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Comparison Study for the Quantity of Titanium Exist in Different Type of Dental Implant Alloy

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الخلاصة

الأهداف: تهدف الدراسة الى مقارنة كمية عنصر التيتانيوم (Ti) الموجودة في سبيكة زرعات الأسنان ذات المناشئ المختلفة والمستخدمة من قبل أطباء الأسنان في الزراعة لتعويض الأسنان المفقودة . **المواد وطرائق العمل:** ثلاثة أنواع من الزرعات السنية ذات مناشئ مختلفة (الماني ، ايطالي ، كوري) فحصت لبيان نوع المعادن (Chemical Structure) الموجودة في سبيكة الزرعة السنية باستخدام جهاز انحراف الأشعة السينية (XRD: Model S1Turbo^{SD} LE^{CE}, BRUKER) . الصلادة ، مقاومة الشد ومعامل المرونة تم حسابها باستخدام جهاز قياس الصلادة (Micro Hardness, AMSLER, Germany, 1978). أما جهاز فحص البنية المجهرية للمعادن (Microscope Metallurgy- Japan -1978) وبقوة تكبيرية (٦٠٠)مرة أوضح عن تكون أطوار ألفا (α) وبيتا (β) في سبيكة الزرعة السنية والتي تعطي المتانة للسبيكة. **النتائج:** اظهرت النتائج أن نسبة عنصر التيتانيوم (Ti) في النموذج الالماني كانت (95.14%) والأيطالي (91.21%) بينما في الكوري كانت أعلى نسبة وهي (95.21%). مقاومة الشد في النموذج الألماني (755) N/(mm)^2، الأيطالي (781) N/(mm)^2 اما الكوري (785) N/(mm)^2 . الصلادة وفق نظام (Vickers) للنموذج الألماني (277)، الايطالي (285)أما الكوري (287) . معامل المرونة في النموذج الألماني (107) Gpa. ، الأيطالي (115) Gpa.، والكوري (107) Gpa. التصنيف (حسب الجمعية الأمريكية لأختبار المواد والمعادن) وجد للنموذج الالماني (Ti 3-2.5) والأيطالي (Ti6-2-1-1) أما النموذج الكوري كان (Ti 3-2.5).
الاستنتاجات: نستنتج من الدراسة ان النموذج الكوري أفضل لثلاثة أسباب هي :كمية التيتانيوم ، الصلادة ، مقاومة الشد ومعامل المرونة للنموذج الأيطالي أفضل. بينما وجد أن البنية المجهرية للنموذج الألماني افضل. بصورة عامة وبما أن النماذج الثلاثة يمتلكون نسبة تزيد على (90%) من التيتانيوم لذلك فأن النماذج الثلاث من الزرعات السنية تمتلك مقاومة جيدة تجاه التآكل (Corrosion) من حيث تعرضها للحوامض (Acid) والهيدروفلوريك (HF) .

ABSTRACT

Aims: The current study aims to compare alloys of dental implants and to find the ratio of titanium element (Ti) with different origins which are used by dentists in dental implant to restore the missing teeth. **Materials and Methods:** Three types of dental implants from Germany, Italy and Korea used in this study for statement the chemical structure of these alloys using (XRD: X-Ray Diffraction) (Model S1Turbo^{SD} LE^{CE}, BRUKER). Hardness, tensile strength, and flexibility coefficient tested by hardness measuring device Micro Hardness – AMSLER, Germany, 1978. The microstructure of samples obtained by Metrology Microscope (600X), ME-3125, UNION, 1978, Japan. **Results:** Different elements appeared in each alloy, and the titanium (Ti) ratio was the main one, where the Germany type (95.14%), Italy, (91.21%), while Korea type was the highest (95.21%). Tension Resistance in Germany model (755) N/(mm)^2, Italian (781) N/(mm)^2, and Germany (785) N/(mm)^2. Hardness Vickers (HV) in Germany (277), Italy (285) and for Korean type (287). Modulus of elasticity, in Germany (107) Gpa, in Italy (115) Gpa. and in Korean (107) Gpa. The classification according to the American Society for Testing and Materials found in Germany Ti 3-2.5, Italy Ti6-2-1-1, and in Korean Ti 3-2.5**. Conclusions:** The Korean sample is best for three reasons the quantity of Titanium, Hardness Vickers (VH) and Tension Resistance are more. The Italy type is found better for Modulus Elasticity, while the Germany type is better in Microstructure. In general, and since, the three types have more than (90%) of Titanium there for all the types of dental implant are good against corrosion from acid and Hydrofluoric (HF).

