Survival Rates of a Lithium Disilicate–Based Core Ceramic for Three-Unit Esthetic Fixed Partial Dentures: A 10-Year Prospective Study

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Purpose: The aim of this prospective study was to evaluate the clinical efficacy and long-term survival rate of three-unit fixed partial dentures (FPDs) made from lithium disilicate–based core ceramic. ***Materials and Methods:*** Twenty-one three-unit FPDs were placed in 19 patients to replace single lost teeth in the esthetic area, following a study protocol that took clinical, esthetic, and radiologic aspects into consideration. Each case was reviewed at 1 week following placement, at 6 months, and then annually for 10 years. Statistical analysis was performed using Kaplan-Meier survival analysis. ***Results:*** Out of the 19 patients, 14.3% presented reversible postoperative sensitivity. Recession was observed in 24% of dental posts, and 7.1% presented marginal discoloration. Treatment did not increase either Bleeding or Plaque Index scores at prepared teeth; secondary caries did not appear either. The restorations' survival rate at the 10-year follow-up was 71.4%; six FPDs had fractured and one debonded. ***Conclusions:*** Fracture failure rate was 28.6% after 10 years; a high percentage corresponded to connector fractures and occurred during the first 5 years. Lithium disilicate glass-ceramic FPDs present a higher risk of fracture than standard therapies (metal-ceramic) or other more recently developed ceramic materials. The prognosis for survival improves for Class I occlusion and nonparafunctional patients. *Int J Prosthodont 2013;26:175–180. doi: 10.11607/ijp.3045*

Replacing missing teeth in the anterior sector represents a challenge in terms of both function and esthetics. Treatment options include dental implants and fixed partial dentures (FPDs), which may be metal-ceramic or all-ceramic.

In spite of the fact that their clinical efficacy has been demonstrated, metal-ceramic FPDs may not be ideal when it comes to esthetics (discoloration, opacity) and may suffer other problems such as galvanism or toxicity.[1–3] Advances in the development of dental ceramics have allowed ceramic cores to be substituted for metal, and these are now widely used.

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The advantages of ceramic compared to metal-ceramic systems are greater light transmission,[4] lower opacity, and perfect transition between the restoration and gingival tissues. However, the use of an all-ceramic restoration suffers the risk of chipping of the porcelain veneer or fracture in the connector area.[5,6]

Zirconia–based ceramic offers another option with very high mechanical resistance but less translucency compared to lithium disilicate glass-ceramic due to the greater opacity of its core.[4,6] The use of lithium disilicate in the esthetic zone offers an excellent option due to its unsurpassable esthetics.

The IPS Empress II system (Ivoclar Vivadent) first came onto the market in 1998. At present, having been updated and improved, it has been renamed as the IPS e.max Press system. Its composition is based on phase I lithium disilicate crystals ($Li_2O{\cdot}SiO_2$) and phase II lithium orthophosphate, distributed homogeneously in a glass matrix. The mechanical properties of this material are due to the high percentage of these crystals (70% ± 5% in volume) of sizes varying from 0.5 to 5.2 μm in length and 0.8 μm in diameter.[7,8]

The internal core of the restoration is fabricated through injection molding of high-resistence feldspathic ceramic with the lost-wax technique, which is then covered with another low melting–point

Fig 1 Three-unit FPD made from lithium disilicate–based core ceramic.

Fig 2 Buccal view of prepared abutment teeth.

feldspathic ceramic sinterized using a layering technique that gives the finished FPD or crown its external appearance. Flexural strength varies from 290 to 450 MPa.[9,10] This ceramic is indicated for fabricating three-unit FPDs and single-piece crowns for either anterior or posterior teeth (Fig 1).

The aim of this prospective study was to evaluate the clinical behavior and the survival rate over 10 years of 21 esthetic three-piece FPDs made from lithium disilicate–based core material (IPS Empress II).

