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The utilization of Y-TZP for endosseous oral implants: current perspectives

ABSTRACT

Metallic ion release has raised concerns for the utilization of titanium and titanium alloys in implant dentistry. As an alternative, yttria-stabilized tetragonal zirconia (Y-TZP) has been considered the material of choice due to its favorable biological and mechanical properties. Zirconia has been shown both *in vitro* and *in vivo* experiments to exhibit desirable osseointegration, cell metabolism, and soft tissue response. According to the mechanical testing of unaged Y-TZP one-piece implants, catastrophic failure of ceramic implants in anterior esthetic regions is unlikely. The utilization of a one-piece Y-TZP implant might be an option to fulfill the esthetic and mechanical needs in oral implant treatments when esthetics is the major concern.

KEYWORDS Ceramic implants; Titanium; Zirconia.

From a chemistry and biocompatibility standpoint, oral implants may present a wide range of surface composition, texture, energy, and cleanliness. Despite

the recognized biocompatibility of titanium and titanium alloys and their surfaces' protective oxide layers, metallic ion release has raised concerns over the last decade (1). Increased concentration of titanium has been observed in tissues close to the implant surfaces (2) and also in regional lymph nodes (3). Besides the fact that the clinical relevance of these observations is uncertain, alternative metal-free treatments are under active research (Fig. 1).

As an alternative to titanium and titanium alloys commonly used in implant dentistry, yttria-stabilized tetragonal zirconia (Y-TZP) has been considered the ceramic material of choice due to its high flexural strength (900-1,200 MPa), favorable fracture toughness (KIC 7 to 10 MPa) and Young's modulus (210 GPa) (4). In addition, zirconia has been shown both *in vitro* and *in vivo* experiments to exhibit desirable osseointegration, cell metabolism, and soft tissue response (5-7). Zirconia implant human histology has also demonstrated a morphology suggestive of lamina dura and thereby the potential for increased quality of osseointegration (6). Other biological properties include negative *in vitro* carcinogenicity and mutagenicity (8, 9).

Since its introduction in the '80s, Y-TZP has been



Fig. 1 This series of images shows Y-TZP implant being placed (a) via flapless technique. Note X-ray (b) showing implant positioning immediately after surgery. The image (c) represents the final restoration cemented on the one-piece ceramic implant.

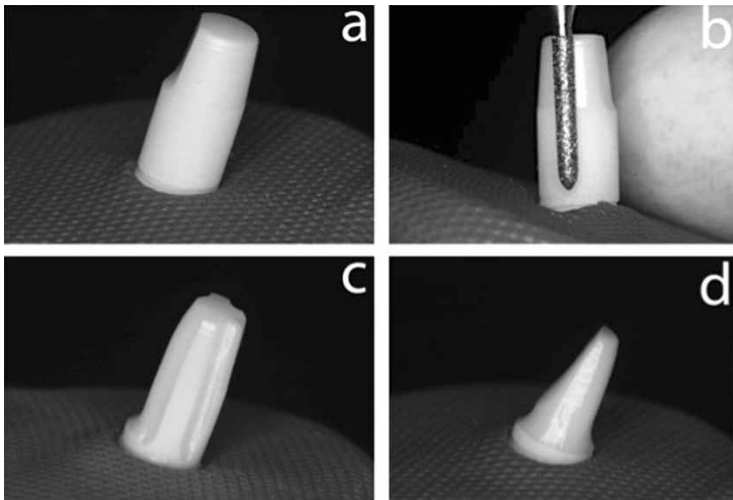


Fig. 2 This is a sequence of full crown preparation of ceramic implant (a) embedded in PMMA using length and diameter of the burs (b and c) as references to obtain correct shape, inclination and dimension of each crown preparation; d shows the side view of the final full crown preparation.

extensively utilized as a material for ball-heads in total hip replacement (10). In dentistry, Y-TZP has been largely used as a material for cores and frameworks in all-ceramic restorations as well as for ceramic abutments in oral implant prosthesis, and has also been investigated as an endosseous implant material (7).

The utilization of a one-piece Y-TZP implant might be an option to fulfill the esthetic and mechanical needs in oral implant treatments when esthetic is the major concern. However, unlike orthopedic applications, where as-processed devices do not undergo manual modification during placement, single piece endosseous oral implants sometimes need to be modified for full crown restoration by means of rotating diamond burs (Fig. 2). This procedure, as in any abrasive procedure applied to structural ceramics, may result in surface damage associated with crack initiation sites (11, 12).

Abrasive surface damage has been shown to decrease dental ceramics clinical life expectancy (13). Recently, Silva et al. (14) showed that full-crown preparation performed on one-piece Y-TZP endosseous implants did not influence the reliability of those implants when loads less than 600 N were applied under mouth-motion simulation. Considering that the utilization of these implants is likely to be in anterior esthetic regions, where the maximum biting force is approximately 200 N (15) overload catastrophic failures are unlikely. However, structural property maintenance over time is yet to be determined for Y-TZP endosseous implants, especially since property degradation has been shown accelerated in wet environments.

Clinical experience with zirconia in the field of orthopedics has shown that femoral Y-TZP components failed in a short period following placement (16). These failures were attributed to an accelerated aging phenomenon and a change in the

processing technique. Since then, numerous *in vivo* and *in vitro* studies have been proposed to better understand Y-TZP aging and its relationship to mechanical and chemical properties. It has been demonstrated that phase transformation from the tetragonal to the monoclinic phase occurs more rapidly at bulk regions where the surface is exposed to moist environments (16).

While definitive answers are not given regarding the effects of low-temperature degradation for Y-TZP, clinical studies are being performed using one-piece ceramic implants. A previous study (17) presented a one-year follow-up of 100 ceramic implants placed in patients with ages ranging from 18 to 80. The authors also compared implants with two different types of surface roughness and five different designs which were placed in anterior and posterior regions following standard surgical procedures. The overall success rate was 98% and no fracture on the implants was observed. Long-term follow up is highly desirable for comparison with previously investigated metallic implants.

According to the mechanical testing of unaged Y-TZP single piece implants, catastrophic failure of ceramic implants in anterior esthetic regions is unlikely. However, the aging phenomenon and its implication on the long-term success of ceramic implants warrants further laboratory and clinical investigation. Appropriately designed long-term prospective and retrospective studies concerning one-piece Y-TZP oral implants are necessary.

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