

CLINICAL OUTCOMES OF LAYERED LITHIUM DISILICATE RESTORATIONS: A RETROSPECTIVE ANALYSIS

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ABSTRACT

This study investigates the survival rates and failure modes of layered lithium disilicate restorations with feldspathic ceramic layering, observing a total of 546 restorations across 62 patients, evenly distributed by gender (31 males and 31 females), over an average follow-up period of 52.1 months. The findings reveal an impressive overall survival rate of 97.6%, with 13 failures identified, predominantly fractures (8 cases), followed by debonding (2 cases) and dyschromia (2 cases). Kaplan-Meier analysis demonstrated no statistically significant differences in survival rates between male and female patients (Log Rank Test, $p=0.877$), although males exhibited a marginally longer mean survival time. These results correspond with existing literature that emphasizes the prevalence of fractures in layered restorations, particularly in high-stress areas. The study suggests that careful consideration of clinical factors is essential for optimizing the performance of these restorations. Future research should focus on exploring various restoration designs and conducting prospective studies in standardized settings to validate these findings and improve clinical protocols.

Key words: Anterior Jig, Intermaxillary Relations, Centric Relation.

INTRODUCTION

The development and adoption of lithium disilicate restorations have redefined approaches in aesthetic and functional dental restorations, merging durability with exceptional esthetic outcomes. Initially introduced in the early 2000s, lithium disilicate ceramics have become a go-to material in restorative dentistry, attributed to their unique combination of mechanical strength and superior aesthetics. Unlike traditional feldspathic ceramics, lithium

disilicate offers a favorable balance between strength and esthetic versatility, which is critical for clinical success in various applications [1, 2]. Early research provided a foundation for using lithium disilicate in a range of applications, including crowns, veneers, inlays, and onlays, based on its strength, esthetics, and compatibility [3]. Today, practitioners choose between full-contour and veneered (stratified) lithium disilicate restorations, considering both esthetic needs and functional demands. Full-

contour restorations exhibit higher strength and are ideal for areas exposed to substantial occlusal forces, while veneered restorations, consisting of a lithium disilicate framework with an added feldspathic layer, offer nuanced esthetic outcomes, though with a slight compromise in mechanical strength [4, 5]. In this study, we used lithium disilicate e.max frameworks with feldspathic ceramic layering, aiming to achieve optimal aesthetic outcomes, especially for anterior restorations where translucency and natural color are essential. The literature suggests that feldspathic veneering on lithium disilicate enhances aesthetic appeal due to feldspathic ceramics' translucency, mimicking natural enamel, which is particularly advantageous in visible areas [6, 7]. Studies have demonstrated that veneered lithium disilicate restorations replicate the visual characteristics of natural teeth more closely than full-contour options, which can appear less translucent and more uniform [8]. Mechanically, the distinction between fully contoured and veneered lithium disilicate is significant. Research comparing these configurations reports greater flexural strength and fracture resistance in full-contour lithium disilicate, making it a preferred option in posterior zones where high occlusal loads are present [9, 10]. Additionally, full-contour lithium disilicate is advantageous in minimizing wear on opposing teeth due to its lower abrasiveness compared to zirconia, thus preserving antagonistic dentition more effectively [11]. Our selection criteria adhered strictly to lithium disilicate's clinical indications, with restorations limited to cases suitable for lithium disilicate's mechanical and esthetic properties. Notably, in cases involving multiple adjacent restorations, spans were restricted to a maximum of three units to avoid excessive stress, in line with studies supporting shorter-span frameworks for increased stability and longevity [12]. Additionally, the decision to use e.max lithium

disilicate with feldspathic layering was reserved for cases with pronounced aesthetic demands, exemplifying lithium disilicate's versatility in balancing durability and aesthetics [13]. When choosing dental restorative materials, aesthetics and functionality often play equally significant roles. Research supports that restorations with feldspathic ceramic layered over lithium disilicate frameworks exhibit enhanced light diffusion and color adaptation, resulting in a look that closely mimics natural teeth, especially in anterior regions where aesthetics are critical [14,15]. Although monolithic (full-contour) lithium disilicate offers notable durability and strength, veneering with feldspathic ceramic allows for superior color matching, making it ideal for cases where a high level of natural appearance is desired [16]. However, monolithic lithium disilicate proves more durable under high-stress conditions, with fracture toughness and flexural strength often measured between 400-500 MPa, favoring its use in posterior restorations [17,18]. In side-by-side comparisons, full-contour lithium disilicate restorations generally show higher fracture resistance than layered lithium disilicate, a key reason they're preferred for posterior restorations or high occlusal stress areas [19,20]. Studies also emphasize that lithium disilicate has a gentler wear profile against opposing teeth than zirconia, which reduces the risk of wear on natural teeth—a critical advantage in preserving the health of opposing dentition [21,22]. This aspect is especially beneficial in patients with parafunctional habits, where maintaining antagonistic tooth integrity is essential [23]. Lithium disilicate brings an ideal blend of moderate mechanical strength and flexibility for layering with feldspathic ceramic to enhance aesthetics, despite feldspathic ceramic alone exhibiting lower flexural strength (~100-120 MPa) compared to lithium disilicate [24].

