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Multifunctional Uses of a Novel Ceramic-Lithium Disilicate

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INTRODUCTION

As the progression of developing all-ceramic materials continues, clinicians are constantly seeking the ideal material that can be used for different clinical applications, whether veneers, full-coverage crowns, inlays/onlays, or implant-supported restorations. The first metal-free material developed, feldspathic porcelain, is still in use. It enables the creation of a beautiful result, allows good light transmission, and can be used on metal or by itself.

The next materials developed were the Dicor materials, which demonstrated better strength and very good translucency. Subsequently, pressable leucite-reinforced glass ceramic materials were introduced, and these materials were translucent and roughly double the strength of feldspathic porcelains. However, bridges were contraindicated. An earlier version of lithium disilicate was then developed to address this issue, and this material allowed bridges from the premolars forward. Later, zirconium frames were introduced that allowed full bridgeworks. These frameworks were veneered with either pressed or feldspathic porcelain, and it has been shown in clinical studies that this veneering porcelain introduces areas where restorations could chip or fracture.

Today, the next generation of lithium disilicates (IPS e.max Press/IPS e.max CAD, Ivoclar Vivadent, Amherst, NY, USA) that has multiple translucencies and opacities and utilizes full press or milling fabrication techniques provide a monoblock approach to final restorations that can then be surface stained and glazed. These monolithic restorations are roughly five times stronger than traditional feldspathic porcelains. The greatest advantage of this material is its extremely low fracture rates based on research analysis.

This is in contrast to what traditional monolithic (i.e., single layer) porcelain restorations were known for. In fact, single-layer tooth color porcelains had been indicated for

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Figure 1. Different Ingots of e.max pressable ceramic material exhibiting shades.

patients with esthetic needs, but not many structural demands.[1] Copings and substructures of less esthetic materials were usually used and then layered when greater strength was required.[1]

As such, lithium disilicate has the potential to provide new options for a variety of restorative indications. In particular, today's monolithic lithium disilicate is an esthetic, high-strength material that can be conventionally cemented or adhesively bonded.[2] Because it can be fabricated into a full-contour restoration from one high strength ceramic, it can be placed in all areas of the mouth when specific criteria are met.[3]

This article introduces the reader to the material characteristics of lithium disilicate. Additionally, examples of the indications and/or types of cases for which lithium disilicate restorations are applicable are showcased.

UNDERSTANDING LITHIUM DISILICATE

Lithium disilicate is a well-known glass ceramic categorized based on its chemical composition and application.[3,4] The IPS e.max lithium disilicate, in particular, is composed of quartz, lithium dioxide, phosphor oxide, alumina, potassium oxide, and other components.[3] This composition creates a thermal shock resistant glass ceramic because of the low thermal expansion that occurs during processing. Restorations can be fabricated from this type of resistant glass ceramic with either lost-wax hot pressing techniques or modern CAD/CAD milling procedures.

The pressable form of lithium disilicate is manufactured according to a bulk casting production process to create the ingots. This continuous manufacturing process is based on glass technology (e.g., melting, cooling, simultaneous nucleation of two different crystals, and growth of crystals) that is constantly optimized to prevent defects (e.g., pores, pigments). The microstructure of the pressable lithium disilicate material consists of approximately 70% needle-like lithium disilicate crystals that are embedded in a glassy matrix. These crystals measure approximately 3 to 6 μm in length.[3]

Polyvalent ions dissolved in the glass provide the material's desired color. These color-releasing ions are homogenously distributed in the single-phase material, thereby eliminating color pigment imperfections in the microstructure (Figure 1).

The machineable block form of lithium disilicate is manufactured according to a similar process, but only partial crystallization is achieved. This ensures that the blocks can be milled rapidly in a crystalline intermediate phase (i.e., blue, translucent state). The partial crystallization process forms lithium metasilicate crystals responsible for the material's processing properties, relatively high strength, and good edge stability. The restorations reach their fully crystallized state and their desired high strength after the milling procedure and firing. The microstructure of partially crystallized machineable lithium disilicate consists of 40% platelet-shaped lithium metasilicate crystals embedded in a glassy phase. These crystals range in length from 0.2 to 1.0 μm. The postcrystallization microstructure consists of 70% fine-grain lithium disilicate crystals embedded in a glassy matrix.

