ПОГЛЯД НА ПРОБЛЕМУ

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SOME ASPECTS OF TITANIUM APPLICATION IN DENTAL TREATMENT

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Titanium is a light grey metal found in such minerals as ilmenite, rutile and titanite. Nanoparticles are becoming more widely used in medicine, dentistry, pharmacy and as food additives. The aim of this work was to highlight some aspects in applying titanium and its alloys in dental restorations. Both medical and dental implant surgeons despite of huge efforts in using biocompatible materials face some challenging issues on complications which might appear even when using as inert metals as titanium. These problems may develop due to the penetration of aluminium and vanadium ions, found in negligible quantities in the implant alloys, into the body tissues. Failures in placing titanium implant can be caused by galvanic or electrochemical corrosion in the oral cavity due to release of titanium ions into the neighbouring tissues. Other possible failures in implant placement may develop due to bacterial contamination, and the development of implant inflammatory reaction supported by presence of macrophages may lead to implant rejection and loss. Released titanium ions inhibit the growth of hydroxyapatites. During corroding process metal ions or corrosion products penetrate body tissues and enter the body cells. Their local activity is known as 'metallosis'. From the biological point of view this results in tissue damage. Another possible adverse effect that might be caused by metal implants and their corrosion is allergic reactions. Side effects are rare as physical and chemical properties of titanium, first and foremost, its biocompatibility, define it as s recommended material to use in oral surgery, endodontics, prosthetics and orthodontics.

Key words: titanium, alloy, implant placement, adverse reaction.

The aim of this work was to highlight some aspects in applying titanium and its alloys in dental restorations based of available literature recourses.

Titanium is a widespread element makes up 0,61% of the Earth crust. It is a light, grey metal found in such minerals as ilmenite, rutile and titanite [1].

Titanium whites have been widely used for years in the building construction, dyeing and car industries. Fragmentation of metal particles to the nanoparticle scale has made it possible to broaden the spectrum of its application. Nanoparticles are used in medicine, dentistry, pharmacy and as food additives [2]. Due to extensive application of titanium, its permanent presence in the environment (water, soil) is increasing. There have been numerous studies done over the past few years on the influence of titanium white nanoparticles on plants. The results of the studies vary. Titanium is a biostimulator that affects the growth and yielding of vegetables, orchard and ornamental plants [3]. According to Michałowski, titanium provides a positive effect on the increase of iron ions activity, intake of nutrients, as well as plant health [4]. Other aspects of wide use of titanium include its polluting effect on the environment and its toxicity for living organisms [5]. The mean dose of titanium intake is 0,8 mg. The tests show that most of the dose is not absorbed but has the potential of accumulating in plant tissues (from 1 ppm to 80 ppm). Titanium dioxide nanoparticles may reach lungs, liver, spleen and brain via respiratory or digestive tract. They cause imbalance of biochemical parameters and changes in gene expression and consequently the damage of internal organs [6].

The acceptable level of titanium dioxide nanoparticles concentration is 0,3 mg/m3.

Titanium takes the form of two allotropes: low-temperature alpha and high-temperature beta. In the ambient temperature, there is alpha phase with dopants like oxygen, hydrogen, iron, nitrogen, and all they can influence properties of titanium alloy to various degrees (e.g. oxygen increases titanium hardness, while hydrogen increases its brittleness) [7].

The use of titanium in medicine is possible due to its biocompatibility with living tissues and resistance to corrosion [8,9,10]. Moreover, titanium is resistant to diluted acids i.e. hydrochloric and sulphuric acids, organic acids, sulphides, chlorides, hydrogen sulphide, hydrogen peroxide when it is dissolves in concentrated acids.

There is a marked affinity between titanium and oxygen, and titanium creates a tight and durable layer of oxides, mainly titanium dioxide on the metal surface. The layer of titanium dioxide is not dissolved in the oral cavity and titanium ions, which might react with the living body tissues, are not released. Biological inertness of the oxides layer has a positive influence on the healing process and bone tissue re-modelling [11].

An important parameter of titanium is its low Young's elasticity modulus similar to the cortical bone elasticity modulus, which when properly chosen can prevent bone resorption, overstraining and implant destruction.

Titanium alloys have higher material fatigue resistance than pure titanium [12,13,14,15]. In practice, the most common alloys are titanium and vanadium or titanium and aluminium (Ti6Al4V) [13].

Resistance to corrosion that decreases along with decreasing material homogeneity, is the obvious advantage of titanium alloys. It has been proven that titanium alloys of decreased homogeneity can release increased number of titanium ions to the environment [13]. Implants can be made from pure titanium and their surfaces modified in the process of sandblasting or other preparation techniques, e .g. machine processing. The use of pure titanium or its alloy processed by sandblasting does not significantly influence the surface structure or chemical composition. The rough implant surface obtained by preparation has good contact with bone tissues [11,12,16].