Conversely, while zirconia restorations are more robust, they often lack the translucency and depth of color required for anterior applications [25]. This highlights the importance of selecting materials tailored to the specific aesthetic needs of such cases. In this study, lithium disilicate e.max restorations were carefully applied according to clinical indications. Single-unit and small-span fixed dental prostheses were prioritized, with multi-unit applications capped at three units to maintain stability, consistent with literature recommendations [26,27]. The design choice leveraged feldspathic layering on a lithium disilicate base to optimize both structural integrity and visual appeal, achieving a balance between strength and aesthetic results. Compared with full-contour restorations, layered options generally better emulated enamel's natural optical properties, though with a slightly higher risk of fracture, consistent with findings in other clinical studies [28,29]. In summary, lithium disilicate restorations offer both monolithic and veneered options that provide adaptability to specific aesthetic and mechanical needs. Full-contour versions generally favor durability, while layered types offer superior aesthetics for visible areas.

MATERIALS AND METHODS

This retrospective study evaluated 62 patients who received restorations in the anterior and posterior regions of the dental arch. The sample consisted of 31 males and 31 females, with an average age of 57. All restorations were standardized and placed following a strict protocol. The inclusion criteria for this study encompassed patients who received lithium disilicate restorations (e.max, Ivoclar Vivadent, Liechtenstein) in the anterior and posterior regions of the dental arch, specifically layered with a feldspathic ceramic (VITA VM® 13, VITA Zahnfabrik, Bad Säckingen, Germany). Patients were

included if they met the requirements for lithium disilicate restorations with feldspathic ceramic layering, were indicated for such restorations, and had no contraindications for these types of restorations. Exclusion criteria included patients with periodontal disease, those with insufficient enamel unsuitable for stable bonding, and patients for whom lithium disilicate layered restorations were not indicated. Following the initial evaluation, patients requiring treatment underwent a diagnostic wax-up to aid in the restorative planning process. This wax-up was subsequently transferred into the patient's mouth using a temporary resin material, creating a direct mock-up (Protemp 4, 3M ESPE, Seefeld, Germany). After a testing period of 1–2 weeks with the mock-up in place, the decision to proceed with lithium disilicate restorations (e.max, Ivoclar Vivadent, Liechtenstein) was made based on occlusal parameters observed both on the articulator and during the testing period in the oral cavity. These parameters were verified using articulation paper (Arti-Fol®, XYZ Dental Products, USA). To ensure optimal conditions for the restorations, the teeth were prepared with a modified chamfer margin (Sitea, Romania). A rubber dam (OptradDam® Plus, Ivoclar Vivadent) was used to isolate the teeth and maintain a dry working field during the cementation process. The dental preparations involved reducing the occlusal and incisal surfaces to 2.0 mm, while the facial and lingual surfaces were reduced to 1.5 mm. The minimum height for abutments was established at 5 mm, with an angulation degree maintained between 6° and 8°. Rounded or deep chamfer margins were finalized to facilitate optimal integration of the restorations. Before the cementation of the lithium disilicate restorations, both the abutment surfaces and the inner surfaces of the restorations were conditioned according to the manufacturer's guidelines. In this study,

