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Influence of ceramic thickness and cavity design optimization on fracture resistance of partial coverage restorations.

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Abstract

Background and Objective: Literature suggests the use of thinner indirect partial coverage restorations. The purpose of this *in vitro* study was to evaluate the influence of cavity design optimisation and bio-substitution with various cuspal and fissure designs, for indirect lithium disilicate partial coverage restorations. The influence on the initial crack formation and subsequently the catastrophic fracture force were evaluated.

Method: Forty molars were prepared and randomly divided into four test groups (A, B, C and D). Indirect partial coverage restorations were milled with different cuspal and fissure thicknesses of lithium disilicate ceramic. Group A (cusp 1; fissure 0.7 mm thickness) and group B (cusp 0.8; fissure 0.5 mm) received a composite restoration in the class I preparation additionally. Group C (cusp 1; fissure 1.7 mm) and group D (cusp 0.8; fissure 1.5 mm) had ceramic included in the class I cavity.

The restored specimens were thermo-cycled and force application was completed with a Universal testing machine in two phases. Phase one was the determination of initial first crack formation with various pre-set forces. Phase two was the maximum catastrophic fracture force. Statistical analysis was completed with the Kruskal-Wallis test and confirmed by the Dunn-Sidak multiple comparison test ($p < 0.05$).

Results: The catastrophic fracture force in group A (2460N) was significantly greater than group B (1523N), with no difference between group C (3142N) and group D (2591N).

Conclusion: The cuspal thicknesses of 1 mm for indirect partial coverage restorations were advisable, with or without composite in the class I cavity.

Keywords: Lithium disilicate; indirect ceramic restoration; partial coverage restoration; cavity design optimization; catastrophic failure; initial crack.

Introduction

In some clinical scenarios the volume of tooth structure that has been lost is extensive. Clinicians then require the application of an indirect restorative technique to create a functional and durable restoration (Smithson et al, 2011). Traditionally, this has been achieved through the use of laboratory manufactured all-metal or metal-ceramic restorations (Seymour et al, 1999). The volume of lost tooth structure and the ability to prepare the tooth determine whether the restorative options can include ceramic inlays/onlays. Cuspal reduction might be indicated to provide sufficient space for the dental material, in order to resist the occlusal forces (Smithson et al, 2011).

Dental adhesive systems together with the subsequent increase in compressive strength of composite, has led to the development of adhesive luting systems that reduce the need for mechanical retention (Blatz et al, 2003; Dietschi and Spreafico, 2015). The development of lithium disilicate ceramics with increased compressive strengths provided the possibility of thinner restorations (Politano et al, 2016). The reduction in tooth preparation with the use of lithium disilicate ceramics are in line with the principle of minimally invasive dentistry (Ericson, 2004). Such conservative preparation designs aim to both increase the longevity of the tooth and its restoration (Veneziani, 2017).

It was previously accepted that ceramic restorations should be as thick as possible. This approach changed based on the principle of cavity design optimization (CDO), with the improved dental material properties of composites and lithium disilicate ceramics (Beier et al, 2012). The concept of “Biomimetic dentistry” aims to maintain as much tooth structure possible and therefore furthers the minimally invasive approach of tooth preparation (Magne and Douglas, 1999). The biomimetic approach further attempts to increase the longevity of the underlying tooth structure (Veneziani, 2017) by replacing lost dentine with composite and enamel with ceramic partial coverage restorations. Sasse et al (2015) suggested that the CDO approach where composite was added to replace the dentine in the class I preparation had minor influence on the fracture resistance of the restorative ceramic. With the combination of various restorative dental materials improving, it is possible that a restoration with a higher resistance to compressive force could be produced. Sasse et al (2015) found that a reduction in catastrophic failure of the tooth and the restorative option occurred when the ceramics were thinner than 0.7 mm in the fissure and 1 mm for the cuspal thickness when using a composite core, as per the CDO approach. The ideal scenario between a minimal tooth preparation and the thickness of the ceramic restoration should be determined by the material’s resistance to fracture in thin thicknesses and the clinical situation (Skouridou et al, 2013).
One such situation present as cases where composite

