

Dental Apatite Glass Ceramics: Sprue and Dimension for Ability to Cast

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ABSTRACT

This study evaluated the ability of apatite-based glass ceramic $20\text{CaO}-10\text{P}_2\text{O}_5-10\text{MgO}-10\text{Al}_2\text{O}_3-50\text{SiO}_2$ including CaF_2 and B_2O_3 to cast into ethyl silicate-bonded cristobalite-quartz (CQ) investment. The mould was kept at 910°C for 30 min and the molten glass was cast into it by vacuum-pressure casting machine. The wax patterns as disc, plate and net samples were used to examine the glass ceramic castability. The castability exhibited that the sprue shape and dimension attaching to wax patterns determined the magnitude, showing that a large-sized sprue attachment to their patterns was useful significantly to cast glass ceramics into CQ mould.

INTRODUCTION

The wax pattern and sprue dimension for the ability to cast glass ceramic into a mould was an important variable similar to the castings of metal crown¹⁻⁴. The straight sprue attachment optimized the ability to cast into a phosphate-bonded investment mould using a simulating wax pattern of crown². Castability test patterns used were tapered wax pattern⁵, mesh pattern⁶, line segments surrounding the 100 squares⁷, a plate $40 \times 40 \times 0.4$ mm⁸ and coil pattern for dental high fusion metals and alloys⁴. A sprue/wax pattern interface was conven-

tionally jointed without flaring or tapering, exhibiting that porosity in the casting minimized at the junction. A developed dental glass ceramic was applied to cast crown^{3,9,11}, representing that mechanical strength as the crown was improved by thermal ceramming treatment for crystal formation. The ceramics cast into the investment mould were obtained by vacuum-pressure casting machine⁹⁻¹² and centrifugal casting machine¹³⁻¹⁵. Little attempt was, however, made to examine the method to measure castability of glass ceramics. The castability was evaluated by the sprue attachment as the variable that affected the occurrence of porosity in crown and bridge alloys^{1,2,8}. In this study, the castability of apatite-based glass ceramics during dental casting was evaluated by the sprue attaching to various wax patterns using vacuum-pressurized-casting machine.

MATERIALS AND METHODS

Wax patterns were invested using ethyl silicate-bonded cristobalite-quartz (CQ) investment mould within a steel ring (32 mm diameter and 50 mm height)¹¹. Three types of wax patterns were disc (18 mm diameter \times 0.5 mm thickness), plate ($10 \times 10 \times 0.5$ mm) and net ($12.5 \times 16 \times 1$ mm and $5 \times 16 \times 1$ mm with a line segment; 2.5×2.5 mm). The wax pattern had the sprue attachment of 1.5, 2.0, 3.2 and 4.0 mm diameter and length of 3 and 10 mm (wax pattern and ready casting wax; GC Co, Tokyo). CQ investment mould developed for glass ceramic casting was made using a mixture of pH=8.8 (A and B) (A; pH-adjusted silica sol (pH=3.5), B; aqueous ammonia (pH=9.4))^{11,12}. The investment powders were used as the investment mould of 55 wt% alpha cristobalite and 45 wt% alpha quartz powders. The liquid/powder ratio was 0.34 using the liquid mixture of A (16 mL) and B liquids (1 mL). CQ mould was placed to a burnout furnace heated to 910°C and held for 30 min (Jelenko Accu-Therm II 500, J. Morita

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Co, Tokyo). Apatite glass ceramics were 20 wt% CaO-10P₂O₅-10MgO-10Al₂O₃-50SiO₂ including a very small amount of CaF₂ and B₂O₃ as the C1 ingot (transparent)¹⁰ and other metallic compounds-added ingot (C2; brown colour) to C1 ingot¹¹.

The ceramic was cast into CQ mould using experimental vacuum-pressure casting machine (PROTOTYPE II, J. Morita Co, Tokyo). The castability was evaluated as the length (castability length; CL) from the interface junction between the castings and sprue edge (plate and net patterns) and the area fraction calculated by the impression method (disc) (sample size=10 for each castability test). The casting condition of PROTOTYPE II casting machine was carried out under a pressure duration time (10 sec) using vacuum-pressurized-casting machine¹².