Key words: Dental Implant, Titanium, Alloy.

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INTRODUCTION

Dental implants operations began growing strides in Iraq compared to the countries in the world that are working on since time, and these operations have required more useful information to beneficiaries over the extensive experience used in the world for the quality of materials used by dentists in osseointegrated. Osseointegration is a phenomenon where a bone biologically bonds to a titanium element (example, dental implant). This phenomenon was discovered in 1952 by a Swedish professor of orthopedics named Branemark who found that titanium (a very strong and non-corrosive metal) attaches itself to bone when it is implanted in it. [1,2] The current research study focused on three types of dental implants predominant used by dentists which are the Korean, Italian and German, to find the amount of titanium in each alloy and its importance in osseointegrated in addition to the role of other elements and physical properties owned.

Overview of titanium

The use of titanium and titanium alloys for medical and dental applications has been increased dramatically in recent years. Historically, titanium has been used extensively in aerospace, aeronautical and marine applications because of its high strength and rigidity, it's low density and corresponding low weight, its ability to withstand high temperatures and its resistance to corrosion. [3] Titanium has long been successfully used as an implant material, and widely used in odontology because of it's excellent characteristics such as chemical inertia, mechanical resistance, low density, absence of toxicity, resistance for corrosion and biocompatibility.[4] Titanium and its alloys are commonly used for implant devices replacing failed hard tissue, for example, artificial hip joints, artificial knee joint, bone plate, dental implants, dental products, such as crowns, bridges and dentures, and used to fix soft tissue, such as blood vessels. In the elemental form, titanium has a high melting point (1668 ^{0}C) and possesses a hexagonal closely packed structure (hcp) – α up to a temperature of (882.5 ^{0}C). Titanium transforms into a body centered cubic structure (bcc) β above this temperature. One titanium alloy (Ti6Al4V) is widely used to manufacture implants. The main alloying elements of the alloy are Aluminum (5.5-6.5%) and Vanadium (3.5-4.5%). The addition of alloying elements to titanium enables it to have a wide range of properties: Aluminum tends to stabilize the α - phase; it increases the transformation temperature from α - to β -phase. Vanadium stabilizes the β -phase by lowering the temperature of transformation from α to β. [5, 6] Many of titanium's physical and mechanical properties make it desirable as a material for implants and prostheses. The strength and rigidity of titanium are comparable to those of other noble or high noble alloys commonly used in dentistry and titanium's ductility, when chemically pure, is similar to that of many dental alloys. Titanium also can be alloyed with other metals, such as aluminum, vanadium or iron, to modify its mechanical properties. ASTM International (the American Society for Testing and Materials) recognizes four grades of commercially pure titanium, or Ti, and three titanium alloys (Ti-6Al-4V, Ti-6Al-4V Extra Low Interstitial and Ti-AlNb), or these metals are specified according to ASTM as grades 1 to 5. Grades 1 to 4 are unalloyed, while grade 5, with 6% aluminum and 4% vanadium,[3, 7] (Table 1).

Table (1): Summary of the most important Ti materials

Material name	Composition	Typical application
CP Ti grade 1	Ti; 0 < 0.18%, N < 0.03%	Medical and dental
CP Ti grade 2	Ti; 0 < 0.25%, N < 0.03%	Medical and dental, Chemical industry
CP Ti grade 3	Ti; 0 < 0.35%, N < 0.05%	Medical and dental
CP Ti grade 4	Ti; 0 < 0.40%, N < 0.05%	Medical and dental
Ti6Al4V grade 5	Ti; Al 6%; V 4%; 0 < 0.20%, N < 0.05%	Aerospace, motor sport, sports goods, Medical and dental
Ti6Al4V ELI	Ti; Al 6%; V 4%; 0 < 0.15%, N < 0.05%	Medical and dental