in combination with indirect ceramic restorations was used in molars that showed excessive tooth loss or undercuts. Posterior partial ceramic coverage in combination with CDO attempts to retain the maximum strength of the tooth structure by restoring the inner cavity with composite, as well as partial occlusal coverage with a non-retentive ceramic restoration as the indirect restoration (Jackson, 1999). The recommended thickness for lithium disilicate ceramics were established between 1 and 1.2 mm (Fennis et al, 2004), but could be up to 1.5 mm (Schlichting et al, 2011). In order to bond the ceramic restoration to the tooth/composite interface Blatz et al (2003) indicated that the luting cement will bond to the underlying restoration and tooth structure. Clausen et al (2010) investigated the fracture resistance of two types of lithium disilicate ceramics bonded to varying amounts of enamel and dentine. The conclusion was that the volume of dentine and enamel did not influence the fracture resistance of the materials, but rather the type of ceramic and its thickness had a far greater impact (Clausen et al, 2010). Sasse et al (2015) showed that the fracture resistance of lithium disilicate ceramics led to a high survival rate of restorations when bonded to composite material used to restore the lost dentine. In order to assess the fracture modes on the restored molars an indirect ceramic posterior partial coverage restoration was made in accordance with the study completed by Guess et al (2013).

The aim of this *in vitro* study was to assess the compressive force at initial failure (first crack formation) and the maximum failure force (catastrophic failure) of lithium disilicate indirect ceramic posterior partial coverage restorations with various designs.

The null hypotheses were that 1). there would be no influence of the cavity design optimization with composite restorations in the occlusal class I restorations for the initial crack force or the catastrophic failure with cusp thicknesses of 0.8 mm or 1 mm and 2). the additional ceramic thickness in the class I area with the 0.8 mm or 1 mm cusp thicknesses would not influence the maximum fracture force at the initial crack force or at catastrophic failure.

Materials and Methods

Research ethical clearance was obtained from The University of the Western Cape Dental and Biomedical research committees (Study reference number: BM/16/3/29). The teeth were voluntarily donated to the research by periodontally compromised patients; they were appropriately discarded and incinerated after completion of the study. Forty sound and crack free mandibular 1st or 2nd molars were collected, cleaned with pumice and stored in moist gauze at 2-5°C until the sample size was reached. The molars were then stored in a 0.1% thymol solution (Thymol Crystal; Merck KGaA, Darmstadt, Germany) for 24 hours. The specimen preparations were based on the CDO and the bio-substitutive approach as previously described (Clausen et al, 2010; Sasse et al, 2015).

The roots of the molars were embedded along their long axis with auto-polymerizing acrylic resin (Technovit 4000, Heraeus Kulzer, Wehrheim, Germany) in Unplasticised Polyvinyl Chloride (UPVC) cylinders (Ø 15 mm). The cemento-enamel junctions of the molars were located 3 mm above the level of the resin (Schlichting et al, 2011). They were prepared for an indirect ceramic posterior partial coverage restoration, and subsequently received an additional preparation with a central class I cavity.

A butt joint, using a pre-shaped diamond wheel under constant water cooling was prepared. A 130° preparation angle was maintained bucco-lingually between the cusps with straight bevelled finish lines (Arnetzl and Arnetzl, 2009) and checked with a pre-shaped guide. The central dentine was exposed and a circumferential enamel margin of at least 1 mm was present. A class I cavity with a depth of 1 mm from the central fissure using a round bur (size 10) was prepared. The circumferential outline of the preparation was maintained within the dentino-enamel junction. These forty molars were divided randomly into four groups (*n*=10 per group).

Groups A and B received the composite restoration in the prepared class I cavity (Tetric N-Ceram, Ivoclar Vivadent, Schaan, Liechtenstein) using an Universal self-etching adhesive with a selective etch technique (Tetric N-Bond Universal, Ivoclar Vivadent). The 130° preparation angle was maintained bucco-lingually between the cusps and checked with the pre-shaped guide. The preparation was smoothed and all sharp edges rounded (Figure 1).

Group A: The CAD/CAM monolithic lithium disilicate posterior partial coverage restorations were designed and manufactured to create a ceramic restoration with a cuspal thickness of 1 mm and a 0.7 mm fissure depth. Composite was used in the class I dentine cavity to simulate a CDO approach.