Titanium was mostly found on the surfaces of implants prepared by machine working; no oxygen was detected. In the samples prepared by sandblasting method, the contents of titanium and oxygen were similar and aluminium and sodium were also present. The presence of these elements in the pure titanium samples could be the consequence of using abrasive. Thus, the implant surface composition depends both on the chemical composition of the material used for machine working and on the preparation method. Metalworking of titanium and its alloys, hence dental restorations made from them, present a serious challenge [12,17].

Based on the results of tests, Tani has proved that titanium an alloy sandblasting requires more time than sandblasting other alloys, e.g. Au-Ag-Pb and Ni-Cr. Some patients with titanium restorations complained of oversensitivity (Muller, 2006) and slight metallic flavour [18].

Dental plaque build-up on titanium crowns is similar to the plaque formed on the crowns made up of other metal alloys [19]. Probste et.al (1991) showed that titanium restorations: 'have the tendency to develop plaque on the surface' [20].

The process of osteointegration that according to Branemark: 'is a direct structural and functional connection of live bone with the surface of a loaded implant', is vital in the dental treatment [21]. The procedure of implant placement is influenced by the bone condition, the technique applied, biocompatibility of the material, physical and chemical properties of the implant surface.

Studies have shown that activity of body cells, which are in direct contact with an implant is susceptible to implant properties such as chemical composition of the surface, roughness, thickness of the oxides layer. Medium-rough implants intensify the osteointegration process [11, 16, 22, 23,].

Due to its physical and chemical properties and excellent biocompatibility titanium and its alloys are used in oral surgery, endodontics, prosthetics and orthodontics [24].

Titanium casting is a real problem as dental restoration casts exhibit empty spaces which, if big, produce some quality problems. Empty spaces can be detected by X-ray, and can not during clinical evaluation [13]. Despite of many advantages of dental implant placement, there are some contraindications for this type of restoration, they include:

– cardiovascular diseases e.g. valvular heart diseases
– kidney diseases
–osteoporosis
– diabetes
– radiotherapy
– drug addiction, smoking, alcoholism

Among relative contraindications there is pregnancy, systemic diseases, immune suppressed conditions, mental disorders, some anatomical conditions, for example, atrophy of bone surface. Age is not as a contraindication for implant placement although age-related diseases may be regarded a limitation [8, 24].

Both medical and dental implant surgeons despite of huge efforts in using biocompatible materials face some challenging issues on complications which might appear even when using as inert metals as titanium.

These problems may develop due to the penetration of aluminium and vanadium ions, found in negligible quantities in the implant alloys, into the body tissues.

Morphology of oral cavity mucous membranes, especially lamina propria is designed to provide protection. Ions released from implants are absorbed by the mucous membrane and their spreading within the body is limited [25,26]. Failures in placing titanium implant can be caused by galvanic or electrochemical corrosion in the oral cavity due to release of titanium ions into the neighbouring tissues. Such corroding activity of titanium-containing materials differs depending on the environmental pH and chemical composition [27].

Other possible failures in implant placement may develop due to bacterial contamination, and the development of implant inflammatory reaction supported by presence of macrophages may lead to implant rejection and loss. Released titanium ions inhibit the growth of hydroxyapatites [10, 16, 22]. Therefore, it seems quite appropriate to apply pure, class IV titanium, which has physical parameters similar to titanium alloys and is characterised

by good strength and corrosion resistance. Elements made of titanium alloys are covered by a thin layer of titanium oxide forming so- called passive layer in the oxidizing atmosphere.

During corroding process metal ions or corrosion products penetrate body tissues and enter the body cells. Their local activity is known as 'metallosis' by Nicole [30,31,32]. From the biological point of view this results in tissue damage [33].

Another possible adverse effect that might be caused by metal implants and their corrosion is allergic reactions. Most often they are reactions to trace quantities of chromium, nickel, cobalt [34].

Another unfavourable reaction caused by the presence of metal implants and their corrosion are allergic reactions. There are available studies that suggest unfavourable reactions after pure titanium implant surgeries with complications involving fistulas, matallosis or allergic reactions [35,36,37].

Some of these reactions may be delayed and appear as bone or bone marrow inflammations and are described during orthopaedic treatment [38]. Patients after dental procedures may experience skin allergic reactions that disappear once the implants are removed [39].

Valentine-Thon et al. suggest that allergic reactions are reactions to trace quantities of nickel, cobalt and palladium, although the implants are reported as the pure titanium ones [40].

There is no scientifically confirmed evidence that titanium causes allergic reactions [35].

There are also no titanium specific skin tests that should be administered to supersensitive patients whose implants might be rejected [41].

Side effects are rare as physical and chemical properties of titanium, first and foremost, its biocompatibility, define it as s recommended material to use in oral surgery, endodontics, prosthetics and orthodontics.