The term corrosion is defined as the process of interaction between a solid material and its chemical environment, which leads to a loss of substance from the material, a change in its structural characteristics, or loss of structural intergrity. The most common form of corrosion, which is generally present in dental implant, is galvanic corrosion. Titanium has been chosen as the material of choice for end-osseous implantation. Long term studies and clinical observation establish the fact that titanium does not corrode when used in living tissue however galvanic coupling of titanium to other metallic restorative materials may generate corrosion. [9] Commercially pure titanium (CP-Ti) and titanium alloys are frequently used as dental and orthopedic implant materials because of their excellent mechanical strength, chemical stability and biocompatibility. The biocompatibility of titanium is closely related to the surface properties such as surface roughness, surface topography and surface chemistry. The most widely used commercial techniques for the surface treatment are sandblasting and acid etching (SLA), and plasma spray coating of hydroxyapatite. Electron beam evaporation of calcium phosphate is another recent development.[10] Recent studies on implant surfaces have demonstrated the benefit of increasing the hydrophilicity of a titanium implant.[11] Pure Ti has a high initial surface free energy and is hydrophilic due to passivation; formation of a titanium oxide (TiO2) layer. However, the TiO2 layer readily absorbs contaminants and becomes hydrophobic.[12] Wettability and surface charge both play an important role in protein adsorption to titanium (Ti) Dioxide. Thus, changes in the physico-chemical properties of Ti dioxide will modulate protein adsorption and further cell attachment.[13]

MATERIALS AND METHODS

The measurements of research study doing at Technical Education Foundation, Mosul Technical Institution, Department of Mechanical Techniques, Mechanical Test Laboratory 2012, by using:

1. Three types of different dental implants have been study in this research describing in Table (2).

Table (2): Technical details of Dental Implant used in research

No.	Origin	Company	Code Manufacture	Size (mm×mm)
1	**Germany**	FRIADEN	FRIALIT-2,45-03439	(D) 3.8 × 13.0 (L)
2	**Italy**	LEADER	E0210420, 01I33710 TTS	(D) 3.75 × 10.0 (L)
3	**Korea**	Dentium H.J	Fx4512sw, F27DOO211	(D) 4.3 × 12.0 (L)

2. Cutting Machine – METASERV, 1978, Germany, used for samples of dental implant, processes by machined specimens as cutting, grinding and polishing (Figure 1), prepared for matching with XRD and optical microscope

Figure (1): Three types of Dental Implant after cutting, grinding and polishing process

3- X-Ray Diffraction (XRD) Device Model S1 TURBO^{SD} LE^{CE}, S.\N. 1648, July 22 2011. (BRUKER). (Figure 2), to display the chemical composition (elements) that exist in dental implant alloys.

Figure (2): X-Ray Diffraction Device Model S1 TURBO^{SD}, (BRUKER).

4. Microscope Metrology (Optical Microscope), ME-3125, UNION, 1978, Japan, this device used to show the phases combinations (α, β) of alloys.
5. Micro Hardness, AMSLER, 1978, Germany, to measure the hardness (HV)*, tension resistance N/ (mm)^{2}, and Modulus of elasticity (Gpa).

RESULTS

Results of X-ray diffraction on the samples test by giving the complete analysis of all material (chemical composition) that exist in dental implant alloys appear same elements (Ti, Al, V, Fe, and C) in both Germany and Korea but in different magnitude ratio, while the Italy sample contains the above material as well as to the (Mo, Ni), Table (3) and (Figure 3).

Table (3): Chemical structure for the three types of dental implant.

Types	Ti %	Al %	V %	Fe %	C %	Mo %	Ni %
Germany	95.14	2.75	1.9	0.13	0.08	0	0
Italy	91.21	5.7	1.79	0.2	0.07	0.23	0.8
Korea	95.21	2.54	1.81	0.34	0.1	0	0