Group B: The CAD/CAM monolithic lithium disilicate posterior partial coverage restorations were designed and manufactured to create a ceramic restoration with a cuspal thickness of 0.8 mm and a 0.5 mm fissure depth. Composite was used in the class I dentine cavity to simulate a CDO approach.

Group C: CAD/CAM monolithic lithium disilicate posterior partial coverage restorations were designed and manufactured to create a ceramic restoration with a cuspal thickness of 1 mm and a 1.7 mm fissure depth. The class I cavity formed part of the CAD/CAM restoration.

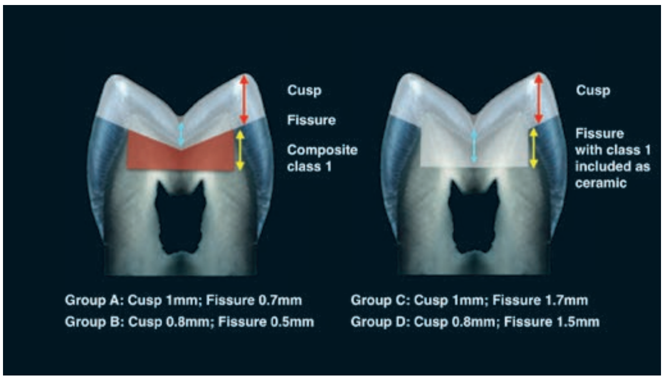


Figure 1 Groups A, B, C, D restorative variations

Group D: CAD/CAM monolithic lithium disilicate posterior partial coverage restorations were designed and manufactured to create a ceramic restoration with a cuspal thickness of 0.8 mm and a 1.5 mm fissure depth. The class I cavity formed part of the CAD/CAM restoration.

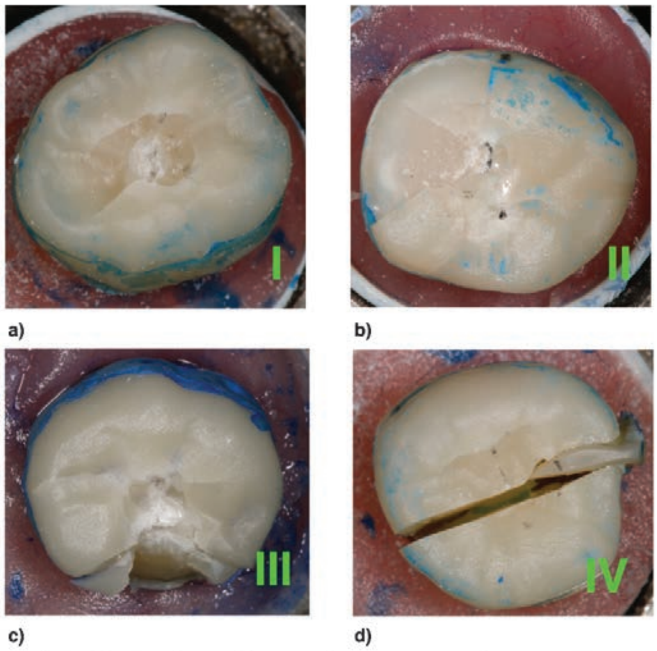
The optical impression and restoration design were completed with the CEREC Omnicam (Sirona Dental Systems GmbH, Bensheim, Germany). All specimens were fitted with standardised occlusal veneers and were done using the CEREC database and generated with the CEREC version 4.4 software (Dentsply Sirona, PA, USA). The teeth were placed in gauze moistened with distilled water until the adhesion steps were performed.

