Ceramic Dental Implants: An Alternative to Titanium and Titanium Alloys

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Introduction

Since Dr. Brånemark first introduced titanium dental implants, a variety of materials have been used successfully for about 40 years. Today implants are made either of commercially pure titanium (cpTi) or titanium alloys. In addition to its biocompatibility, titanium was also initially believed to be inert, non-toxic and nonallergenic [1,2]. However, several drawbacks have been documented in the literature with the use of titanium and titanium alloys as implant materials in medicine and dentistry. High concentrations of titanium have been detected in tissue surrounding dental implants mostly as a result of wear or corrosion of the titanium implant surface. In an animal study Weingart et. al [3]. showed that nine months after titanium implantation, titanium particles had spread and were found in adjacent lymph nodes. This indicates the possibility that phagocytes could transport titanium particles to the lymph nodes without any initial or immediate inflammatory response and potentially cause later immunologic reactions.

Discussion

An increasing number of people who suffer some form of tooth loss are choosing to replace their teeth with dental implants. For the last thirty plus years the only and highly successful option for freestanding tooth replacement available in the United States and other countries has been titanium and titanium alloy dental implants. There are increasing reports both in dentistry and medicine of individuals developing sensitivity and allergies to titanium and/or titanium alloys. Even of more concern some of these implants are corroding once exposed to body fluids such as saliva and developing electrical activity when they are coupled with prosthetic components made of other metal alloys. Titanium implants as they corrode are known to release metal ions which create low level electrical currents through the body but also weakens the structural integrity of the implants. With recent advances in implantable biomaterials research and technology, bioceramics such as zirconia (zirconium dioxide) are now available and a new generation of modern implants is made of zirconia. Zirconium Silicate ($ZrSO_4$) is mined and is treated and transformed into zirconium dioxide which is also called zirconia. Zirconia is the crystal form of the material zirconium which is a transitional metal. After mining and processing of zirconium silicate, zirconium is isolated and further processed under high temperature and pressure. Zirconium then undergoes an oxidation and crystallization process which allows it to transition into a structurally stable and inert crystal. This bioceramic crystal is called Yttrium Stabilized Tetragonal Zirconium Polycrystal (Y-TZP) also called zirconium dioxide. Therefore zirconium dioxide is not a metal and presents exceptional physical and biological properties. Zirconia can sustain an extreme load capacity, features a very long service life, and presents no conductivity or interference in the body's meridian systems; it is the most hygienic, non-electricity conducting and stable material for dental implantology and orthopedics. Zirconia implants also present no danger of corrosion, something that is often a serious problem with metal based dental implants. Corrosion of a titanium dental implant occurs when it is coupled with the metal framework or abutment of the crown which more often than not is a less noble metal or alloy than that of the titanium implant. The implant and crown assembly bathes in saliva which is an electrolyte and a good conductor of electricity; this leads to all sorts of chemical and electrical imbalances in the body and to a phenomenon called "battery mouth". Another advantage of zirconia is its low affinity for

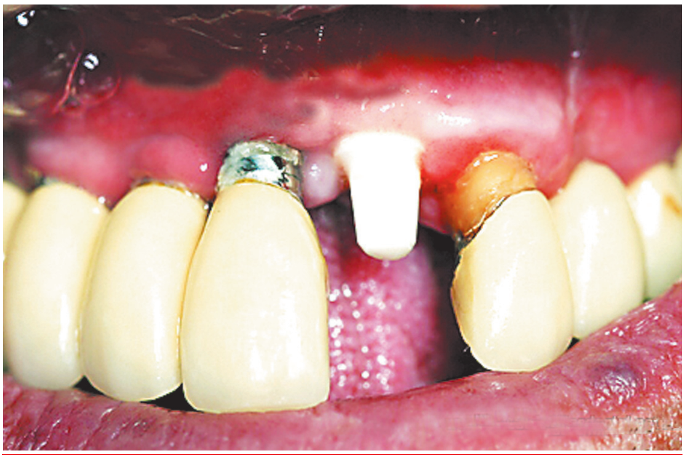

Fig.1: Plaque Retention: Titanium versus Zirconium

Fig.2: Soft Tissue Health and Aesthetics Around Zirconia

plaque (Fig.1). Clinical observations and studies [4]. show that zirconia implants compared to or next to titanium implants accumulate much less plaque and allow for superior gingival health. (Fig.2)

There is a controversial and highly misunderstood aspect of zirconium dioxide in terms of its radiological output. Zirconium Silicate (ZrSO4) depending where it is mined can be contaminated with natural radioactive isotopes including radium (226Ra) and thorium (228Th). This was a major concern in the early 1990's because the ores selected were contaminated. Today zirconium dioxide processing plants have the technology to remove these contaminants and are able to yield and use very pure powders. For example, the radiation emitted by a 3 mol% Y2O3-ZrO2 powder was the same order of magnitude as alumina powder, both of which were several orders of magnitude less than that typically measured for water, vegetables and livestock. Zirconia hip ball replacements weigh approximately 100mg and have a natural radiological output of 1mSv per year. The average weight of a zirconia dental implant is 1g, translating into a natural radiological output of roughly 0.01mSv/year. Therefore the radiation risk of zirconia bioceramics is negligible and given that the World Nuclear Association states that the typical background radiation experienced by most people in North America is 3.4mSv, there is little concern for adverse biological effects on the implant recipient.

Conclusion

Zirconia dental implants are a sensible and clearly a healthier alternative to conventional and titanium implant bridges, partials or Overdentures. Furthermore zirconia by virtue of its translucency and all-white color makes it the most aesthetically pleasing option available today for tooth replacement (Fig.3 & Fig.4). This is a new era in implant dentistry and the science of oral implantology.

Fig.3:Tooth shade selection for ceramic Implant

Fig.4: Crown on Zirconia Implant

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