lithium disilicate restorations underwent conditioning using hydrofluoric acid (IPS Ceramic Etching Gel, Ivoclar, Liechtenstein) at a concentration of 3-7% HF for 20 seconds. After conditioning, the restorations were thoroughly rinsed with water and air-dried. Next, a 36% orthophosphoric acid (Total Etch, Ivoclar, Liechtenstein) was applied, followed by rinsing and drying. A layer of silane (Monobond Plus, Ivoclar, Liechtenstein) was then applied to enhance bonding effectiveness, and after a 60-second application, it was air-dried. Prepared surfaces were subsequently sandblasted with aluminum oxide (Korox, Bego, Germany) to remove the hybrid layer and improve adhesion. A selective etching technique followed: 36% orthophosphoric acid (Total Etch, Ivoclar, Liechtenstein) was first applied to enamel and margins for 30 seconds, then to the dentin for an additional 15 seconds, totaling 45 seconds on enamel. For bonding, an adhesive (Adhese Universal Vivapen, Ivoclar, Liechtenstein) was applied to the tooth surfaces for 20 seconds, followed by light-curing for another 20 seconds. A thin layer of dual-cure resin cement (Variolink Esthetic, Ivoclar, Liechtenstein) was applied inside each restoration before positioning it onto the prepared tooth. Afterward, the excess cement was removed carefully with a microbrush, and any remaining cement was cleared away using a microsurgical scalpel. Final curing was completed, and a glycerin-based gel (Liquid Strip, Ivoclar, Liechtenstein) was applied to inhibit the oxygen-inhibition layer, ensuring full polymerization. Once the cementation was complete, occlusal adjustments were made, and the surfaces were polished using diamond-impregnated rubbers and diamond paste (Optrafine Assortment,

Ivoclar, Liechtenstein). In cases of slight overcontouring, a red-coded fine diamond bur (Komet Dental, Germany) was used for correction, followed by additional polishing with a fine diamond rubber. Finally, marginal adaptation was checked with a dental probe to ensure a seamless integration between the ceramic restoration and the tooth. The choice of natural dentures (NDs) played a crucial role in achieving a successful aesthetic outcome. The selection process involved evaluating the shade, shape, and contour of the natural dentition to ensure that the restorations would blend seamlessly with the patient's existing teeth. A thorough discussion with the patient regarding their preferences and expectations helped guide the selection of NDs, ensuring that both functional and aesthetic goals were met. Final impressions were taken using polyvinylsiloxane (Virtual 380, Ivoclar Vivadent, Schaan, Liechtenstein) employing a single-impression double-mixing technique with a standard tray. This was performed immediately after the removal of the mock-up from the teeth for both arches. The impressions were poured immediately using type IV dental stone (GC Fujirock EP, Tokyo, Japan), ensuring high accuracy. The color of the restorations was recorded using a VITA classical shade guide (VITA Zahnfabrik, Bad Säckingen, Germany) to ensure that the final restorations would match the patient's existing dentition. Temporary restorations were fabricated using the mock-up technique to preserve tooth alignment, functionality, and aesthetics until the definitive restorations were completed. This meticulous approach ensured that all factors were considered to achieve optimal outcomes for the lithium disilicate restorations.



a)



b)

Figure 1. Figure 1. (a) Conditioning of restorations. (b) Restorations following preparation.



a)



b)



c)

Figure 2. (a) Application of orthophosphoric acid. (b) Application of silane. (c) Insertion of restorations along the insertion axis.

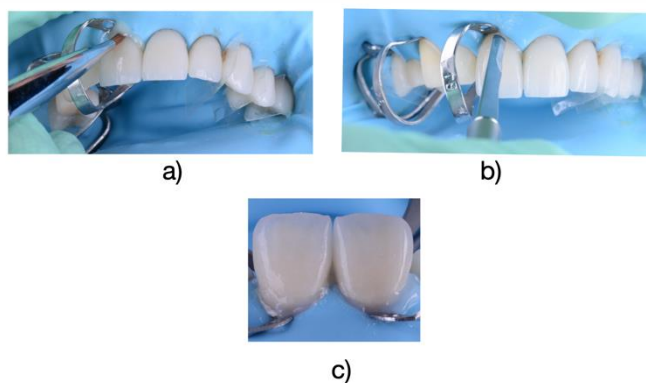


Figure 3. (a) Removal of excess cement at the cervical margin. (b) Removal of remaining cement using a microsurgical scalpel. (c) Final curing with a glycerin-based gel (Liquid Strip, Ivoclar, Liechtenstein).

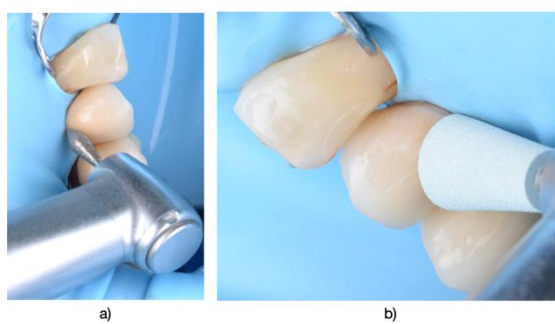


Figure 4. (a) Correction of overcontouring using a red-coded fine diamond bur (Komet Dental, Germany). (b) Additional polishing performed with a fine diamond rubber. (Denmark).