The un-crystallised ceramic partial coverage restorations were milled from lithium disilicate ceramic blocks (IPS e.max.CAD, Ivoclar Vivadent) using the CEREC MCX Wet/Dry Milling Unit (Dentsply Sirona, PA, USA). The posterior partial coverage restorations were milled in Fine Mode with the sprue at the lingual surface. The restorations were visually inspected for milling cracks and the correct thickness, as per the specifications described in groups A, B, C and D. They were crystallized according to the manufacturer's specifications using a Programat CS2 (Ivoclar Vivadent) with standard crystallization setting no 1. After crystallisation and cooling, polishing with Eva Diapol and Eva Diacera polishing wheels were completed (Eve Ernest Vetter GmbH, Keltern, Germany). The restorations received the glass ceramic self-etching primer (Monobond Etch-and-Prime Ceramic Primer, Ivoclar Vivadent) and cementation with the dual cure luting composite (Variolink Esthetic, Ivoclar Vivadent) covered with Glycerine air block (Liquid Strip, Ivoclar Vivaden), all in accordance with the manufacturer's instructions. Curing was completed with a LED curing light (Bluephase Style, Ivoclar Vivadent). Final polishing was done with Eve Ecoceram polishing burs (Eve Ernest Vetter GmbH) and the restored molars stored in distilled water for 24 hours at 37°C in order to achieve complete maturation of the resin cement.

The specimens were then thermocycled 7500 times at 5°C and 55°C in a 2% methylene blue solution with a 30 second dwell time at each temperature.

Assessment on the Universal testing machine

The study was divided in two phases. Phase one consisted of the application of a pre-set force that sequentially increased until the initial (first) crack formation. The detection was ensured with the Universal testing machine software and confirmed with visual inspection (the pre-set forces during phase one were: 500, 800, 1000, 1200, 1500, 1700 and 2000N at a speed of 1 mm/min). This recorded force for phase one was termed "initial crack force". Phase two of the study was termed "maximum fracture force". The specimens in phase two were loaded with the free running force at 1 mm/min from zero Newton (N). Catastrophic failure was considered when the software of the Universal testing machine recorded the drop in force application, with the Universal testing machine stopping the force application and its subsequent reverse.



a- d) classification of type of fracture: **I** - extensive crack formation within ceramic; **II** - cohesive fracture within ceramic; **III** - fracture within ceramic and tooth stricture; **IV** - ceramic and tooth structure fracture involving the root

Figure 2 Classification of the mode of fracture.

The fracture pattern in phase two was considered "catastrophic failure" in accordance with the following classification:

I. Extensive crack formation within the ceramic;
II. Cohesive fracture within the ceramic;
III. Fracture within the ceramic and various tooth structures;
IV. Ceramic and various tooth structure fractures involving the root (Guess et al, 2013) (Figure 2).

A steel bar with a 6 mm ball end was centred on the main fissure of each specimen in order to apply the force evenly through a thin tin foil with dimensions of 8x8 mm. The location of the ball was between the triangular ridges of the lingual and buccal cusps. The desired force for "phase one" was preset in the software of the Universal testing machine. For "phase two" the compression force was allowed to continue in free running mode until maximum compression force was achieved and recorded by the software. Phase one and two had a crosshead speed of 1 mm/min while the computer software recorded the graph of force application in N (QMat Testzone, version 4.5.37, Tinus Olsen, Redhill, England). The specimens were loaded with a universal testing machine (H10KT-0293, Tinus Olsen). The preset loading force intervals in phase one was 500, 800, 1000, 1200, 1500, 1700 and 2000N. After each force interval, the computer software constructed a graph and a two-examiner visual inspection reached agreement for any sign of crack(s) formation. Initial failure was considered when the initial crack(s) was/were viewed as a "dip" in the software graph and being visible on the specimen. If no crack formation was present, the next preset force was completed. Between the various forces of phase one photographs under standardised conditions at x1.5 magnification (Canon EOS 70D with Canon EF 100 mm f/2.8L Macro IS USM Lens) were taken to record and view the crack(s). The crack inclusion criteria as described by Guess et al (2013) was used in this study: 1). length greater than or equal to 2 mm and 2). involved the surface of the restoration (Schlichting et al, 2016). Upon this initial failure of phase one, the specimens were subsequently loaded to catastrophic failure for phase two and the maximum fracture force recorded in N.

All specimens from phase two with catastrophic failure fracture patterns that did not affect the underlying tooth structure (I, II and III) were deemed restorable (Guess et al, 2013). Specimens with catastrophic failure pattern IV were regarded as non-restorable.

