Maximizing material selection with CAD/CAM dentistry

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Depending on the clinical situation and the location of teeth, materials with different mechanical properties need to be employed when restoring teeth with fixed porcelain veneer crowns. This is pivotal in full-mouth rehabilitation. However, the use of many different materials may entail difficulties in achieving harmonious shading or even render a uniform outcome impossible.

The exceptional properties of lithium-disilicate glass-ceramic enables dental professionals to create natural-looking restorations, which fulfill the different requirements – without having to make concessions with regard to shading.

Typically, strength values of dental porcelains are relied on to indicate porcelain crown performance. However, strength is a conditional rather than an inherent property of dental porcelains. In vitro strength data alone cannot be used to assume a material’s long-term performance in vivo. In two-phase porcelain systems consisting of a framework and veneering material, the design of the substructure has a decisive influence on the overall strength. It is therefore logical to consider fabrication design as a factor in the overall strength performance of an all-ceramic crown in vivo.

Apart from the physical properties of the materials, the correct dimensional relation between the veneer and the substructure is a prerequisite for the success of two-phase porcelain systems. While the substructure functions primarily as the system’s strength, the veneering porcelain provides its esthetics. Examples of two-phase porcelain systems include porcelain-fused-to-metal crowns, zirconia crowns and veneered lithium-disilicate crowns. Increasing the strength function of the system would imply thickening the substructure. Thickening the substructure creates less room for the outer phase to perform its esthetic function.

Traditionally, creating a structural design to maximize esthetics has reduced the strength value of biphase systems because of small dimensions of the substructure. An example is limiting a substructure to a coping form. While esthetic, the coping design leaves the veneering porcelain unsupported in cusp-to-fossa function and vulnerable to long-term stress fracture. Possessing a high-strength substructure that has considerable esthetic advantages over other substrates can improve the strength of a system without compromising esthetic values.

A hybrid substructure design, which supports a cusp-to-fossa relationship, increases the strength of the system. Refractive index values increase when the substructure thickens; increasing the thickness of the substructure results in a crown of higher value. By acknowledging the individual strengths and weaknesses of the components of the biphase porcelain systems, it is possible to engineer structural stabilization factors in esthetic crown design. The material that most closely fits these ideal synergistic criteria is lithium disilicate.

Applications of lithium-disilicate glass-ceramic

Monophase lithium-disilicate crowns can be used on molars, for which strength is a desirable trait. For anterior reconstructions, however, veneered lithium-disilicate should be used to emphasize es-

Fig. 1
Different indications require different fabrication and layering techniques: IPS e.max® lithium disilicate allows uniform results to be achieved.
A synergy between the strength of the lithium-disilicate substructure and the esthetics of the veneering material can be attained with IPS e.max® System. This product allows all-ceramic restorations to compete with traditional restorations in terms of in vitro strength. At the same time, the esthetic value expected from all-ceramic crowns is not compromised.

Monophasic lithium-disilicate restorations can be used in posterior areas where strength is most important. When used in the bicuspid region, the facial aspect (visible portion) should be layered using IPS e.max Ceram. As a result, esthetics is improved without compromising the core integrity strength. In the fabrication of anterior crowns, the artistic skills of dental technicians are utilized to achieve high esthetics.

When creating full-contour, monophasic IPS e.max LS2 crowns, the cusp-to-fossa relationship should be studied first. Proper "waxing" in cusp-to-fossa physiology limits compression and shearing forces. Monophasic construction also allows higher resistance to fracture. The ideology behind the monophasic lithium-disilicate crown is similar to that of full-cast gold crowns (Fig. 1).

**Case presentation**

In this particular case, a 59-year-old male complained about his unattractive smile and wanted one that was more esthetically pleasing. At the time of presentation, the patient had a long dental history of missing posterior teeth, root canal therapy, tooth mobility issues, sensitive teeth, full-metal crowns, PFM crowns, amalgam fillings, discolored teeth and difficulty in chewing (Figs. 2, 3).

Additionally, the clinical and radiographic examination revealed clicking and popping upon opening of the mouth in both temporomandibular joints (TMs). Upon palpation, there was also a slight discomfort of the posterior capsule of the right TMJ, but the left posterior and lateral capsules were within normal limits.

**Diagnosis: occlusion**

The patient’s maxillary and mandibular midlines were aligned but demonstrated tracking to the right upon opening. There was a Class III occlusal relationship with a deep overbite that approached an edge-to-edge overjet anterior position, with a lack of anterior guiding patterns.

**Diagnosis: gingiva**

A periodontal examination revealed generalized pocketing of 1 to 3 mm, with isolated pocketing of 4 mm. Additionally, anterior and posterior isolated gingival recession was noted, with associated isolated thinning of keratinized gingiva. Other issues, such as wide keratinized gingival banding, blunted papillae and uneven periodontal outline form, were observed during the examination. The gingiva was irritated and demonstrated isolated bleeding upon probing.