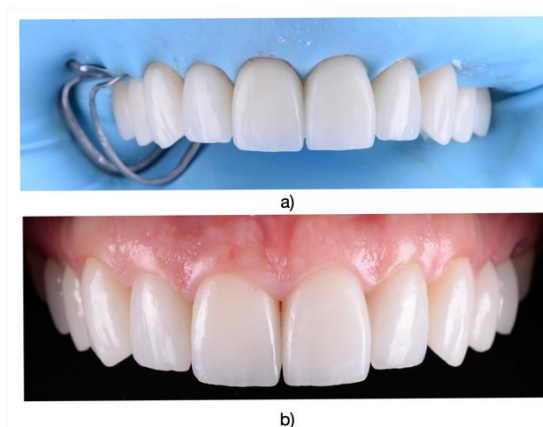


Figure 5. (a) Final intraoral result. (b) Final result after one month.

RESULTS AND DISCUSSIONS

A total of 546 lithium disilicate restorations were evaluated across 62 patients, with an equal distribution between genders (31 males and 31 females). The restorations were placed in both anterior and posterior regions, with 287 restorations in female patients and 259 in male patients. Over the observation period, 13 restorations failed, resulting in an overall survival rate of 97.6%. The failures included fractures, debonding, and cases of dyschromia, consistent with failure types reported in other studies on lithium disilicate restorations [30-32]. Out of the 13 failures, fractures were the most common, occurring in 8 cases, while debonding was observed in 2 cases, and dyschromia in 2 cases. An additional fracture was due to trauma. The prevalence of fractures aligns with literature indicating that fracture is a common complication in layered lithium disilicate restorations, especially in posterior regions subject to occlusal forces [33-35]. The mean survival time (Kaplan-Meier Survival Analysis) for all restorations was 52.1 months (± 13.2), with a 95% confidence interval from 26.2 to 77.9 months. The median survival time was higher, at 71.0 months (± 24.1), with a confidence interval from 23.8 to 118.2 months. The gap between mean and median survival suggests that while most restorations lasted for extended periods, a few early failures likely impacted the mean survival time. This survival rate is consistent with results from similar clinical studies on lithium disilicate restorations, which also report high survival rates over similar timeframes [30,36-37]. A Kaplan-Meier analysis by gender showed no significant difference in survival distributions between male and female patients (Log Rank [Mantel-Cox] Test, $p = 0.877$). Female patients had an estimated mean survival time of 50.4 months (± 17.2), with a confidence interval from 16.6 to 84.2 months, and a median survival time of 11.1 months (± 19.4). Male patients showed a

slightly higher mean survival time of 54.8 months (± 22.8) with a confidence interval from 10.0 to 99.5 months, and a median survival time of 74.0 months (± 81.0). While these differences were not statistically significant, the longer median survival in male patients might warrant further study with a larger sample size to confirm any trends [38]. The overall survival rate in this study is in line with survival rates reported in similar studies on lithium disilicate restorations, reinforcing its reliability for both anterior and posterior applications [31,32,35,37]. The survival rates and distribution of failure types demonstrate the effectiveness of lithium disilicate restorations with feldspathic ceramic layering for long-term clinical success, with few cases of debonding or dyschromia. The Kaplan-Meier analysis further supports the durability of these restorations, showing high survival rates and minimal gender-based performance differences.

The observed survival rate of 97.6% highlights the clinical durability of these restorations, aligning with previous studies on lithium disilicate ceramics, which report survival rates typically between 94% and 99% over similar time frames [32,35-36]. Differences in survival may be attributed to factors such as restoration placement (anterior vs. posterior), layer thickness, and individual patient occlusal forces.

Fractures accounted for the majority of failures (61.5%), a finding consistent with other studies where fractures are a predominant complication, especially for layered or veneered restorations in posterior regions under occlusal stress [34,39]. This trend suggests that while layered restorations provide aesthetic advantages, they may have an elevated fracture risk due to the veneering layer's lower flexural strength compared to monolithic designs [37]. Studies, such as those by Sailer et al. [31], have shown that monolithic restorations exhibit greater

fracture resistance and are preferable in high-stress areas [39].

