



## BIOCOMPATIBILITY OF DENTAL MATERIALS

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**ABSTRACT** The term “biocompatibility” has been gaining recognition, not only in medicine, but particularly in dentistry. It basically means, biocompatible materials should not have a negative impact on the recipient. Currently, there are literally thousands of different components that makeup the materials that are used in common dental procedures, with more being developed each year. Scientific literature is now reporting on the importance of using the most biocompatible material for the patient. Unfortunately, even today, dental procedures are often designed simply for the functionality of the treatment, or for cosmetic purposes, even though it is well established that all foreign materials introduced into the human body will elicit an immune response.

**KEYWORDS :** Biocompatibility; Dental materials; Mercury; Root canal; Titanium; Toxicity; Allergy.

**INTRODUCTION**

Dental amalgam, one of the oldest, most commonly used restorative treatments globally, is often referred to as “silver” fillings. They have been in existence for over 150 years and continue to be used throughout the world. Yet, the main component is approximately 50% mercury, in addition to silver, tin, zinc, and copper [1]. The World Health Organization has deemed mercury as one of the top ten chemicals of major concern. They have also identified the first route of human exposure to mercury, is actually coming from dental amalgam [2].

It has only been since the conclusion of the Minamata Convention on Mercury Treaty in 2013, that countries that are a party to the treaty, are now trying to end the use of dental amalgam [3]. Originally, aesthetics had been the main driver to non-mercury fillings, however, biological/holistic dentistry is now educating patients about the dangers of mercury exposure from dental amalgams, as well as the risks of other commonly used dental materials and procedures. Until recently, dental amalgam was considered inert, however, it is now known to off gas mercury vapor, as well as release particulate matter [4]. In some of the earlier published research on dental amalgam, it had been discovered that papers that found no correlation of risks from the exposure to mercury from dental amalgams, were deemed to be fraught with flaws [5]. Dental amalgam has been studied and reviewed extensively and has established a record of safety and effectiveness [6].” Mutter [7] responded to the European Commission Scientific Committee, whose branch identified as the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), stated “...no risks of adverse systemic effects exist, and the current use of dental amalgam does not pose a risk of systemic disease...” Mutter published a point-by-point analysis of the SCENIHR paper, and like his previous work cited [5], identified “severe methodical flaws”. In the 295 referenced articles used in preparation of the research, autopsy studies were cited, noting that they are the most trustworthy for evaluating mercury levels in tissues. Mutter also provided research on the toxicity of mercury in vitro and in vivo.

**Root Canal-Endodontic Treatment**

According to the American Association of Endodontists (AAE), there are about 25 million root canal procedures performed annually, which is more than 41,000 a day. Root canal treatments are done by both, general dentists and endodontists [8]. In 2011, the AAE stated that bacteria are the main cause of pulpal and periapical disease, due to the intricacy of the root canal system. They observed that bacteria can be reduced using saline irrigation, but antibacterial irrigant are superior. However, none of the irrigant that they reported on, have all of the qualities of an ideal irrigant, with issues such as toxicity being a concern. They concluded that the quest for the perfect material and or technique, has yet to be found [9]. A meta-analysis was conducted on the biotoxicity of commonly used root canal sealers such as zinc oxide eugenol, calcium hydroxide, and resin-based sealers. They stated that