Data Analysis

The statistical analysis was completed in SPSS version 21 (IBM, New York, NY, USA). The influence of the thickness and design for the indirect ceramic partial coverage restorations were assessed with a Kruskal-Wallis analysis and pair wise comparisons confirmed by the Dunn-Sidak multiple comparison test. The analysis considered the initial crack force as well as the catastrophic failure force. The categories of fracture mode were used for the grouping of the various modes of fracture per group. The exact force upon catastrophic failure was used during the statistical analysis for the differences between the groups for the force at catastrophic failure. The results from the groups were also shown as a percentage of the total number of specimens (Tables 1 and 2). The mean force values after initial crack formation were expressed in N and were compared for statistical differences with $p<0.05$ considered as significant. The mode of fracture was evaluated at the catastrophic failure force and categorised according to restorability.

Results

Initial crack force for groups A and B

In the ceramic cusp thickness of 1 mm for group A, the number of initial crack specimens was 20% at a force of 800N with no specimens showing initial crack formation at a force of 500N. In the ceramic cusp thickness of 0.8 mm (group B) with the composite also present in the class I, 20% of the specimens showed signs of an initial ceramic crack formation with a force of 500N and 40% at 800N. At a force of 1000N both groups A and B had 30% of the samples presenting with crack formation (Table 1).

Initial crack force for groups C and D

In the ceramic cusp thickness of 1 mm, the first crack formation was noted at 1000N for 30% of specimens. In the ceramic cusp thickness of 0.8 mm, 10% of specimens showed signs of crack formation at 800N (Table 1).

Maximum fracture force at catastrophic failure for groups A and B with a composite core

The maximum fracture value was significantly greater for group A specimens (2460±316.27N) than group B (1523±688.49N) ($p=0.005$).

Maximum fracture force at catastrophic failure for groups C and D with no composite core

No difference between the mean fracture values of groups C (3142±1038.32N) and D (2591±887.42N) was observed ($p=0.0320$).

No statistically significant difference in the maximum catastrophic fracture force was observed between preparation designs of groups A and C for the 1 mm thick ceramic restoration ($p=0.441$).

A statistically significant difference was noted in the maximum catastrophic fracture force between the

Table 1 Groups A, B, C and D force value of initial crack formation as a percentage of number of specimens.

Groups	Thickness of cusp	500N	800N	1000N	1200N	1500N	1700N	2000N
A	1.0		20%	30%	40%	10%		
B	0.8	20%	40%	30%	10%			
C	1.0			30%	10%	10%		50%
D	0.8		10%	20%		20%	30%	20%

Table 2 Group A, B, C and D–Classification of mode of fracture as a percentage of number of specimens.

Groups	Thickness	I	II	III	IV
A	1.0	10%	50%	10%	30%
B	0.8	40%	40%		20%
C	1.0	10%	10%	10%	70%
D	0.8		30%	10%	60%

group B (1523±688.49) and D (2591±887.42) preparation designs for the 0.8 mm thick ceramic restoration (p=0.009).

Fracture patterns at catastrophic failure for groups A and B

The fracture pattern in the 1 mm specimens (group A) were as follows: half of specimens had cohesive fractures limited to the lithium disilicate ceramic restoration, 10% had cracks that only affected the lithium disilicate of the indirect partial coverage restorations, 10% affected the tooth/composite restoration, and the final 30% of molars were non-restorable with class IV fractures involving the root.

In the 0.8 mm specimens (group B), 40% of fractures were cohesive failures, 40% had crack formation in the ceramic and tooth structure, and 20% had fracture patterns classified as non-restorable due to root fractures. There were no class III fractures into the tooth/composite restoration (Table 2).

Fracture patterns at catastrophic failure for groups C and D

Among the 1 mm specimens with the lithium disilicate ceramic into the class I area of the tooth (group C), 10% fractured with a class I pattern, 10% with a class II pattern, 10% with a class III pattern, and the remainder (70%) had class IV fractures and were non-restorable.

In the ceramic thickness of 0.8 mm with lithium disilicate ceramic into the class I area (group D), the number of the cohesive ceramic fractures increased to 30% of specimens, 10% fractured into the tooth structure, while the remainder (60%) fractured with a class IV pattern (Table 2).