RESULTS

Fig. 1 shows optical micrographs of disc cast patterns when taken by the impression material. (a) to (d) were obtained by sprue attachment with a sprue of 1.5, 2.0, 3.2 and 4.0 mm diameter at 10 mm length. Glass ceramics ingot as C1 tested was 10 gram. Fig. 2 shows castability value as the area fraction for C1 and C2 ingot samples (10 gram) using the same sprue attachment as Fig. 1. Figs. 3 and 4 show, respectively, castability length (CL) of plate pattern (10×10×0.5 mm) and net patterns when a sprue of 1.5 or 4.0 mm diameter was used at sprue length=3 and 10 mm (glass ceramic ingot C1=10 gram).

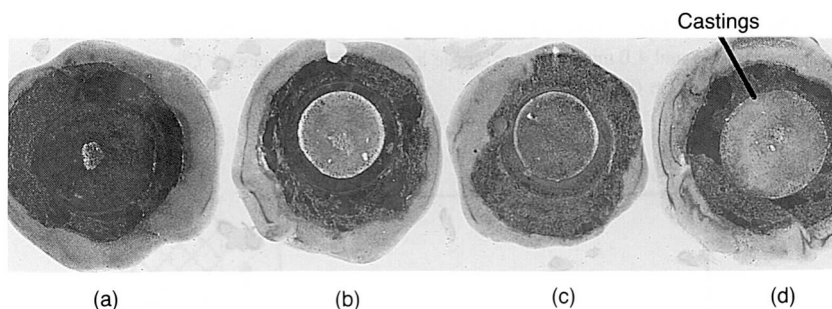


Fig. 1 Photomicrographs ((a) to (d)) of disc cast patterns taken by the impression material; sprue attachment with a sprue (1.5, 2.0, 3.2 and 4.0 mm diameter at 10 mm length). Glass ceramic ingot = 10 gram (C1).

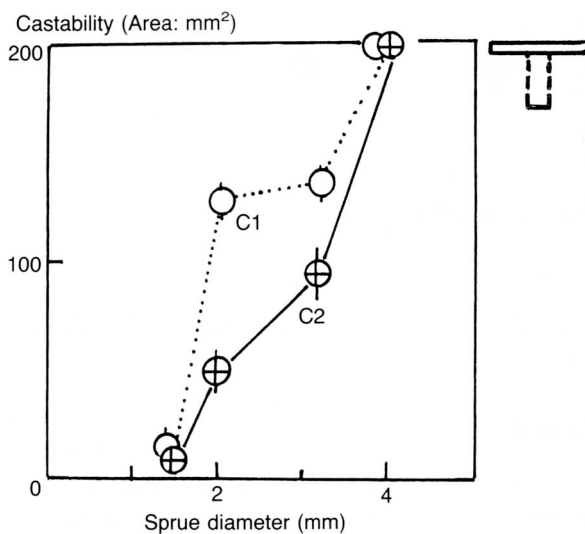


Fig. 2 Castability evaluated as the area fraction for C1 and C2 ingot samples (10 gram). Sprue attachment was the same as Fig. 1. For key, see text.

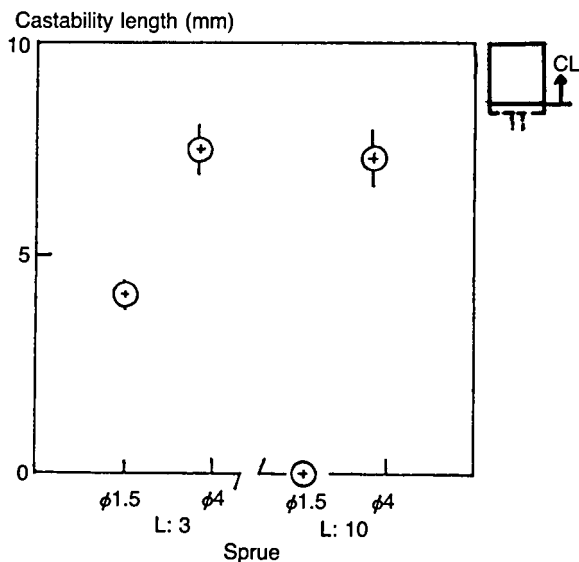


Fig. 3 Castability length (CL) of plate pattern (10×10×0.5 mm) with a sprue of 1.5 and 4.0 mm diameter (sprue length=3 and 10 mm). Glass ceramic= 10 gram (C1).