Materials and Methods

Nineteen patients (16 women and 3 men) requiring the replacement of single anterior teeth were recruited for the study. They were informed of the study objectives, clinical procedures, and materials to be used and gave their written consent to take part in this study, which had been approved by the University of Valencia Ethics Committee, Valencia, Spain.

In accordance with the requirements for prosthetic restorations, the prospective abutment teeth all met the following clinical criteria: periodontally healthy, vital or endodontically treated, an occlusogingival height of at least 4 mm from the col of the interproximal papilla to the marginal ridge of the prospective abutment adjacent to the space to be restored (thus preventing the fabrication of a connector with adequate dimensions), good oral hygiene, freedom from periodontal disease, and opposing natural teeth or fixed prostheses. Fourteen subjects presented Class I occlusal relationships, four subjects presented Class II, and one a Class III edge-to-edge occlusion. A total of 26.3% of subjects had parafunctional habits and a higher percentage (36.8%) showed wear facets; all had splints. Patients with severely untreated occlusal parafunctions and temporomandibular disorders were excluded from the study.[11,12] Nineteen FPDs were placed in the maxilla and two in the mandible. The FPDs replaced 13 incisors, 7 canines, and 1 premolar. Two patients received two FPDs and the rest received one each.

Prosthodontic Procedures

All abutment teeth were prepared as follows: occlusal and/or incisal reduction of 1.5 to 2 mm; axial reduction of 1 to 1.5 mm with 10-degree taper, circular chamfer, or shoulder of 1 mm; and particular attention paid to rounded line angles (Fig 2). The color of each prepared tooth and adjacent teeth was identified and noted. Provisional restorations were fabricated from polymethyl methacrylate (Acry Lux C&B, Dental Manufacturing) and cemented using eugenol-free provisional cement (Temp Bond NE, Kerr Corporation).

When soft tissues were completely healed, a definitive impression was made with polyvinyl siloxane impression material (Exaflex, GC America) using a stock perforated stainless steel tray (Zhermack). Impressions of the opposite arch were taken using irreversible hydrocolloid impression material and maxillomandibular relations were registered in wax (Miltex, Moyco Union Broach). Working dies were fabricated, and the definitive and opposing casts were mounted in a semi-adjustable articulator (Whip Mix).

When the cast had been made in type 4 dental plaster, a wax-up of the FPD's internal structure was made and fabricated using the IPS-Connector (Ivoclar Vivadent) with a connector surface area of 12 mm^2 (4 mm in height by 3 mm in width); the coping thickness was 0.8 mm.

The wax-ups were then placed in a cylinder and cast, and, after eliminating the wax, the cylinder was placed in the press-injection furnace. When the ceramic to be injected reached its plastic state at 920°C,

Fig 3 Fractures occurred at the union between connector and pontic through the core material.

a choice was made between five different colors and two levels of opacity in order to match the restoration to the previously determined natural tooth color. The injected structures were separated from the molds, and final adjustments were made against the master cast, checking and adapting frameworks for fit, following procedures as described in the literature.[13] After the adaptation process, the thickness of the substructure was measured and documented, the restorations were tried in at the clinic, and final individual characterizations were performed. All FPDs were bonded with the same resin cement (Variolink, Ivoclar Vivadent).

Two practitioners performed standardized examinations of the clinical outcomes, assessing the state of soft tissues and hygiene, while also evaluating the Sillness and Löe Plaque Index, Gingival Bleeding Index, any recession quantified in mm, the state of dental posts, and sensitivity. Radiographs (registering apical areas, secondary caries, or fissures) and clinical photos were taken. The general condition of each restoration was evaluated (color changes, marginal pigmentation, debonding, fissures, or fractures), as well as patient satisfaction (regarding esthetics and function) on a scale of 1 to 10. Periodic examinations were performed after 1 week, 6 months, 1 year, and then annually for 9 years. Statistical analysis was performed using Kaplan-Meier survival analysis; log-rank testing was applied to control data.

