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Introduction to Fabrication Methods of Dental Ceramics

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Abstract:. Fabrication Methods of Dental Ceramics includes sintering, heat pressing, slip casting and machining. Some of these techniques, such as machining and heat-pressing, can also be combined to produce the final restoration.

Keywords: Fabrication, ceramics, sintering, heat-pressing, zirconia.

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This includes sintering, heat pressing, slip casting and machining. Some of these techniques, such as machining and heat-pressing, can also be combined to produce the final restoration.

Sintering is the process of firing the compacted ceramic powder at high temperature to ensure optimal densification. This occurs by pore elimination and viscous flow when the firing temperature is reached. Sintering is the most common fabrication technique for the veneering ceramic in metal-ceramic restorations. The production of a porcelain restoration involves the following technical stages: a) Compaction b) Firing procedure c)Glazing. All-ceramic restorations can also be produced by sintering, but they encompass a wider range of processing techniques, including slip-casting, heat-pressing, and CAD/CAM machining. Two main types of *all-ceramic* materials are available for the sintering technique: *alumina-based* ceramic and leucite-reinforced ceramic [(1)].

Heat-pressing relies on the application of external pressure at high temperature to sinter and shape the ceramic. Ceramic ingots are used which are available in a variety of shades. During heat-pressing, ceramic ingots are brought to high temperature in an investment mold produced by the lost wax technique. The heat-pressing temperature is chosen near the softening point of the ceramic. A pressure is then applied through a refractory plunger. This allows filling of the mold with the softened ceramic. The high temperature is held for durations between 10 and 20 minutes. Heat-pressing requires a specially designed automated pressing furnace and classically promotes a good dispersion of the crystalline phase within the glassy matrix. The mechanical properties of many ceramic systems are maximized with excellent crystal dispersion, higher crystallinity, and smaller crystal size, compared to sintered all-ceramics. The main disadvantages are the initial cost of the equipment and relatively low strength compared with other all-ceramic systems. First-generation heat-pressed ceramics contain leucite as a reinforcing phase. The second generation of heat-pressed ceramics contain lithium disilicate ($Li_2Si_2O_5$) as a major crystalline phase [(1)].

Slip-Cast All-Ceramic Materials. The first step of the process involves the condensation of a porcelain slip on a refractory die. The term *slip* refers to aqueous slurry containing fine ceramic particles. The porosity of the refractory die helps condensation by absorbing the water from the slip by capillary action. The restoration is incrementally built up, shaped, and finally sintered at high temperature on the refractory die.

Usually the refractory die shrinks more than the condensed slip so that the restoration can be separated easily after sintering. The sintered porous core is later glass-infiltrated, a unique process in which molten glass is drawn into the pores by capillary action at high temperature. This leads to a microstructure consisting of two interpenetrating networks, one formed by the crystalline infrastructure and the other being the glassy phase. The main advantage of slip-cast ceramics is their high strength; disadvantages include high opacity (with the exception of the spinel-based materials) and long processing times. Three types of ceramics are available for slip-casting: alumina-based (Al_2O_3), spinel-based ($MgAlO_4$), and zirconia-toughened alumina (12Ce-TZP-Al_2O_3) [(2)].

Machinable ceramics can be milled using Computer-Aided Design/Computer Aided Manufacturing CAD/ CAM technology to form inlays, onlays, veneers, and crowns. After the tooth is prepared, the preparation is optically scanned and the image is computerized. The restoration is designed with the aid of a computer. The restoration is then machined from ceramic blocks by a computer-controlled milling machine [(2)].

Copy Milling is another system for machining ceramics to form inlays, onlays, veneers, and crowns. In this system, a hard resin pattern is made on a traditional stone die. This handmade pattern is then copied and machined from a ceramic block using a pantographic device similar in principle to those used for duplicating house keys [(2)].

Hard machining of machinable all-ceramic materials is performed in the fully sintered state. In this case, the restoration is machined directly to final size. Several machinable ceramic bolcks are presently available for hard machining: feldspar, leucite, and lithium disilicate–based [(2)].

Some all-ceramic materials can also be machined in a partially sintered state and later fully sintered, this is called *soft machining*. This latter technique requires milling of an enlarged restoration to compensate for sintering shrinkage and is well adapted to ceramics that are difficult to machine in the fully sintered state, such as alumina and zirconia [(2)].

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