Balancing esthetics and strength in multilayer zirconia: design and in vitro evaluation of UPCERA DUO

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Abstract

UPCERA DUO combines Uniform Particle Dispersion (UPD) technology with a multilayer gradient structure to coordinate optical and mechanical properties. In vitro testing showed incisal and cervical strengths of 891.4 and 1088.4 MPa, respectively; no crown fractures during 1.2 million chewing cycles; and 100% defect-free merlons at wall thicknesses of 0.2–0.4 mm. These results demonstrate favorable mechanical reliability, stable post-fatigue fracture resistance, and thin-wall milling integrity.

Keywords: multilayer zirconia; uniform particle dispersion; flexural strength; chewing simulation; machinability.

Introduction

As all-ceramic restorations advance toward natural esthetics and refined design, zirconia must meet requirements for translucency, mechanical strength and machining accuracy.[1,2] UPCERA DUO uses UPD technology to improve powder dispersion and combines multilayer optical and strength gradients to balance natural appearance with structural reliability. This study evaluates its mechanical properties, post-chewing-fatigue behavior and thin-wall machinability through in vitro tests.

The design behind UPCERA DUO: uniform particle dispersion and multilayer gradients

UPCERA DUO uses UPD technology to improve the dispersion of primary nanoparticles within agglomerated powder. Improved powder homogeneity is linked to green-body density, sintering behavior and a more uniform microstructure. Combined with the multilayer design, the intended improvements include a balance of optical and mechanical properties and consistency during processing.

Can this design deliver the expected regional strength, performance after repeated loading and thin-wall milling integrity? The following tests examine these outcomes at different levels, distinguishing performance observations from validation of the manufacturing mechanism.



Figure 1: Product and layer parameters: flexural strength 850-1200 MPa: transmittance 45%-48% at 1mm thickness

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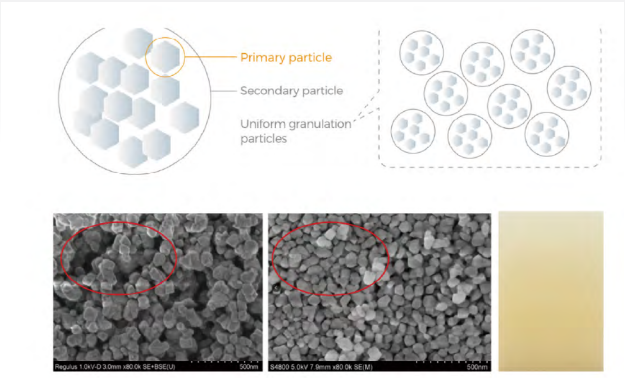


Figure 2: UPD particle dispersion schematic and micro-structural images

Thin-wall integrity during CAD/CAM milling

Four-merlon geometries (wall thicknesses of 0.2, 0.3, and 0.4 mm) were milled using a CAD/CAM system with identical milling strategies for all specimens. After milling, each specimen was visually examined for defects at the three wall thicknesses.

Under identical testing conditions, the machining performance of UPCERA DUO was compared with that of product A. At a thickness of 0.4mm, both materials remained stable. However, at thicknesses of 0.3mm and 0.2mm, the thin-walled sections of A fractured, while UPCERA DUO maintained stability. This demonstrates that under extreme machining conditions, UPCERA DUO exhibits significantly superior machining performance and stability compared to the competing product, enabling it to better meet the demands of practical clinical applications.

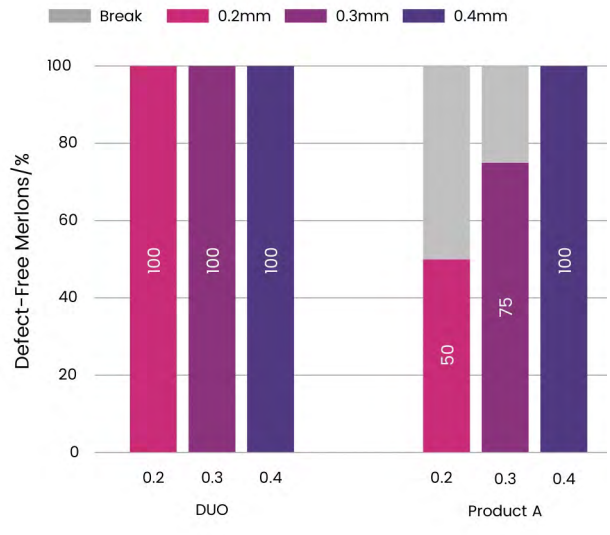


Figure 3: Defect-free merlons.

Regional strength in the incisal and cervical layers

According to ISO 6872-2024, specimens measuring 18.00 mm × (4.00 ± 0.02) mm × (1.20 ± 0.02) mm were prepared and polished on both sides. A universal testing machine (EZ-SX 500N, Shimadzu) applied a vertical load at 1.0 mm/min until fracture, using a 16 mm three-point bending span. Specimens were stored dry until testing. Three-point flexural strength was calculated for each group using $\sigma=(3FL)/(2bh^2)$.