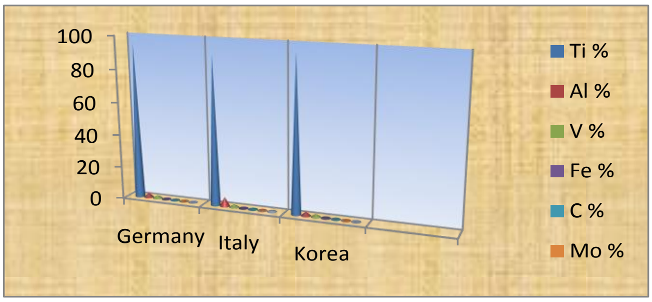
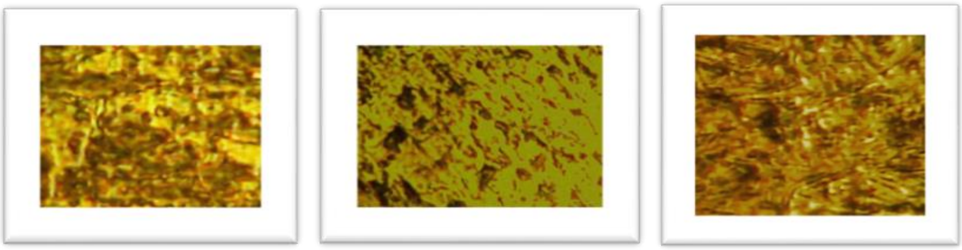


Figure (3): The chemical structure and it's ratio in dental implant.

The results of optical microscope, AMSLER, 1978, Germany, present the magnification (600 X) of the sample test of dental implant which appear the phases combinations (α, β) of these alloys, where the light spot denote to the alpha (α) phase, while the dark one is for beta (β) phase, Figure (4, a-b-c).



(a) (b) (c)

Figurer (4): The Phase's combination of (α, β) alloys of dental implant for:(a): German type. (b): Italy Type. (c): Korea type.

Hardness according to Vickers system (HV), Tension resistance N / $(mm)^2$ and Elasticity factor Gpa, and these results have been obtained by Micro Hardness, AMSLER, 1978, Germany, Table(4).

Table (4): Hardness (HV), Tension resistance N/ $(mm)^2$, and Elasticity factor Gpa.

Types	**Tension Resistance N/ $(mm)^2$**	**Hardness Vickers (HV)**	**Modulus of elasticity (Gpa)**
Germany	755	277	107
Italy	781	285	115
Korea	785	287	107

*(HV): Hardness Vickers system.

The classification ASTM (American Society for Testing and Materials) is known for the German type (Ti3-2.5), Italy (Ti6-2-1-1), and Korea (Ti3-2.5).

DISCUSSION

X-ray diffraction (XRD), optical microscopy and micro hardness, have been used to identify the comparative study of dental implants alloys, the analysis refer that the three types of dental implant share the same minerals (Ti, Al, V, Fe, C) and the main material of the chemical composition of these alloys was Titanium (Ti) with percentage more than (90%) for each type, the corrosion of all types are same because all references confirm that Titanium has a good resistance to corrosion. Figure (4, a-b-c) appears the microstructure of Germany, Italy and the Korean types respectively, and these images have two different contrasts; the light spots refer to alpha (α) while the dark spots are beta (β). Titanium shows an allotropic transformation from the low temperature α (hcp) phase to the high temperature β (bcc) phase at 882^{o}C. The temperature at which β to α transformation occurs is called the β transus and depends on the amount and type of alloying element added.[15]

Different magnitude in the hardness of the three types of dental implant found that for Germany (277), Italy (285) and for Korea (287), because the carbon (C) element is more in Korea, while the (Mo), and (Ni) only exist in Italy type, where the initial hardness of titanium and titanium alloys varies usually between 200 and 400 HV depending on the chemical composition of the material. [14] Modulus of elasticity was found in Italy type (115) Gpa. Which are more than Germany and Korea types and that reason was for (Ni) element, where a Nickel Titanium alloy has been found to have unique properties of shape memory and super-elasticity.[16]

The Tension Resistance in Korea type (785) N/ (mm) ^{2} which is more than other types and that's belong to the quantity of Titanium, and the tension resistance is less in Germany than Italy because the other materials like (Mo) and (Ni) to this alloy.

CONCLUSION

The Korean sample is best for three reasons the quantity of Titanium, Hardness Vickers (VH) and Tension Resistance are more. The Italy type is found better for Modulus Elasticity, while the Germany type is better in Microstructure. In general, and since the three types have more than (90%) of Titanium there for all the types of dental implant are good against corrosion from acid and Hydrofluoric (HF).

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