Like its pressable counterpart, the machineable lithium disilicate blocks are colored using coloring ions. However, the coloring elements exhibit a different oxidation state during the crystalline intermediate phase than in the fully crystallized state. As a result, the blocks appear blue. The material achieves its desired tooth color and opacity when the lithium metasilicate is transformed into lithium disilicate during the postmilling firing process (Figure 2).

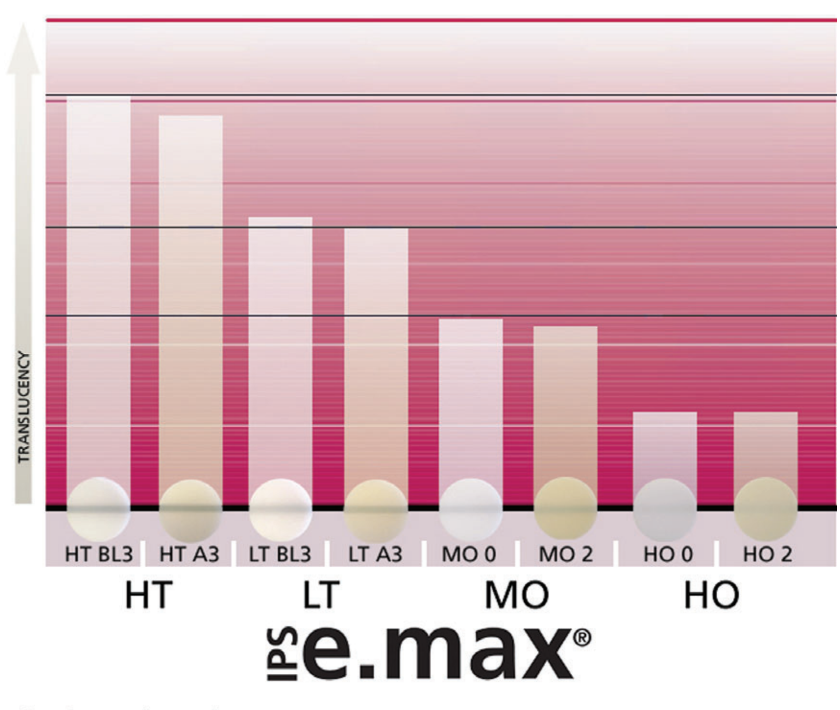

Figure 2. Graph showing levels of opacity and translucency.

PHYSICAL PROPERTIES OF LITHIUM DISILICATE

The IPS e.max lithium disilicate material has been in clinical trials for the last 4 years, with adhesive and self-adhesive/conventional cementation. The results have been positive (Figure 2).[5] Additionally, the material's strength and wear characteristics have been ascertained in other laboratory investigations.

For example, researchers in the ceramic testing group at New York University College of Dentistry determined in 2009 through mechanical mouth simulator testing that the machineable lithium disilicate ceramic (IPS e.max CAD) is the strongest and most durable all-ceramic material yet seen.[6–8] These researchers used the mouth-motion simulator test to compare the strength and durability of IPS e.max CAD lithium disilicate full-coverage crowns with veneered zirconia crowns. By replicating actual human forces exerted in the mouth, this test provided a more realistic assessment of how ceramic materials withstand the forces of chewing. In particular, unlike previous laboratory tests that only assess a material's physical properties to meet minimal standards, the mechanical mouth simulator stressed the restorations using clinically relevant directed loads over thousands of cycles (i.e., similar to how people chew) until failure occurred. Failure was considered to be chip-off fractures of the veneering ceramic in the case of the zirconia crowns, or fracture through the lithium disilicate crowns.

