success of retentive restorations; [xviii] The type of pin used also determines the success rate of the restoration. Among the two pins types, titanium retentive pins have been found to be highly biocompatible with minimal corrosive activity; [xix]

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in the fracture resistance between the non pin-retained e.max press restorations and the pin-retained e.max press restorations (Fig. 11). An unpaired t-test result using $P < .05$ was $P = .4443$ in this assessment. Data were obtained by using an analysis of variance (ANOVA). Significant differences were set at a .05 level (Fig. 11).

**Discussion**

There was no statistical difference between the control group (non-pin-retained restorations) and the test group (pin-retained restorations) in fracture resistance. The results indicated that the test group exhibited greater variability. This could be due to pin location, pin length, differences in pin angulations or variations in the width of the onlay preparation margin. The highest fracture resistance value was a pin-retained e.max onlay, which could be related to the increased surface area and subsequent bond strength.[15] Pin-retained e.max onlays had a tendency to fracture in a very controlled manner, with much of the tooth restoration complex remaining intact.

Conversely, non pin-retained e.max onlays typically fractured in such a violent manner that the tooth restoration complex was destroyed. Due to the degree of variability, further laboratory testing would be warranted with a larger sample size. A clinical investigation, highlighting the procedural aspects, would also be an ideal extension of the research. Further studies should isolate variables and establish a greater sample size. With advances in technology, the digital workflow of records, design and output could be easily implemented for pin-retained restorations. It has been previously shown that digital impressions have the ability to capture all aspects of a pin-augmented substructures (Fig. 12) [4]. It has also been demonstrated that CAD/CAM technology has the precision and accuracy to mill (Fig. 13) the subsequent pin-bored restoration from an e.max CAD block.[5] A digital approach seems to represent a simple and predictable chairside alternative for the clinician.

**Conclusions**

This study explored combining restorative titanium pins with indirect e.max press onlay restorations in extracted human molars. Teeth were then subjected to axial loading in a universal testing machine. There was no statistical difference in fracture resistance between the two groups. However, the highest fracture resistance was displayed from a pin-retained e.max onlay. This may be related to the increased surface area and subsequent bond strength. Observationally, pin-retained e.max onlays fractured in a manner that seemed more controlled than non-pin-retained e.max onlays.

Digital dentistry could simplify this potential alternative by providing the clinician with the tools required to acquire the digital impression, design and fabricate the final restoration. Although pin-retained was termed for the investigatory restorations, perhaps pin-rendored would seem more logical. Further investigations are required to substantiate the research and identify whether this approach may be considered as a clinical alternative.

**Conflict of interest**

Research was supported by the Schuchard Dentistry Summer Research Project and by Research Driven Inc. Les Kalman is the co-owner and President of Research Driven Inc.

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