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PENETRATION OF SILVER IONS INTO HUMAN SKULLS FROM THE PERIOD OF THE SECOND WORLD WAR

Abstract

Introduction and purpose: For many years dental fillings have been made of an amalgam of silver and mercury. In the oral cavity of patients with amalgam fillings, discoloration of the oral mucosa may be observed as a result of the penetration of the released silver and mercury particles into tissues. The research shows that mercury is constantly released in small amounts from amalgam fillings and can penetrate also into the jaw bone. In the moist environment of the oral cavity amalgams are subject to corrosion and in the presence of other metals may also cause the formation of a galvanic cell.

The aim of this work was to determine silver concentration in the area of tissues discoloration (also known as amalgam tattoos), in the human skulls from the Second World War period.

Material and methods: The research was conducted on 86 skulls from the Second World War period. Discoloration was observed in 8 skulls with preserved amalgam-filled teeth. Bone samples were scraped and also taken with a trephine at a depth of 6 mm.

Results: We observed a similar penetration of silver into the bones of mandibles and maxillae, with no statistically significant differences.

Conclusions: Amalgams are not the sole source of mercury (Hg) and silver (Ag), however further studies and thorough analysis of their influence are required. The observed penetration of silver ions into bone suggests that the amount of metals in the oral cavity, both as amalgams and dentures, should be as low as possible.

Key words: Amalgam, biological corrosion, amalgam tattoo.

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PENETRACJA JONÓW SREBRA DO LUDZKICH CZASZEK POCHODZĄCYCH Z OKRESU II WOJNY ŚWIATOWEJ

Streszczenie

Wstęp i cel pracy: *Przez lata wypełnienia stomatologiczne były wykonywane z amalgamatu srebra i rtęci. W jamie ustnej pacjentów z wypełnieniami amalgamatowymi można zaobserwować przebarwienia śluzówki jamy ustnej, jako efekt penetracji uwalnianych do tkanek cząstek srebra i rtęci. Badania wykazują, że rtęć - w małych ilościach - jest stale uwalniana z wypełnień stomatologicznych. W wilgotnym środowisku jamy ustnej amalgamat ulega korozji biologicznej i w obecności innych metali może tworzyć ogniwo galwaniczne. Celem pracy było oznaczenie zawartości srebra w obszarze przebarwień tkanek, zwanych tatuażem amalgamatowym, w czaszkach ludzkich pochodzących z okresu II Wojny Światowej.*

Materiał i metody: *Badaniu poddano 86 czaszek pochodzących z okresu II Wojny Światowej. W ośmiu z nich zaobserwowano przebarwienia pochodzące od zachowanych wypełnień amalgama-towych. Próbki kości szczęki i żuchwy zostały pobrane przy użyciu trepana z głębokości 6 mm.*

Wyniki: *Zaobserwowano podobną penetrację srebra do kości szczęki i żuchwy - bez różnic istotnych statystycznie.*

Wnioski: *Amalgamaty nie są jedynym źródłem rtęci i srebra, jednakże potrzebne są dalsze badania nad ich wpływem na organizm. Obserwowana penetracja jonów srebra do kości sugeruje, że ilość metali w jamie ustnej, zarówno w amalgamatach, jak i protezach dentystycznych, powinna być jak najmniejsza.*

Słowa kluczowe: *Amalgamat, korozja biologiczna, tatuaż amalgamatowy.*

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1. Introduction

For many years dental fillings have been made of an amalgam of silver and mercury. The first amalgam was developed and applied in medical practice by G.V. Black in 1926. Subsequent research on amalgams led to new improved compositions of second and third generations. Conventional amalgams include about 60% silver, 29% tin, up to 6% copper and less than 2% zinc. Amalgamation with mercury results in the formation of $\gamma_1 Ag_3Hg_4$ and $\gamma_2 Sn_8Hg$, and also Ag_3Sn – γ phase. These amalgams are subject to corrosion under the influence of saliva. It is believed that the γ phase is responsible for amalgam corrosion. Amalgams can also form a galvanic cell in the presence of other metals in the oral cavity. Corrosion and electro-galvanic currents may contribute to the migration and penetration of metal ions into surrounding tissues. Some authors have shown that small amounts of mercury are constantly released from amalgam fillings. In addition, discoloration of the oral mucosa (known as amalgam tattoos) has been observed in the oral cavity of patients with dental amalgam fillings. These changes are a result of the penetration of the released particles of silver and mercury into the surrounding soft tissues and bones [1]-[5].

2. Materials and methods

The study was conducted on 86 skulls. The aim was to determine Ag levels in the area of amalgam tattoos in human skull bones from the period of the Second World War. Discoloration was observed in 8 skulls with preserved amalgam-filled teeth (Figs. 1, 2, 3). The research samples were collected from 2 human skulls from the period of the Second World War in which we observed amalgam tattoos in the maxilla and mandible. Bone samples were scraped from the area of the tattoo and from areas without a tattoo (control). We also took samples from a depth of 6 mm from the area of amalgam tattoo using a trephine. In order to protect the sample material, trephine samples were taken only from two sites in order to determine the penetration into the tissue. The collected material was tested for the content of silver (Ag) at the Department of Biochemistry of the Pomeranian Medical University.