Results

The mean age of the 19 patients was 49 years. They received 21 FPDs distributed as follows: 19 maxillary and 2 mandibular; all were placed in the anterior sector, no further than the second premolar. As for sex distribution, 67% of treatments were performed on women.

The results obtained were as follows: Plaque Index for the prepared teeth was 0 in 50% of cases, for 45% the value was 1, and in 5% it was 2. Gingival Bleeding Index results showed 64.3% of patients with a value of 0 and the remaining 35.7% showed a value of 1. Therefore, there were no increases in gingival bleeding or plaque as a result of treatment, nor was the appearance of secondary caries observed.

Gingival recession was observed at 10 (24%) prepared teeth (7 vestibular and 3 palatal). In some cases, the amount of recession reached 4 mm, with an overall mean of 1.7 mm.

A total of 14.3% of patients presented some reversible postoperative sensitivity; in a single case this was irreversible and the patient received root canal treatment.

With regard to the final condition of the restorations, marginal pigmentation was observed in 7.1% of cases and gingival margins were discolored at three prepared teeth (associated with gingival recession). One FPD debonded 2 years after the end of treatment. It was recemented and remained in place throughout the 10-year follow-up. No color changes of the restorations were detected when comparing the color registered using the Vitapan Classical guide (VITA) at the moment of fabrication with color at the end of the 10-year study period.

Six fractures occurred (28.6%), one at the incisal edge and all others at the union between connector and pontic through the core material (Fig 3). All fractures took place during the first 5 years following treatment. In the final review, one fissure was detected radiologically.

Statistical analysis was performed using Kaplan-Meier curves to evaluate restoration survival. The survival rate of the IPS-Empress II FPDs was 71.4% after 10 years (Fig 4).

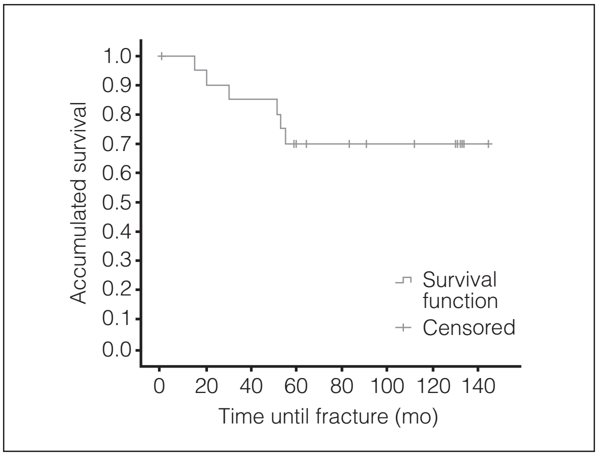

Fig 4 Survival analysis of the IPS Empress II FPDs. At 10 years, the survival rate was 71.43%; after 20 months it was 90%; after 40 months the survival rate was 85%; and at 55 months stabilization began.

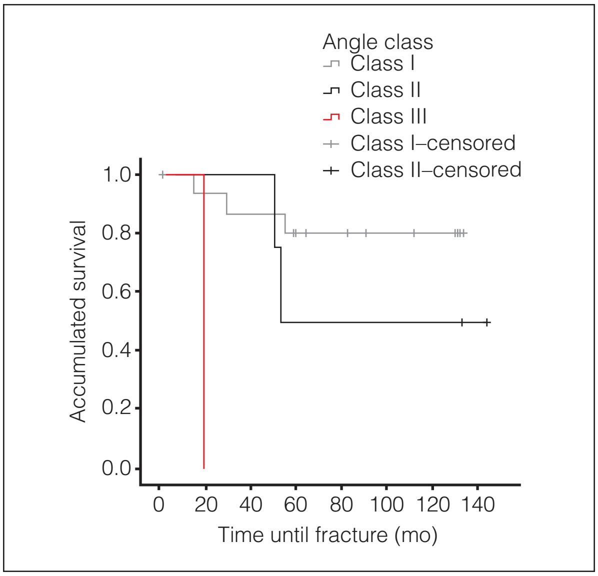

Fig 5 Survival rate of IPS Empress II FPDs in terms of malocclusion.