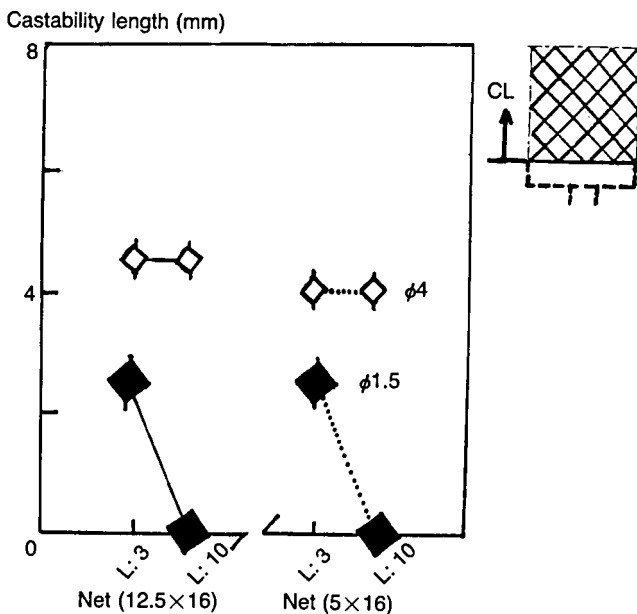


Fig. 4 Castability length (CL) of net patterns with the same sprue dimension as Fig. 3.

DISCUSSION

In Figs. 1 to 4 the factors which affected the castability of apatite-based glass ceramics were a type of wax pattern and sprue dimension attaching to it. The shape and dimension of wax patterns (disc, plate and net patterns)

was chosen to offer a possibility for quantitative analysis of the castability result. It was more difficulty to obtain a complete casting of wax patterns with a small sprue diameter than one with a large sprue diameter. Considering the castability of metals and alloys evaluated by simulation of a metal crown, a sprue attachment design of

wax pattern was the variable of castability test. The straight sprue attachment optimized the castability and minimized the porosity of the alloys investigated. A complete cast disc was obtained for C1 and C2 glass ingots when attached by sprue diameter = 4.0 mm (sprue length = 10 mm) (Figs. 1, 2). Thus the castability of glass ceramic was compared by the sprue attachment to wax pattern (sprue diameter = 1.5 and 4.0 mm). The results showed that there was a significant difference of castability length between the patterns with sprue diameter = 1.5 and 4.0 mm for each sprue length = 3 and 10 mm ($p < 0.05$, Fig. 3). And also a significant difference of castability length was found between net patterns with a sprue diameter of 1.5 and 4.0 mm for each sample of sprue length = 3 and 10 mm ($p < 0.05$, Fig. 4).

As noted in this study, sprue dimension to wax patterns tested was important with the determination of castability of apatite-based glass ceramics. This result suggests that wax pattern approximated to crown or inlay restoration exhibits a good castability using appropriate sprue attachment.

SUMMARY

The castability of as-cast apatite-based glass ceramic $20\text{CaO}-10\text{P}_2\text{O}_5-10\text{MgO}-10\text{Al}_2\text{O}_3-50\text{SiO}_2$ containing CaF_2 and B_2O_3 as a very small amount was determined by sprue attachment with different sprue diameter (1.5, 2.0, 3.2, 4.0 mm) and sprue length (3, 10 mm). The investment mould was ethyl silicate-bonded cristobalite-quartz one mixed by hydrolyzed silica sol and aqueous ammonia. The castability to wax patterns tested was obtained appropriately using a large-sized sprue attachment when cast by vacuum-pressure casting machine.

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