**Diagnosis: dental hard tissue**

During the dental evaluation, missing teeth, crowns, amalgam fillings, composite fillings, heavy wear facets, exposed dentin surfaces, enamel splintering and clinical crown loss estimated between 20 and 70 percent were revealed.

**Treatment plan**

The diagnosis from this evaluation encompassed worn dentition, collapsed occlusion, generalized chronic mild gingivitis, generalized chronic mild periodontitis and mild MPDS/TMD. Based on this diagnosis, it was necessary to develop an extensive treatment plan that would not only increase the esthetic value of the patient’s teeth, but also their functionality. The treatment plan included opening the bite and establishing a vertical dimension of occlusion, establishing anterior guidance patterns and restoring the dentition.
It was also decided that a diagnostic wax-up, based on photographic analysis, would be used in this treatment plan (Fig. 4), which allowed the planned restoration to be built up in a precise and detailed manner. The wax-up was used to establish the length-to-width parameters of the natural teeth, the incisal plane, occlusal plane and the fixed arch parameters. These steps were all necessary to provide an outcome that was both esthetically pleasing to the patient and, more importantly, functional.

_Fabrication considerations_

The benefits of hybrid restorations (veneered frameworks) are that the design of the framework can be adjusted to the requirements of the clinical situation and optimum support of the veneering ceramic can be ensured regardless of whether the press or CAD/CAM technique is used. In the case presented, the CAD/CAM technique was employed (E4D Dentist CAD/CAM System, D4D Technologies, Richardson, Texas). The copings were designed on the computer as described below. A coping form of 1.25 mm to 1.5 mm minimum thickness was designed. The central developmental lobes were designed to within 1 mm of the final desired cusp allocation. Next, the proximal developmental lobes were waxed to within 1 mm of the desired marginal ridge location.

Located on the buccal and lingual aspects of a natural tooth, there is an area of demarcation between enamel and dentin. Ceramists term this area the "enamel break," which is where the enamel appears to become thicker and less supported by the thickness of the dentin. The location of the enamel break should be determined from preoperative photographs. On the working cusps of the crown, a ledge should be waxed at the enamel break to within 0.5 mm of the final survey outline form of the crown. This strengthens the working cusp and creates a stress breaker in the middle of the crown. This stress breaker relieves tension at the margin of the crown where the bond can be subjected to long-term effects of occlusal stresses.

The working ledge can be concealed due to the chameleon effect of the lithium-disilicate material. The balancing (i.e., nonworking) cusps do not require a working ledge of support. However, nonworking cusps should be prepared for the development of parafunctional interferences by waxing shearing stress breakers into the coping design. Once this had been accomplished, the lithium-disilicate high-strength copings were milled using IPS e.max CAD lithium-disilicate blocks (Figs. 5, 6).

Creating the esthetics began with the application of deep stains to the lithium-disilicate coping. Next, to lower the value of the coping and create a luminary zone for light refraction, the crown was built up entirely using IPS e.max Ceram Transpa neutral. Enamel stains and characterizations were applied (Fig. 7). This
envelopes the esthetics particularly in the anterior region. Finally, the outer enamel layer was finished in the appropriate shade S2 enamel, and the crowns were baked again (Fig. 8). The crowns were then textured finished with stones and surface polished with the Astropol® polishing system. A light layer of glaze was then applied for the final bake.

Once the final bake had been completed, the monophasic lithium-disilicate crowns were ready for seating in the mouth (Figs. 9, 10). The lithium-disilicate crowns were tried in to ensure proper seating and to prevent any issues during the final cementation and polishing processes. Once any issues had been addressed, final placement of the lithium disilicate restorations could be accomplished.

Permanent cementation

The prepared teeth were pre-treated using conventional procedures. The pre-treatment of the crowns was carried out according to the respective directions for use. The inner surfaces of the crowns were etched with hydrofluoric acid for 20 seconds, after which a silane coupling agent was applied. Dentin and enamel surfaces were wetted using a bonding agent (Excite®). Excess was blown off using pressurized air, and the surfaces were light cured for 20 seconds. A light-curing bonding agent (HelioBond) was applied on top of the Excite layer, and the excess was blown off. A dual-cure adhesive luting composite (Variolink® II) was placed in the crowns, after which they were carefully seated, cleaned and light cured. The postoperative all-ceramic crown results exhibited excellent biomimetic behavior and physiologic function (Figs. 11, 12).

Conclusion

Creating high-strength lithium-disilicate crowns without compromising the esthetic function of the all-ceramic restorations can be achieved by utilizing monophasic molar crowns, biphasic bicuspid crowns with facial layering and anterior biphasic crowns with lingual support (cf. Fig. 1). In vitro strength values of dental porcelains may indicate the performance of these restorations, but these data alone cannot be used to assume the structural performance of the restoration in vivo. Therefore, it is not only important but necessary to consider fabrication design as a factor in the overall strength and performance of an all-ceramic crown. The use of a lithium-disilicate material, as described herein, can enable dentists and laboratory ceramists to provide patients with structurally durable and esthetically pleasing restorative results even in difficult cases when slight functional problems are present.