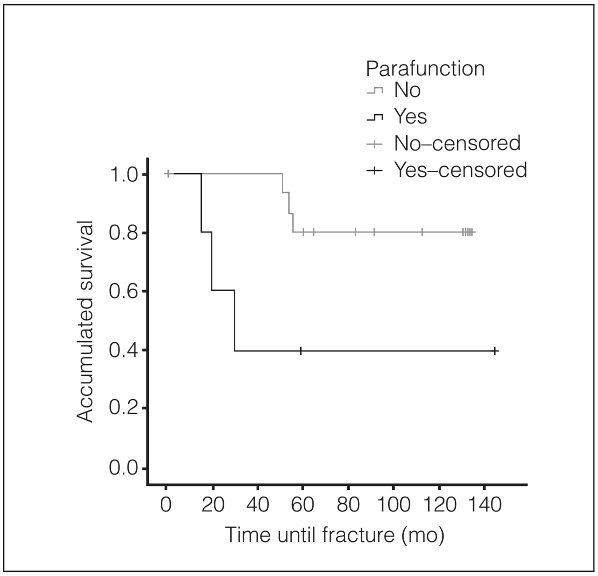

Fig 6 Fracture rate in patients with IPS Empress II FPDs.

It has been argued that malocclusion classification and parafunction influence the survival time of restorations. The FPDs placed in patients with Angle Class I had a 15% higher survival compared with patients with Class II; the log-rank test confirms that the survival curves were statistically different (P = .009 vs < .05) (Fig 5). The single patient with edge-to-edge occlusion suffered an FPD fracture earlier than the other fractures. FPDs in nonparafunctional patients survived 66% more often than those of patients with parafunctional habits; the log-rank test confirms that the survival curves were statistically different (P = .028 vs < .05) (Fig 6). With regard to the patients' subjective assessment, restorations scored 9.1 for function (comfort and mastication) and 8.8 for esthetics on a scale of 1 to 10.

Discussion

To date, few in vivo studies of lithium disilicate glass-ceramic FPDs have been published. Nevertheless, there is an extensive bibliography of this material's characteristics studied in vitro.[7–10] The importance of in vivo studies is beyond doubt when it comes to testing the characteristics, properties, and indications of any material.

The present clinical follow-up period was longer than any in the published literature to date, although the sample number was small (21 FPDs), as in studies published by Taskonak and Sertgöz[14] or Esquivel-Upshaw et al[15] of 30 FPDs. For this reason, the potential of the present study is not great and should be considered an exploratory work.

FPDs did not cause increases in gingival bleeding or plaque at the prepared teeth compared to adjacent natural teeth (which acted as a control group) due to the porcelain's good biocompatibility and the patients' maintenance of correct oral hygiene. A 7.1% marginal discoloration was registered but this is much lower than the results of other studies, in which 16% to 50% discoloration was seen after 5 years.[16] The survival rate of IPS-Empress II FPDs was 71.43% after 10 years, and the results are comparable to earlier short- and medium-term studies.[14,15,17,18]

The fracture rate after the 10-year follow-up was 28.6%; one fracture occurred at the incisal edge (chipping) and the rest were fractures of the union between connector and pontic. One fracture occurred in a patient with an unfavorable edge-to-edge occlusion, while 50% of fractures were seen in patients with parafunctional habits. As yet, there is insufficient clinical data on the efficacy and safety of ceramic systems subjected to excessive occlusal loads, as in the case of patients with parafunctional habits.[18]