Fig. 1. Sampling with a trephine
Source: Material form the Authors' collection

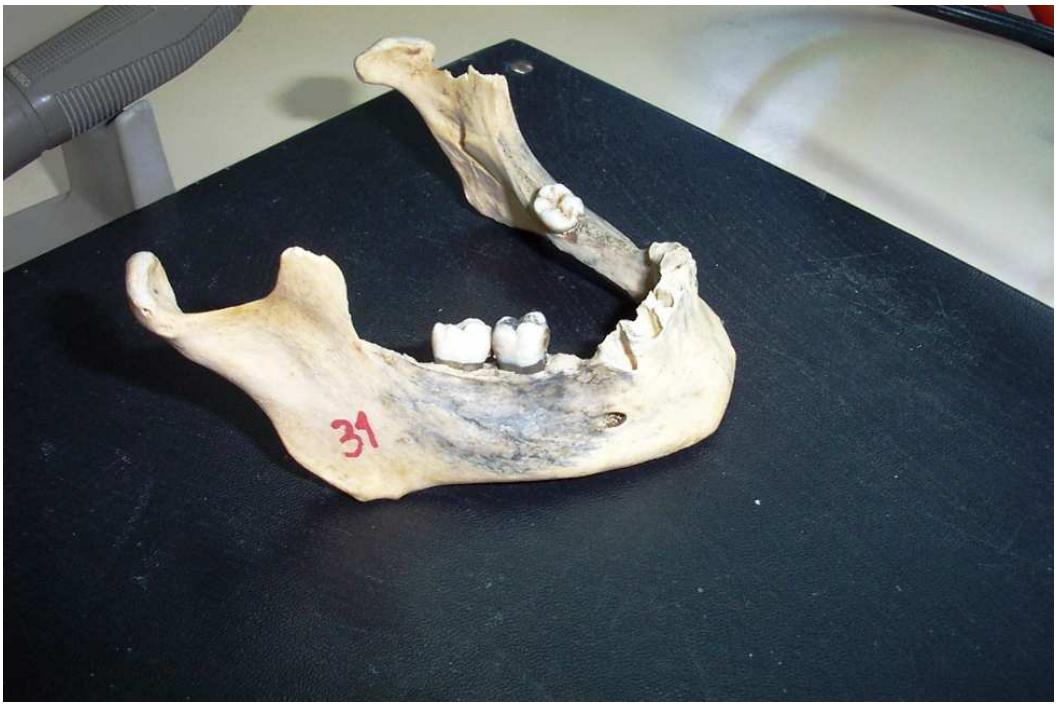

Fig. 2. Discoloration of the mandible in the region of tooth 46 filled with amalgam
Source: Material form the Authors' collection

Fig. 3. Extensive blue-gray discoloration of the mandible in the area of teeth filled with amalgam
Source: Material form the Authors' collection

3. Results

Table 1-3 summarizes the results of silver (Ag) determination in the tested material. We observed comparable Ag penetrations into the mandible and maxilla. The results were statistically analyzed using a Mann-Whitney U test. The level of significance $p \leq 0.05$. There were no statistically significant differences between Ag levels in the mandible and maxilla.

Tab. 1. Ag levels in selected samples

Samples A from sites with discoloration	Manner of sampling	Ag/mg/g
mandible	scraping A	0.012
mandible	scraping A	0.01
mandible	scraping A	0.05
maxilla	scraping A	0.032

Mean = 0.03; SD = 0.02

Source: Elaboration of the Authors

Tab. 2. Ag levels in selected samples

Samples B from sites without discoloration	Manner of sampling	Ag/mg/g
mandible	surface penetration B	0.018
mandible	surface penetration B	0.019
mandible	surface penetration B	0.058
mandible	surface penetration B	0.015
maxilla	surface penetration B	0.007
maxilla	surface penetration B	0.032
maxilla	surface penetration B	0.007

Mean = 0.02; SD = 0.02

Source: Elaboration of the Authors

Comparison of groups with and without discoloration, p=0.79

Tab. 3. Ag levels in samples collected with a trephine

Samples A from sites with discoloration	Method of collection trephine at a depth of 6 mm	Ag/mg/g
maxilla	treping C	0.011
mandible	treping C	0.011

Source: Elaboration of the Authors

4. Discussion

Silver occurs in nature, both in a free and bound form. Its content in the soil is 0.03-0.1 ppm, while in the tissues of marine and land organisms its concentration ranges from 0.005 to 0.6 ppm. The deposition of silver in the body occurs via the liver. Importantly, silver has both negative and positive effects, the latter based on its strong antibacterial and immunostimulatory properties. In dentistry, silver has been used for many years in amalgam for the direct filling of cavities.

Undoubtedly, any material containing metal ions in the oral cavity will release a number of ions as a result of complex electrochemical processes. Otulakowska [6], [7] reported high susceptibility to corrosion of silver-containing alloys.

The corrosion processes bring about a transfer of Ag ions to the surrounding tissue. Local argyrosis is mostly caused by the penetration of particles of silver from the amalgam to tissues, mainly the connective tissue. Importantly, the problem of Ag ion penetration into the tissue is also accompanied by the release of mercury [8].

Muller-Mina [9] measured the release of mercury from amalgam fillings during magnetic resonance imaging and found an increased release of mercury from amalgam without gamma phase, and observed the formation of artifacts in the MRI scans.

The discoloration is usually found on the gums and mucous membrane - regions easily available in clinical studies. However, so far there have been no reports on deeper penetration into the bone, but the results of our study on human skulls show that deep penetration does take place. Tissue reaction to implantation of amalgam can vary, but usually the reaction is defensive, with an observed increased presence of macrophages, lymphocytes, neutrophils and eosinophils.

The release of Hg and Ag is not the only problem as amalgams in the oral environment are subject to corrosion and thus can be the cause of electro galvanic currents [10]-13].

Conclusions

- According to the results of our analysis amalgams are likely to pose a threat to both human health and the entire environment. Amalgams are not the sole source of Hg and Ag, however further studies and thorough analysis of their influence are required.
- The observed penetration of silver ions into bone suggests that the amount of metals in the oral cavity, both as amalgams and dentures, should be as low as possible.

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