Discussion

The null hypotheses that the cavity design optimization (CDO) with composite in the occlusal class I restorations would have had no influence on the initial crack formation nor the catastrophic failure and initial crack formation was rejected for group B. The initial crack formation for group B occurred from 500N and the catastrophic force was significantly lower than groups A, C and D. The hypothesis regarding the additional ceramic thickness in the class I area with a 0.8 mm or 1 mm cusp thickness would not influence the initial crack formation nor the maximum catastrophic failure fracture force was accepted for group A, but rejected for group B. Additionally the initial crack formation was accepted for groups A, C and D, since crack formation occurred at 800N or higher.

When evaluating the performance of non-retentive minimally invasive lithium disilicate partial coverage restorations, the maximum masticatory forces that humans produce should be considered. Such values can guide a clinician to evaluate the literature for restorative options that could indicate clinical performance. The maximum masticatory forces that exist during function contribute to the fatiguing of both the restoration and remaining tooth structure. In an attempt to evaluate the impact and the clinically relevant masticatory forces, the catastrophic fracture force of the ceramic restoration and CDO designs must be considered. In the study design each specimen from the various groups A, B, C and D were electronically and visually evaluated between loads until the initial crack force was reached. The specimens that had first crack formation below 800N could be regarded to be at risk of failure under clinical load (DeLong and Douglas, 1983).

During this *in vitro* study, various thicknesses of indirect ceramic posterior partial coverage restorations with various preparation designs were investigated. By evaluating the thickness of the restorations, this study aimed to simulate molar teeth where dentine was missing. The maximum catastrophic fracture forces of unprepared natural posterior teeth were cited as 2041±838.3N (Stappert et al, 2006); 1604±477N (Stappert et al, 2008) and 2905.3±398.8N (Saridag et al, 2013). Considering the aforementioned fracture forces the loss of a large volume of tooth structure through caries or erosion could pose clinical difficulty to the restoration longevity with composite alone. When restoring such large areas, the clinician needs to decide on the ideal restorative thickness and technique that would be best suited as an indirect ceramic posterior partial coverage restoration.

Often, large amounts of healthy tooth structure are sacrificed to allow for sufficient restorative space to accommodate the manufacturer's recommended thickness in order to overcome the inherent weakness of the restorative material (when needed, (2Silva et al, 2012; Dietschi and Spreafico, 2015; Rocca et al, 2015; Valenti, 2015). This sacrifice leads to a reduction in the strength of the remaining tooth, often leading to an increase in fractures that are difficult to repair, or fractures that are seen as catastrophic, leading to the loss of the tooth (Beier et al, 2012). Groups C and D had the thickest areas of ceramic in the central fissure, yet the highest percentage of class IV catastrophic failures. Alternately, too thin a restoration as per group B, led to a reduction of the material strength with lower clinical survival rate due to an increased material crack formation and ceramic fracture (Krämer et al, 2005)especially about inlays and onlays having proximal margins in dentin. The present prospective controlled clinical study evaluated the clinical performance of IPS Empress inlays and onlays with cuspal replacements and proximal margins below the cementoenamel junction over eight years. METHODS Ninety six ceramic restorations were placed in 34 patients by six dentists. The restorations were bonded with an enamel/dentin bonding system (Syntac Classic. Clausen et al (2010) indicated that the thickness of the ceramic played the most important role, as in the case of group B that had initial crack formation at 500N. The 1 mm thickness of the cusp with (group A) or without a composite class I composite restoration (group C) illustrated and corroborated the results of Clausen et al (2010), that no significant difference was seen with the maximum catastrophic failure force. Based on the results from groups C and D the catastrophic failure force was similar. These results suggest that the thickness of the ceramic was in fact the determining factor in the reduction of initial crack formation for the ceramic.

CDO was developed to help overcome some of the unnecessary tooth removal when creating inner-cavity designs for indirect restorations (Jackson, 1999) aesthetics, reinforcement, adequate seal. Using such principals in a bio-substitutive manner (Dietschi and Spreafico, 2015)when needed, (2, the clinician has the opportunity to maximise the strength of the restorative material while preserving the sound tooth structure.