The researchers found that none of the IPS e.max CAD lithium disilicate crowns failed below 900 N and 180 K cycles, independent of loading profiles. Additionally, the IPS e.max CAD lithium disilicate crowns withstood a ration fatigue of 1 million cycles at loads of

1,000 N. In comparison, the veneered zirconia crowns that were tested demonstrated limited reliability, with approximately 90% of the crowns tested failing from veneer chip-off fractures by 100 K cycles at 200 N, which is similar to previous research findings. Also, 90% of the veneered zirconia crowns that were tested failed by 350 N, independent of the number of cycles.[8]

Overall, in comparison with the veneered zirconia systems that were tested, the IPS e.max CAD lithium disilicate full-coverage crowns can be expected to demonstrate excellent clinical performance relative to chipping or fracture based on the findings of the mouth-motion simulator testing. Any failures reported in this study mimic those reported in clinical studies, suggesting that IPS e.max lithium disilicate is the most robust all-ceramic system tested to date.[8]

The mouth-motion fatigue studies at New York University confirmed the chipping of veneered zirconia restorations that has been reported in the marketplace by clinicians, laboratories, research centers, and referenced studies.[9,10] It should be noted that all commercial systems have been reported with limitations, such as Christensen and Ploeger,[11] who reported 81% defective prostheses, and Raigrodski and colleagues[12] who reported 25% chipping.

Additionally, in terms of the enamel wear against the lithium disilicate material, researchers conducted a study to determine if the wear rates of ceramic are equivalent to the wear rates of their enamel antagonists, as well as to determine if the wear rates of contralateral teeth are equivalent to wear rates of ceramic crowns.[13] They found that based on in vivo wear rates, lithium disilicate is within the range of normal enamel wear.

MULTIPLE INDICATIONS FOR TODAY'S LITHIUM DISILICATE

Today's lithium disilicate (IPS e.max Press/IPS e.max CAD) delivers the strength and the esthetics necessary to meet the highest demands of dentists and patients alike. It enables truly multifunctional use because of its ability to be pressed out to full wax contour, or milled in a CAD/CAM fabrication mode.

Pressable lithium disilicate is ideal for inlays, onlays, thin veneers, veneers, partial crowns, anterior and posterior crowns, 3-unit anterior bridges, 3-unit premolar bridges, telescope primary crowns, and implant superstructures.[14–16] When minimal tooth preparation is desired (e.g., thin veneers), IPS e.max lithium disilicate enables ceramists to press restorations as thin as 0.3 mm while still ensuring strength of 400 MPa. If sufficient space is available (e.g., retrusion of a tooth), no preparation is required.

The machineable lithium disilicate material is indicated for inlays, onlays, veneers, partial crowns, anterior and posterior crowns, telescope primary crowns, and implant superstructures. For a posterior crown fabricated to full contour using CAD methods, lithium disilicate offers 360 MPa of strength through the entire restoration. As a result, restorations demonstrate a "monolithic" strength unlike any other metal-free restoration.

INDICATIONS OR SAMPLE CASES

This article emphasizes four different types of cases. A thin veneer case, a three-fourth veneer case, a full mouth rehabilitation utilizing crowns, and an inlay case. This array of cases demonstrates the flexibility of the material and all of its potential uses in mixed types of cases (Figures 3–27).

DISCUSSION

Although the use and development of ceramic materials has progressed from traditional feldspathics to Dicor to eventual pressing technology of leucite reinforced materials, the overall thought process of how and where to use these materials is

Figure 3. Patient presented with short clinical crowns and excess osseous tissue.

Figure 4. Minimal preparation 0.3 mm without the use of anesthetic.

Figure 5. Note the lack of restorative dentistry and uniform high value of intact enamel.

Figure 6. Nonlatex split rubber dam revealing adhesive cured on teeth.

Figure 7. Postoperative smile of 10 MO-0 ingot veneers enhancing patients smile.

Figure 8. Pleasing embrasures and flow from anterior to posterior of mouth.

Figure 9. The final ceramics were untouched after adhesive placement; no recontouring necessary.

