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

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Abstract
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 benefitted 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. Indirect dental restorations benefit from excellent form, function, esthetics, and strength; however, the retention of indirect restorations can prove problematic. This is primarily due to the variable technique-sensitive chemical bond of the restorative material with the tooth. The type of restoration used largely depends on the magnitude of tooth destruction and dictates unique preparation design characteristics.

Fig. 1: No pin onlay tooth preparation.
Fig. 2: Pin onlay tooth preparation.
With the increasing demand in esthetics, use of ceramics has become more prevalent in restorative dentistry. E.max, a ceramic and metal-free restorative material, has been demonstrated to be an extremely strong, dependable restoration with ideal esthetics. It is a highly biocompatible glass ceramic composed of lithium disilicate. E.max is also among the most durable dental materials to date. 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. Traditionally, retentive pins were employed to offer significant retention to direct restorations when minimal tooth structure remained. Effective utilization of pins required proper application of biomechanical principles in each clinical case. Adequate dentin, to support the pin, remains an important factor in the evaluation of the clinical success of retentive restorations. The type of pin used also determines the success rate of the restoration. Among the two pin types, titanium retentive pins have been found to be highly biocompatibility with minimal corrosive activity.

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 3-D intra-oral 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 10 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
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pin-retained amalgam guidelines. Titanium pins with a diameter of 0.6 mm were used (Stabilok; 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 top 1mm was sheared off and smoothed. Pin length was slightly variable among the teeth. Radiographs were taken in a buccolingual and mesiodistal fashion to verify pin placement (Fig. 3). All tooth specimens were packaged and sealed in a moisture controlled container and shipped to a dental lab (DentUSA) for restoration fabrication with e.max press (IPS e.max Press; Ivoclar Vivadent). Specimens were returned in the same manner along with the e.max onlay restorations (Figs. 4 & 5). Tooth specimens and restorations were prepared and bonded (Fig. 6) using Multilink adhesive cementation system (Multilink Automix; Ivoclar Vivadent) following manufacturing recommendations.

Cement flash was removed and the restorations were polished following standard Schulich Dentistry protocols. The prepared tooth was fixed with ortho resin (Fig. 7) (acrylic resin, DENTSPLY Caulk) 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 teeth in the control and test groups (Fig. 10).

Results

The force (Newtons) required to cause fracture of either the restoration or tooth, or a combination of the two, was extremely variable (Table I). The test group suggested greater variability among the values and the highest fracture resistance value. There was no significant difference 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. 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 pro-
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Conclusions

This study explored combining retentive titanium pins with indirect e.max press onlay restorations in extracted human molar teeth. Teeth were then subjected to axial loading in a universal loading 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 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 investigative restorations, perhaps pin-reinforced 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 Schulich Dentistry Summer Research Project and by Research Driven Inc. Les Kalman is the co-owner and President of Research Driven Inc.

Acknowledgements

The authors thank Victoria Yu, a dental summer student, who assisted with aspects of the methodology, and Dr. Amin Rizkalla, BSc, MEng, PhD, Associate Professor & Chair of the Division of Biomaterials Science, who facilitated the testing.

Editorial note: A complete list of references is available from the publisher.

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Fig. 11: Fracture resistance averaged for each group with standard deviation: graphical.
Fig. 12: Digital impression of a pin-augmented substructure.
Fig. 13: Milled e.max restoration with pin-bore holes.