Zirconia Ceramics in Dentistry: Structure, Properties and Clinical Applications

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In the past decades, there have been major advances in the application of sintered yttria partially stabilized zirconia (Y-TZP) ceramics for load-bearing applications in restorative dentistry. Superior mechanical properties of Y-TZP, compared to other bioceramics, allow them to be used for the fabrication of multi-unit dental bridges. Additionally, they enable a substantial thickness reduction of those fixed dental prostheses (FDPs) in the visible part of the dental arch that is subjected to lower mechanical stresses. However, the main driving force for the replacement of traditional metal-based ceramic prosthetic crowns and bridges is the improved aesthetics, and excellent tissue compatibility achieved using tooth-colored, metal-free systems. For the same reasons, Y-TZP ceramic post-and-core systems and implant superstructures were introduced to replace traditionally used metals in dentistry.

Clinical use of porcelain veneering Y-TZP FDPs is often connected with chipping or fracturing of the veneering porcelain. Less porcelain delamination from Y-TZP ceramic framework can be attained by the use of veneering porcelains with thermal expansion coefficient adapted to zirconia framework ceramics. Frequent chipping of veneering porcelain and the development of new translucent zirconia ceramics have dictated the introduction of the use of monolithic zirconia ceramic restorations without veneering porcelain.

Under clinical conditions, dental restorations are exposed to cyclic mechanical and thermal loadings in the chemically aggressive environment of the oral cavity, where they are expected to be in service for at least 7-10 years. The strength tends to diminish steadily with time, from stress corrosion and fatigue as well as other mechanisms, e.g., during mechanical surface treatment and enhanced low-temperature degradation (LTD), i.e. aging of Y-TZP ceramics.

The long-term survival rate of zirconia-based dental restorations largely depends also on the adhesive bond between zirconia ceramics and tooth surface. Unfortunately, the establishment of a durable chemical or mechanical bonding to zirconia has been proven to be difficult because of its surface stability. Chemical methods, such as acid-etching or silanization, proved to be ineffective. For this reason, surface roughening by sandblasting, which enhances the mechanical interlocking, remains the most commonly used surface-preparation technique. However, subsurface cracks may be introduced during abrasion; this process represents a potential threat of a premature failure. Therefore, we have recently proposed an alternative solution to the adhesion problem by a non-invasive functionalization of the core ceramic surface, by applying a thin nanostructured alumina coating.

Contemporary clinical applications of zirconia ceramics in dentistry with the CAD (computer aided design)/ CAM (computer aided machining) technology will be presented.