A Recent Updates on Zirconia Implants: A Literature Review

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Surface analysis

Yang et al. examined zirconia with 3% Y2O3 and zirconia with 4% CeO2 coatings that were deposited on CoCrMo and titanium implants with the use of method of plasma spraying. Structural properties, adhesive properties, and morphological properties of plasma sprayed coatings were assessed. e mean surface roughness of zirconia with 4% CeO2 and zirconia with 3% Y2O3 was interrelated with the substrates and initial powder size. Hardness of substrates and the coatings showed no considerable di erence. e adhesive strength of zirconia with 4% CeO2 coating t CoCrMo and titanium substrates was found to be greater than 68MPa and very much higher than that of zirconia with coating of 3% Y2O3 [1,40].

In yet another study, evaluation of machined Zirconia, SLA zirconia and sandblasted zirconia surfaces was done. ere was an increase in surface roughness by airborne particle abrasion and acid etching. Cell proliferation showed statistically signi cant values greater at three days for surface treated zirconia compared to machined sample. But there were no observed di erences among zirconia groups and SLA titanium for 6 and 12 days [41].

Gahlert et al. made another study on zirconia implants with sandblasted or machined surface and compared these to SLA titanium implants [5]. It was revealed by surface analyses that highest surface roughness was recorded for SLA titanium implant, followed by sandblasted zirconia and machined zirconia implant. In last study by Stubinger et al., e ect of erbium-doped yttrium aluminum garnet, CO_2 and diode laser irradiation on the surface characteristics of polished zirconia implants were evaluated. SEM analysis revealed that the diode and ER-YAG lasers have not caused visible surface changes. But $C0_2$ Laser made distinct alterations to zirconia surface [42].

Removal torque testing

Study by Sennerby et al. observed the bone tissue responses to surface modi ed and machined zirconia implants [43]. To make the surface porous, zirconia implants were coated by two slurries containing zirconia powder and pore-former, which provided di erent surface structures. e non-coated implants were used as controls. Additionally, they used titanium implants. Coated zirconia and titanium implants revealed higher TRQ compared to machined implants. RTQ values of machined zirconia implants, SLA Titanium and sandblasted zirconia implants were evaluated by Gahlert et al. Machined zirconia implants exhibited statistically signi cant lesser values of RTQ than other implant types a er eight and twelve weeks and SLA titanium implant showed higher RTQ values than sandblasted zirconia implant was 25.9 N/cm, while mean value for zirconia rough implants was 40.5 N/cm and mean value of RTQ for SLA titanium implant was 105.2 N/cm [1].

e e ects of ceramic coating (hydroxyapatite and Zirconia) on bond strength between bone and implant was evaluated by Alzubaydi et al. along with cell compatibility of screw-shaped dental implants of titanium [44]. Biochemical testing was conducted at healing time points at 2, 6 and 18 weeks. RTQ value increase was observed in bone-
implant interface w in boste was observon w Tw 0 2ed zirconia imzsc co37e e. [44]. Bio7inede2Ci 4um 09 4dte wn ti50stinct altmi50stinimplan -1.83 Td4
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implant and unaltered pen-implant marginal bone levels were noted. There was no bleeding on probing [51,52].

Case reports

Kohal et al. presented a first clinical case report of zirconia dental implant [53]. A custom built two-piece zirconia implant replaced a left upper central incisor with the zirconia abutment and zirconia single crown. Additionally, Oliva et al. reported a first clinical case of ovoid zirconia implant. A specially designed, anatomically oriented ovoid zirconia implant was used to replace missing premolar was discussed [54].

Recent Developments in Titanium Based Implant Biomaterials

New developments in R&D in titanium-based biomaterials have the aim of developing alloys with non-allergic and nontoxic elements having excellent mechanical characteristics such as high strength and low modulus, and good workability [54]. These developments are attempting to replace aluminum and vanadium with non-toxic components like Fe, Nb, Ta, Mo, Pd and Zr. These materials exhibit lower modulus of elasticity which is near the value of bone (17-28 GPa) and are also β alloys. The lower value of modulus of elasticity is beneficial as it produces a more favorable distribution of stress in bone implant interface [55-57]. Also, these alloys can attain higher strength and toughness. Recently, a new alloy has been developed for manufacture of narrow diameter implants (by name Roxolide, Straumann, Basel, Switzerland) for use in dentistry. The new alloy is based on binary formulation of titanium (83-87%) and Zirconium (13-17%). This is claimed that the alloy has better mechanical properties compared to CpTi and Ti-6Al-4V, having a tensile strength of 953 MPa and 40% more fatigue strength. Adding Zirconia to the Titanium results in better osseo-integration and the alloy made of Zirconium and Titanium exhibits more bio-compatibility than pure titanium [38].

Another titanium alloy in the application of surgical implant material is Ti12.5Zr2.5Nb2.5Ta or TZNT which is very promising. This alloy has the unique advantage of having closer modulus of elasticity to human bones compared to conventional titanium alloys. It also has approximately same equivalent admission strain (at 0.65%) compared to human bones (at 0.67%). Adding the elements like, Zr, Ta and Nb to alloy have detected no toxicity or adverse tissue reactions. They also show better resistance against corrosion [58].

Recent Developments in Zirconia Based Implant Biomaterials

Presently, considerable research is going on with the aim to improve reliability of ceramics generally and specifically about zirconium-based biomaterials in mainly biomedical and dental applications. There are several developments focusing on application of zirconia and alumina ceramic composites which consist of ZTA or ATZ. Generally, such advanced composites gain benefits due to transformation toughening characteristics of Zirconium and also are less vulnerable to degradation in biological fluids at low temperatures [4].

Recently, ceramic blocks called as TZP-A was produced by adding small quantity of alumina to 3Y-TZP. Alumina traces improved stability and durability under humid environments and high temperatures. But this was achieved at the compromise of reduction in translucency of ceramic blocks and hence it is considered aesthetic disadvantage [38].

Minimizing LTD in 3Y-TZP systems is attempted by adding small quantities of silica, using yttria-coating instead of co-precipitated powder, reducing grain size and increasing stabilizer content and formation of composites with Aluminum Oxide (Al_2O_3). The composite material processed with tertragonal zirconia polycrystals (ZrO2-TZP) and Alumina at 20% (Al_2O_3) is claimed to show excellent mechanical and tribiological characteristics. Adding alumina to Zirconium reduces aging or in the least, diminishes its kinetics as it alters from grain boundary chemistry and limits tetragonal grain growth during process of sintering, resulting in more stable structure. Another enhancement in Zirconia is Zirconium based bulk metallic glass; for example, Zr61Ti2Cu25Al12ZT1, which exhibits good combination of requirements, restoring of zirconia implants with high strength ceramics would prove bene cial. ough there are some short-term clinical reports provide satisfactory results, there should be controlled clinical trials having 5 year follow up or more should be done so as to evaluate properly, the clinical performance of zirconia implants so as to recommend them for regular clinical use.

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