Figure 10. Final close-up of 0.3-mm lithium disilicate veneers.

Figure 11. Close-up smile—note surface texture and translucency.

Figure 12. Preoperative view of worn dentition.

Figure 13. Close-up of worn incisal edges and old restorative dentistry.

Figure 14. Retracted view of maximum intercuspation.

Figure 15. Final close-up of full LT ingot lithium disilicate crowns and minimal incisal translucency.

Figure 16. Final view of maximum intercuspation.

Figure 17. Preoperative smile of old ceramic veneers completed 20 years ago.

Figure 18. Close-up revealing microleakage and wear of 20-year-old feldspathic veneers.

Figure 19. Preparation revealing dark tetracycline staining, minimal preparation.

Figure 20. Postoperative smile utilizing the HT BL1 ingot.

a constant work in progress. Whereas these materials were quite esthetic in nature, they have flaws such as the potential for excessive opposing wear, overall strength, and potential fracture points if certain criteria are not met. The mechanical testing of strength using static load with a universal testing machine, subcritical eccentric loading using a chewing simulator (Willytec), and long-time cyclic loading with a chew simulator (eGa) have proven several factors contributing to the success of lithium disilicate. First, it is important to consider the minimum thickness of the lithium disilicate frame. Secondly, the internal aspects of crowns should NOT be sandblasted. Finally, compared with other materials for crowns (e.g., leucite glass ceramic, metal ceramic, zirconia), the lithium disilicate material demonstrates superior results.[16] At this point of use, it is still best to utilize these materials in the anterior of the mouth and for the restoration of premolars. Only by following long-term clinical trials of preferably 5 years or longer can we be fully confident in its use in the restoration of molars. In vitro studies, while promising, are not absolute predictors of success. Only clinical experience and trials will allow "real world" assessments of this material in posterior teeth. Ample time must be allowed for the observation of potential chipping, wear, and fracture. However, initial lab-based studies and clinical observations to date are quite promising.

Figure 21. Final close-up; note masking ability of the ingot material.

CONCLUSION

Although dentistry has had multiple ceramic materials for over 40

Figure 22. Preoperative of old leaking amalgam restorations.

Figure 23. Final lithium disilicate monolithic inlays fabricated from Opal ingot.

Figure 24. Conditioned preparations prior to application of 5th generation adhesive.

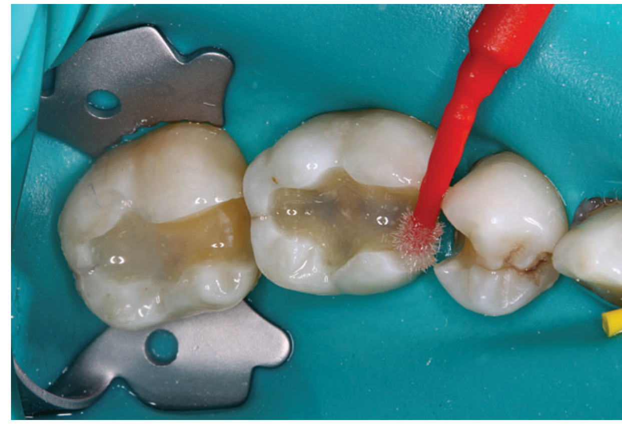

Figure 25. Application of 5th generation adhesive for 15 seconds, air agitated and light cured.

Figure 26. Removal of excess resin cement facilitated by a rubbertip.

Figure 27. Final postoperative of inlays.

years, it is only within the last 10 years that we have had materials that potentially can exhibit the necessary strength being demonstrated to withstand the large masticatory forces that will be required to prevent fracture. The latest materials to exhibit this are zirconium and lithium disilicate-based materials. The main advantage of lithium disilicate over zirconium is the multifunctional use and the ability to keep the restoration a monobloc, thus potentially eliminating the failure of overlying ceramics chipping from their substructures. However, as noted earlier, only time will fully affirm this observation.

DISCLOSURE

The author does not have any financial interest in any companies mentioned in this article.

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