The CDO approach was supported where the marginal preparation design had no significant influence on preventing the initial crack formation, since all the initial crack formation occurred on the occlusal aspect where the force was applied. There were a greater percentage of class I and II ceramic initial crack formations in the composite groups A and B than in groups C and D with the thicker central fissure. The results indicated that in group A, the ceramic cusp thickness of 1 mm had only 20% of specimens showing signs of initial crack formation at values below 800N. In the ceramic cusp thickness of 0.8 mm this increased to 60% below 800N. The clinical significance is that when normal occlusal forces are considered to be below 800N, the clinician should incorporate CDO preparation techniques with a cuspal thickness of 1 mm or consider a preparation as per group C, since the initial crack formation occurred at 1000N.

It has been shown that thicker ceramic restorations show more catastrophic fractures with extensive damage to the underlying tooth structure, rendering it un-restorable. In contrast the literature suggests that the catastrophic failure of thinner ceramic restorations generally showed less damage to the underlying tooth (Guess et al, 2013; Magne et al, 2015; Sasse et al, 2015)within enamel and dentin or within enamel and an occlusal composite resin filling. For each test group, occlusal all-ceramic restorations were fabricated from lithium disilicate ceramic blocks (IPS e.max CAD. This has a direct influence on the restorability and long term prognosis of the tooth. The greater thickness in the fissure for group C and D should result in a more resilient restorative option to fracture. It was noted in this *in vitro* study that with the increase in the ceramic thickness groups C and D had a greater number of root fractures at 60 and 70% for groups C and D respectively. Subsequently, when the lithium disilicate ceramic material thickness over the cuspal area decreased from 1 mm (group A) to 0.8 mm (group B), a significantly lower resistance to catastrophic fracture occurred and the root fractures were reduced compared to groups C and D (Magne and Belser, 2003; St-Georges et al, 2003).

The mode of fracture pattern and the risk of non-restorable failure is an important component. The comparison of the mode of fracture between equal cusp thickness for group A and C resulted in 10% having class I catastrophic failures. The increased thickness of the ceramic of group C presented with class IV catastrophic failures at 70% of the samples. Group A with the CDO showed class II catastrophic failures of 50% of the samples and class IV for 30%. This supported an assumption that the thicker ceramic in the fissure area increased the strength of the ceramic creating a clinically resilient restoration, but increased the risk for a Class IV catastrophic failure, that will render the tooth non-restorable. When evaluating the mode of catastrophic fracture of the restorations and the remaining tooth, restorative designs that made use of CDO principals with a direct composite restoration, showed less complicated fractures and may contribute to the longevity of the underlying tooth. The clinician would then still have an opportunity to replace the restoration upon fracture for most cases.

The CDO approach confirmed in this *in vitro* study that the ideal thickness of the lithium disilicate ceramic bonded to the composite substrate in the bio-substitutive model with an ceramic cuspal thickness of 1 mm and a fissure of 0.7 mm (Vargas et al, 2011; Sasse et al 2015) and all failures for the fissure thickness of 0.7 mm that occurred with Magne et al (2015) were classified as restorable. The similarities between the results of the current study and those of Sasse et al (2015) indicated that the clinical situation where the dentine is present, rather than the Class I defect being restored with composite would have achieved similar results for the maximum force and catastrophic failure (Sasse et al, 2015).

This *in vitro* study used static loading in stages and not dynamic loading, as may be the case in the oral environment. Only one ceramic material was tested and there could be variation between different manufacturers.

Conclusion

The restorative material combination should approach the fracture force resistance of the natural unprepared tooth, but subsequent restorability after first crack formation or catastrophic failure are also important considerations. When the maximum masticatory forces between 500–800N are considered, no signs of initial crack formation at values below 800N could result in clinically acceptable initial crack force and catastrophic fracture forces.

This research has shown that the restoration of a tooth with a lithium disilicate ceramic material does not require composite in the cavity preparation of the class I with the CDO approach provided: 1) the ceramic is 1 mm thick over the cusp and 2). a ceramic thickness at the fissure is 1.7 mm. This is the recommendation, since these two pre-requisites achieved higher forces than the 0.5 mm fissure thickness with a 0.8 mm cuspal thickness. When the ceramic in the cuspal area is 0.8 mm thick it becomes advantageous for the lithium disilicate ceramic to additionally occupy the class I preparation.

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