No statistically significant difference in survival rates between genders was observed, as confirmed by the Kaplan-Meier analysis (Log Rank Test, $p=0.877$). This aligns with existing literature indicating that gender does not have a substantial impact on ceramic restoration survival rates [33,38]. Although male patients showed a slightly longer mean survival time, the difference was not significant, suggesting that factors such as occlusal load and restoration location may have a more prominent role than gender [40]. A limitation of the study is the focus on lithium disilicate restorations with feldspathic layering. Although this configuration provides aesthetic benefits, it may not fully represent other lithium disilicate types (e.g., monolithic), which are commonly used in high-stress areas and may exhibit different performance characteristics.

Studies have indicated that monolithic lithium disilicate restorations often show enhanced fracture resistance and may have distinct survival outcomes compared to layered restorations [7,41]. Future research including both monolithic and layered restorations would help clarify these differences and support more targeted clinical decision-making. The observed failure modes—primarily fractures and debonding—also suggest potential areas for improvement in adhesive techniques or layering methods to enhance restoration longevity. Studies indicate that optimizing adhesive protocols and refining layering methods could reduce the risk of fractures and debonding, especially in load-bearing areas [42-44].

Table 1. Means and Medians for Survival

Means and Medians for Survival Time							
Mean				Median			
Estimate	Std. Error	95% Confidence Interval		Estimate	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound			Lower Bound	Upper Bound
52.081	13.190	26.229	77.932	71.016	24.086	23.808	118.225

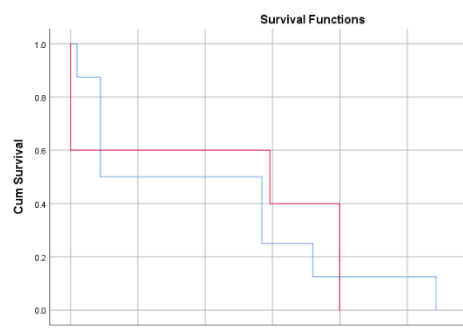


Figure 77. Survival Fuction

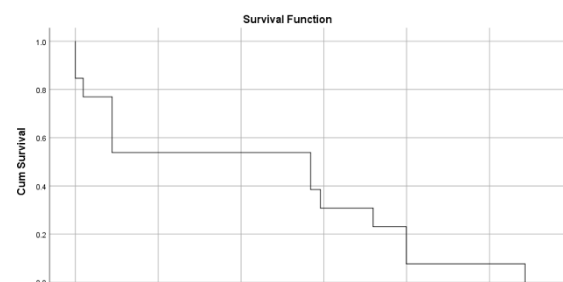


Figure 78. Kaplan-Meier Survival Analysis by Gender (Log Rank Mantel-Cox Test, $p = 0.877$)

Table 2. Means and Medians for Survival Time by Gender

Means and Medians for Survival Time								
Mean					Median			
Gender	Estimate	Std. Error	95% Confidence Interval		Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound			Lower Bound	Upper Bound
Female	50.410	17.237	16.625	84.194	11.082	19.419	.000	49.143
Male	54.754	22.849	9.970	99.539	73.967	81.027	.000	232.780

Table 3. Overall Comparison by Genders

Overall Comparisons			
	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	.024	1	.877

Test of equality of survival distributions for the different levels of Sex.

CONCLUSIONS

1. This study shows that layered lithium disilicate restorations have a high survival rate of 97.6% over an average follow-up of 52.1 months, reinforcing their effectiveness for both aesthetic and functional applications, particularly in anterior regions where aesthetics are paramount.
2. Fractures emerged as the most common type of failure, notably in posterior areas, suggesting that while these restorations excel in visual appeal, they may be more susceptible to mechanical issues under high-stress conditions compared to monolithic options.
3. Survival analysis found no significant difference in restoration longevity between

male and female patients, indicating that factors like occlusal load and restoration location are more influential than gender on long-term outcomes.

4. The meticulous preparation and bonding techniques used in this study were essential in achieving optimal restoration integration, indicating that adherence to standardized protocols can significantly enhance the clinical success of layered lithium disilicate restorations.
5. Although feldspathic layering enhances translucency and aesthetics, it may compromise mechanical strength, underscoring the need for careful case selection to balance esthetic with durability.

6. Future research should examine alternative configurations, such as monolithic lithium disilicate, and conduct prospective studies under controlled conditions to validate these results and refine clinical guidelines for optimal outcomes.

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