Here, σ is flexural strength (MPa), F is the load applied at the specimen center (N), L is the support span (mm), b is specimen width (mm), and h is specimen thickness (mm).

UPCERA DUO zirconia consistently achieves flexural strength above 850 MPa. Compared with other multilayer zirconia materials, it provides enhanced incisal strength while maintaining exceptionally high cervical strength. This optimized functional strength gradient enables an ideal balance between esthetic translucency and long-term mechanical reliability throughout the restoration.

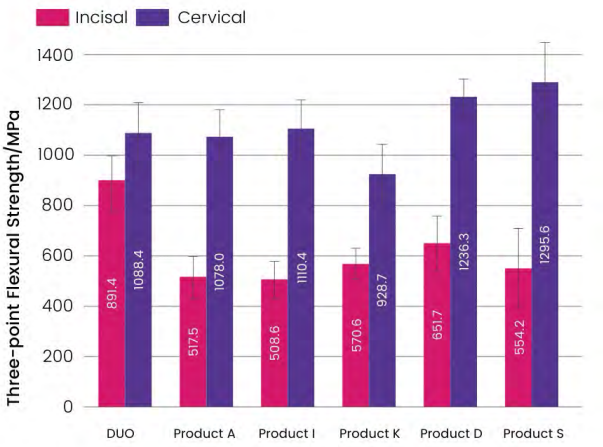


Figure 4: Three-point flexural strength

Crown fracture resistance after simulated chewing

A standardized full-contour mandibular first-molar crown (#36, ISO tooth notation; wall thickness 0.8 mm) was designed using 3Shape Dental System. Three commercially available zirconia materials, including UPCERA DUO, were evaluated. Eight crowns were milled from the central region of each blank using the same CAD/CAM workflow to minimize material variability. All groups were sintered according to manufacturer instructions in the same zirconia furnace. Crowns were visually inspected for defects before mechanical testing.

Each group was divided into an aged subgroup subjected

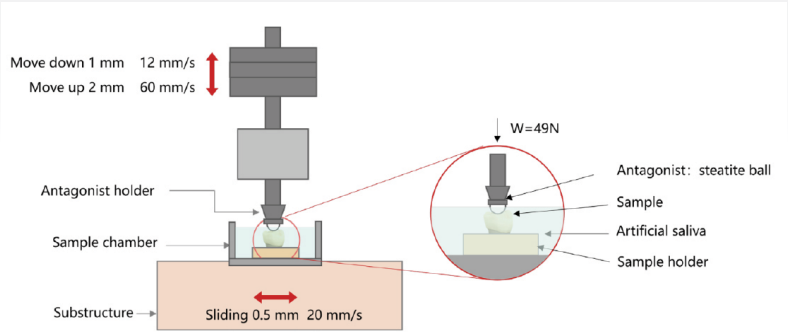


Figure 5: Chewing simulator and movement schematic

to 1,200,000 chewing cycles (49 N, 0.72 Hz) in a chewing simulator (CS-4.4, SD Mechatronik, Germany) and a non-aged control subgroup.[3] After simulation, a universal testing machine loaded the crowns with a 6 mm diameter stainless-steel indenter at 1 mm/min until cracking occurred.[4] One-way ANOVA was used for intergroup comparisons and independent-samples t-tests for corresponding aged and non-aged groups, with significance set at $p < 0.05$.

After 1,200,000 chewing cycles, no UPCERA DUO crowns fractured during fatigue simulation. Fracture load remained comparable to that of non-aged specimens, with no statistically significant reduction ($P > 0.05$). These findings indicate stable fracture resistance after simulated long-term chewing fatigue and favorable mechanical reliability under the present in vitro conditions.

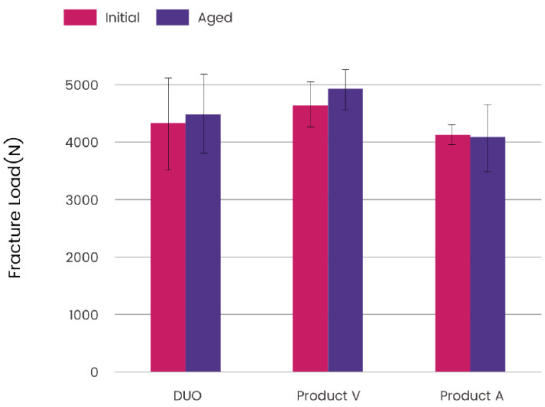


Figure 6: Fracture load before and after fatigue

Conclusion

UPCERA DUO multilayer dental zirconia combines high incisal strength with stable post-fatigue fracture resistance and particularly favorable structural integrity in thin-wall milling. Together with its translucency and multilayer property gradients, UPCERA DUO offers a combination of esthetic performance, mechanical reliability and precision machining capability, providing in vitro support for dental restorative applications.

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