Marquardt and Strub[17] obtained similar results, finding a 30% failure rate in 31 patients observed over a 5-year period, relating fracture to connectors of insufficient dimensions, which did not meet the manufacturers specifications. In another study, a 13.3% failure rate was observed over the same time period.[15] Zimmer et al[18] found a fracture rate of 27.6% over a 3-year follow-up. Other studies with 2-year follow-up periods have found varying FPD fracture rates of up to 50%.[14]

A recent prospective study by Wolfart et al[19] evaluated the clinical outcomes of 36 FPDs made from lithium disilicate glass–ceramic with 84% in posterior sectors and 16% in anterior sectors. A 7% fracture rate was observed over an 8-year period. The difference in results between this study and the present may be due to the fact that IPS e.max Press was used, which offers improved flexural strength and fracture toughness compared to Empress 2 because of a smaller crystal size.

Nevertheless, given that the failure rate was high in comparison with standard therapies using metal-ceramic FPDs, future research should focus on other ceramics currently available that may offer better outcomes, such as IPS e.max Press, as in the study outlined above.[19]

Zirconia is a material that offers an alternative to lithium disilicate, and several studies have shown that it has sufficient strength to function as an FPD substructure.[20–22] When fractures occur, they tend to be located in the veneering porcelain at a rate of 25%.[23] According to the literature, metal-ceramic prostheses have demonstrated failures rates of 10% over 10 years and 26% over 15 years, only involving cracks in the ceramic outer surface while the metal substructure remains intact.[23]

Conclusions

The survival rate of lithium disilicate glass-ceramic FPDs was 71.4% after 10 years. The fracture failure rate was 28.6% after 10 years, with a high percentage corresponding to connector fractures and occurring during the first 5 years.

As an alternative for replacing a tooth in the esthetic zone, lithium disilicate glass-ceramic FPDs present a higher risk of fracture than standard therapies (metal-ceramic) or other more recently developed ceramic materials. The prognosis for survival improves for Class I occlusion and nonparafunctional patients. Biologic complications found in the clinical examinations were few, and the patients were satisfied with their FPDs.

Acknowledgments

The authors thank D. Luis Casado of Ceramotecnic Dental Laboratory, Valencia, Spain, for his kind support and collaboration. The authors reported no conflicts of interest related to this study.

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Literature Abstract

Visiting the emergency department for dental problems: Trends in utilization, 2001 to 2008

This study tested the hypothesis that with secular changes over time (eg, economic downturn, increased unemployment, budget deficits, public program reductions), there would be decreased access to appropriate sources of dental care as well as preventive dental care, resulting in increased reliance upon emergency departments (ED) for dental care. The utilization of ED for dental care was also compared with ED use for asthma. ED visits for dental care and asthma from 2001 to 2008 were obtained from the National Hospital Ambulatory Medical Care Survey (NHAMCS). Population-based overall ED as well as both dental and asthma ED visit rates were calculated using annual estimates reported by the US Census Bureau. Relative ED visit rates were calculated by dividing each of the year- and diagnosis-specific visit rates by their baseline rates in 2001. The change in ED visit rates over time was calculated by using weighted linear regression models fitted to estimates from 2001 to 2008. The results showed: *(1)* an increasing trend of ED dental visit rate, *(2)* ED dental visit rates increased the most among those aged 18 to 44 years (7.2 to 12.2 per 1,000, $P < .01$), the uninsured (9.5 to 13.2 per 1,000, $P < .01$), and African-Americans (6.0 to 10.4 per 1,000, $P < .01$), *(3)* ED dental visits increased at a faster rate than overall ED visits and ED asthma visits. The authors concluded that the results of this study suggested that unless there is improvement to the delivery of preventive dental care to the community, ED dental visit rates would continue to increase.

Lee HH, Lewis CW, Saltzman B, Starks H. *Am J Public Health* 2012;102:e77–83. **References:** 38. **Reprints:** Dr Helen H. Lee, 4800 Sand Point Way NE, M/S W-9824, Seattle, WA 98105, USA. Email: Helen.lee@seattlechildrens.org—*Simon Ng, Singapore*