The research conducted by Makuch has proven that the content of titanium in oral mucosa membrane covering endogenous dental implants varied and most probably depended on the type of implant placement method used. Titanium content is estimated at 0.00 μg/g to 122.5 μg/g [42] while the implant location, age and sex of the patient has no impact on the titanium content in the mucous membrane tissues. .

Conclusion

Despite objections of some scientists, titanium has been proven as a material worth recommending and using in medical implant surgery.

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Реферат

ПРИМЕНЕНИЕ ТИТАНА В СТОМАТОЛОГИЧЕСКОЙ ПРАКТИКЕ

Бачанек Тереза, Зименковский Анджей, Сибинский Володимир, Питура Каролина, Хендзел Барбара, Волянска Ева, Самборский Дарюш, Боровиц Януш, Тимчин-Боровиц Барбара

Ключевые слова: титан, сплав, размещение имплантатов, побочные реакции.

Титан представляет собой легкий металл серого цвета, который встречается в таких минералах, как ильменит, рутил и титанит. Наночастицы его используются в медицине, стоматологии, фармацевтике и в качестве пищевых добавок. Целью данной работы является ознакомление с некоторыми избранными аспектами применения титана в стоматологической практике на основе имеющейся литературы. Несмотря на огромное стремление использовать биологически совместимые материалы, и в медицинской, и в зубной имплантационной хирургии возникают нежелательные проблемы даже при использовании металлов, считающихся инертными, например, титана. Эти проблемы являются следствием проникновения в ткани организма ионов алюминия и ванадия, которые в незначительных количествах входят в состав имплантата. Неудачи при лечении с использованием титана могут происходить из-за гальванической или электрохимической коррозии в полости рта, т. е., высвобождения ионов титана в прилегающие ткани, что связано с их реакцией с биологическими жидкостями организма. Другие неудачи в имплантационной хирургии могут вызываться бактериями, причем присутствие макрофагов при воспалительной реакции на имплантат может вызвать отторжение имплантата. Высвобожденные ионы титана затормаживают увеличение гидроксилапатитов. В процессе коррозии ионы металла или продукты коррозии проникают в ткани организма, т. е., в межклеточные каналы или же проникают в клетки организма. Их местное воздействие было названо «металлозом». С биологической точки зрения это представляет собой результат повреждения ткани. Другая неблагоприятная реакция вызывается присутствием металлических имплантатов и их коррозией, что вызывает аллергические реакции. Побочные эффекты случаются редко благодаря физическим и химическим свойствам титана, что делает его биологически совместимым и рекомендуемым материалом для применения в хирургической стоматологии, эндодонтии, протезировании и ортодонтии.

Реферат

ЗАСТОСУВАННЯ ТИТАНУ В СТОМАТОЛОГІЧНІЙ ПРАКТИЦІ

Бачанек Тереза, Зіменковський Анджей, Сибинський Володимир, Пітура Кароліна, Хендзел Барбара, Волянська Ева, Самборський Дарюш, Боровиць Януш, Тимчин-Боровиць Барбара

Ключові слова: титан, сплав, розміщення імплантатів, побічна реакція.

Титан - це легкий метал сірого кольору, який зустрічається в таких мінералах, як ільменіт, рутил і титаніт. Наночастки його використовуються в медицині, стоматології, фармацевтиці та в якості харчових добавок. Метою даної роботи є ознайомлення з деякими обраними аспектами застосування титану в стоматологічній практиці на основі наявної літератури. Незважаючи на величезне прагнення використовувати біологічно сумісні матеріали, і в медичній, і в зубній імплантаційній хірургії виникають небажані проблеми навіть при використанні металів, що вважаються інертними, наприклад, титану. Ці проблеми є наслідком проникнення в тканини організму іонів алюмінію і ванадію, які в незначних кількостях входять до складу імплантату. Невдачі при лікуванні з використанням титану можуть відбуватися через гальванічну або електрохімічну корозію в порожнині рота, тобто, вивільнення іонів титану в прилеглі тканини, що пов'язано з їх реакцією з біологічними рідинами організму. Інші невдачі в імплантаційній хірургії можуть викликатися бактеріями, причому присутність макрофагів при запальній реакції на імплантат може викликати відторгнення імплантату. Вивільнені іони титану загальмовують збільшення гідроксилапатиту. У процесі корозії іони металу або продукти корозії проникають в тканини організму, тобто, в міжклітинні канали або ж проникають в клітини організму. Їх місцевий вплив було названо «металозом». З біологічної точки зору це є результат ушкодження тканини. Інша несприятлива реакція викликається присутністю металевих імплантатів та їх корозією, що викликає алергічні реакції. Побічні ефекти трапляються рідко завдяки фізичним і хімічним властивостям титану, що робить його біологічно сумісним і рекомендованим матеріалом для застосування в хірургічній стоматології, ендодонтії, протезуванні та ортодонтії.