**Republic of Iraq**
**Ministry of Higher Education**
**and Scientific Research**
**University of Baghdad**
**College of Dentistry**

# Laser Surface Structuring and Coating of Titanium Implant with High Performance Poly Ether Ketone Ketone Polymer (*In vitro - In vivo*) Study

A thesis submitted to the council of the College of Dentistry at the University of Baghdad, in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Prosthodontics

By
**Aseel Mohammed Sadeq Al-Khafaji**
B.D.S., M.Sc. Prosthodontics

Supervised by

**Prof. Dr. Thekra Ismael Hamad**

B.D.S., M.Sc., Ph.D. Prosthodontics

Baghdad-Iraq

**2020 A.D.** **1441 A.H.**

# Abstract

**Background:** replacement of the missing dentition by dental implants can be regarded as a unique and successful treatment alternative. The implant surface structuring and implant coatings can enhance the implant characterization and bioactivity which improve the osseointegration and offer immediate implant with decreasing healing time by increase bone formation in bone implant interface.

**The aim of the study**: evaluation of the commercially pure titanium implant (CP Ti) with and without laser surface structuring and laser coating with poly ether ketone ketone (PEKK) by measuring the new bone formation area and the removal torque value after (2, 6 and 12 )weeks of implantation. No study was done that used PEKK coated material on the CP Ti by using $CO_2$ laser techniques with or without dot design surface structuring of the CP Ti by Computer numerical control (CNC) fiber laser.

**Material and methods:** in the pilot study dot and groove design in three laser scans (5, 15, 25) were tested for laser surface structuring of the CP Ti by using CNC fiber laser machine; the results of optical microscope, scanning electron microscope (SEM), surface roughness, phase analysis by X-Ray diffraction (XRD) and wettability test shown that the 25 laser dot design was the most preferable design for surface structuring.

*In vitro* study, two watt power of $CO_2$ laser with frictional mode at 6 milliseconds pulse duration was used to produce uniform coating of PEKK polymer on the CP Ti disks and screws. Evaluation and characterization of the coated and structure surface were done by using field emission scanning electron microscope (FESEM), energy dispersive X ray analysis (EDX), FESEM\EDX mapping, roughness test, XRD, water contact angle test and microhardness test.

*In vivo* study, two hundred and forty CP Ti implants with screw shaped were implanted in the femur of sixty New Zealand rabbits (Four implants for each

rabbit). The experimental rabbits were divided into three main groups for each healing interval (two, six and twelve weeks) each main groups consist of twenty animals, ten of them were sacrificed for histopathological study, while the other ten were sacrificed for mechanical test (removal torque test). The uncoated screws with and without laser surface structuring were implanted in the right femur, while the PEKK coated screws with and without laser surface structuring were implanted in the left femur.

**Results:** The *in vitro* results gained from the disks characterization showed that the wettability, roughness and microhardness tests for the group with laser surface structuring and PEKK coating (LS-P) was greater and highly significant than the other groups and the group without any laser structuring and coating (C) was the lowest group, while the groups of laser surface structuring (LS) and PEKK coated (P) were in between them (LS-P and C).

The results of *in vivo* study showed that for the three healing time (two, six and twelve) weeks the removal torque value and the new bone formation area tests were greater for the group with laser surface structuring and PEKK coating then the laser surface structuring group, PEKK coated group and lastly the group without any laser structuring and coating. Also the removal torque value and the new bone formation area were increase with increase healing time in all study groups with more values were for twelve weeks healing period then followed by six weeks and lastly the two weeks which had the lowest values.

**Conclusion:** CNC fiber optic laser can be used successfully for commercially pure titanium implant surface structuring that produced a uniform dot structure design at twenty-five laser scan. Also, the frictional mode $CO_2$ laser can be used effectively for PEKK coated on the commercially pure titanium substrate with or without laser structuring surface. Additionally, the laser structuring and PEKK laser coating of the commercially pure titanium group display more value of removal torque and higher new bone formation in all healing period than the other studies groups.

**جمهورية العراق**
**وزارة التعليم العالي والبحث العلمي**
**جامعة بغداد**
**كلية طب الاسنان**

# تشكيل السطح بالليزر وطلاء غرس التيتانيوم بواسطة البوليمر ايثر كيتون كيتون العالي الاداء دراسة (خارج وداخل الجسم الحي)

اطروحة مقدمة الى مجلس كلية طب الاسنان في جامعة بغداد
كجزء من متطلبات درجة دكتوراه فلسفة في صناعة الاسنان

من قبل
**اسيل محمد صادق الخفاجي**
بكلوريوس في طب وجراحه الفم والاسنان
ماجستير صناعة الاسنان

باشراف
**ا.د. ذكرى اسماعيل حمد**
دكتوراه في صناعة الاسنان
**بغداد-العراق**

**ميلادي 2020** **هجري 1441**