all of the current endodontic sealers are known to have some toxic properties [10]. Jung et al. [11] investigated the cytotoxic effects of four root canal sealers on human osteoblasts using the precise preparation protocols of the manufacturers. One epoxy resin-based (AH-Plus), one zinc oxide eugenol (Pulp-Canal-Sealer), and two calcium silicate containing sealers (MTA-Fillapex and BioRoot-RCS) were studied. They found BioRoot may be recommended for root canal obturation, showing the lowest toxicity in both a freshly mixed state and when the sealer was set. AH-Plus was cytotoxic in a freshly mixed state, but not when set. MTA-Fillapex and Pulp-Canal-Sealer were cytotoxic, in both states. They recommended that contact of MTA-Fillapex and Pulp-Canal-Sealer or freshly mixed AH-Plus to osteoblasts should be averted [11]. In addition to the four sealers investigated by Jung et al. [11] & Poggio et al. [12] included the investigation of the cytotoxicity of four more root canal sealers, TotalFill BC Sealer, Sealapex, EasySeal, and N2, by incubating immortalized human gingival fibroblasts, over a period of 24, 48 and 72 hours. They stated that the biocompatibility of an endodontic sealer is the foundation for a positive treatment outcome, and healing of the periodontium. Again, the eight root canal sealers were prepared following the specific protocols of the manufacturers. Only BioRoot RCS, TotalFill BC Sealer and AH Plus showed no cytotoxic effects at least in the first 24h. The other sealers that were tested, revealed moderately or severely cytotoxic activity during all the extraction times [12]. A study by Bojar et al. [13] investigated Endodontic Cement N2®, which contains 50mg of paraformaldehyde in 1g of material. They stated that well established research has definitively confirmed that paraformaldehyde-containing filling materials and sealers, can not only cause permanent damage to tissues near the root canal system, but also other serious problems, such as chronic infections of the maxillary sinus. Specifically, they noted that the active ingredients of Endodontic Cement N2®, have been found in various parts of the body that infiltrated the blood, lymph nodes, adrenal glands, kidney, spleen, liver, and brain [13].

**Titanium Implants**

In 2014, the ADA had reported that there are over 5 million dental implants placed each year [14]. Like dental amalgam fillings, titanium implants are not inert and also contain other components, such as the heavy metals, aluminum and vanadium. Originally titanium was thought to be a biocompatible material, however, new research is finding that exposure to titanium nanoparticles can cause DNA damage and cell death in a dose dependent manner [15].

Exposure to these various metals have been shown to cause serious health consequences [16]. Other environmental factors can cause considerable corrosion, such as low pH or high concentrations of fluoride. Using SEM imaging, Penarrieto-Juanito et al. studied ion releases from dental implants when exposed to fluoride and hydrogen peroxide. They found excessive oxidation in the implant-abutment joint surfaces and the discharge of titanium, aluminum and vanadium

after being submerged in 1.23% sodium fluoride gel, while minimal corrosion was detected in the hydrogen peroxide environment [17]. Another risk factor is the formation of biofilm on the surface of implants and prostheses, which may increase the risk of biological complications.

Monitoring oral biofilm is critical because it can determine the success or failure of implant treatments. The two most significant standards that should be met in dental implantology are, superior biocompatibility and superior resistance to microbial colonization [18]. Regrettably, while material studies are done prior to availability in the marketplace, long term effects are unavailable.

Since dental amalgam and titanium implants have now been used for a very long time, the current research which includes case studies, are now showing negative health consequences from that exposure. Internal and external exposure to metals can also cause allergic reactions, which is why biocompatibility testing is essential to achieve the best outcome for the patient [19].

## CONCLUSION

New dental materials are constantly being created, it is understood that the negative impact that may develop over time is not known, until the material can be studied years or even decades later. This is why it is prudent to follow the precautionary principal and not guess which is the “best” restorative materials to use on the patient. The importance of knowing what materials to use prior to treatment, and how to protect the patient when removing any dental material, especially any type of metal restoration due to the exposure of particulate matter, is extremely important. Using strict protocols in all of these procedures and or processes and most importantly to perform biocompatibility testing to ensure that the restoration is the least reactive specifically for the individual patient, is essential. Sadly, much of the current research does not look at long term exposure of dental materials, which due to the continuous wear and tear, breaks down and can translocate to various organs far from the oral cavity. Several of the studies mentioned above were investigated for only one day to several days, while this may be an indicator of the potential biocompatibility of a particular material, it doesn't tell the whole story. Regrettably, the dentist is not looking at the etiological harm from the toxicity of dental materials, therefore, it is not reported as a possible cause of disease manifestation. Since dental amalgam has not been banned globally, an ApoE genetic test should be done, prior to its use.

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