MICRO-EXAMINATION OF DENTAL SAMPLES TO ENABLE THE QUALITY CHARACTERISTICS REQUIRED BY THE CLINICAL EXPERIENCE USING BIOMEDICAL METROLOGY

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Abstract

In the study of dental implants, quality characteristics required by the clinical experience is the basis for the improvement and optimization of future work in biomedical engineering. Replacement of human tissues and organs with artificial human parts is a vital discipline in the biomedical engineering that needs the application of modern computerized measurement techniques and utilization of measuring devices with new technologies. It is presupposed that artificial dental parts must be constructed according to defined geometry and kinematic regularities otherwise it would it would not be possible that these parts will stay in correct function during the whole lifetime.

In this study, the advanced measurement and evaluation of the dental structures have been described and the measurements have been compared using a contact-stylus profilometer, a digital microscope, a 3D laser scanning system and a scanning type confocal laser microscope. The quantitative results of the measurements were used to characterize the roughness levels of the surfaces that describe the effect activity of the samples. The model representation of tooth surfaces can give the basis for quality assurance of tooth preparations and restorations and also the production of artificial teeth.

Keywords: dental sample, quality, metrology, biomedical, surface measurement

1. INTRODUCTION

There exists rapid development in biomedical engineering and this demands the application of novel measurement techniques and utilization of measuring devices with new technologies. The dental applications affect the life quality of patients assured by the factors of longer lifetime and stable integration of the implant.

In this study, the surface roughness is a critical parameter to be measured and evaluated in cooperation with the clinical experience. In the study of medical implants, not only the macroscopic structural shape and material but also the microscopic structure such as the contribution of surface roughness and precision are absolute necessary determinants for a long-term successful enhanced biocompatibility providing quality criteria.

The quality characteristics and the application reliability are the main requirements of today's biomedical engineering. The basis for the improvement and optimization of the biomedical engineering must be also considered from the point of view of international standards dealing with quality management and quality assurance [1, 2].

The dental implants are characterized for every individual tooth. The process flow of the implantation and manufacturing of the implants consist of handmade modeling as presented in the Fig. 1. The implants are sandblasted using Aluminum oxide pearl powder by a range of pressure between 1.5 and 3 bar.

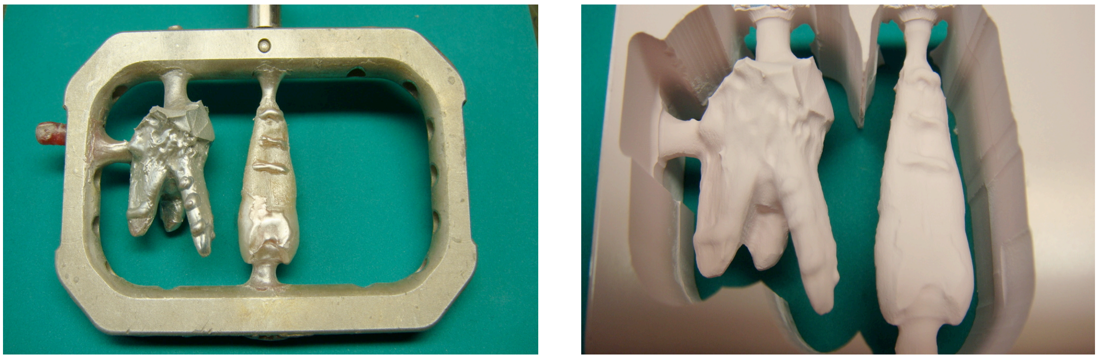

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Fig.1. The preparation of two dental implants by hand (a) Wax model (b) Sintered milled Zircon dioxide implants.

The measurement and evaluation of the dental samples require precise and accurate metrology techniques. At the time being biomedical metrology is a very important tool for solving various problems in especially in the case of high flexibility and high accuracy are demanded [3].

In this study, the target is to achieve the best application method to be used in clinical praxis by following the patients conditions (Fig.2)

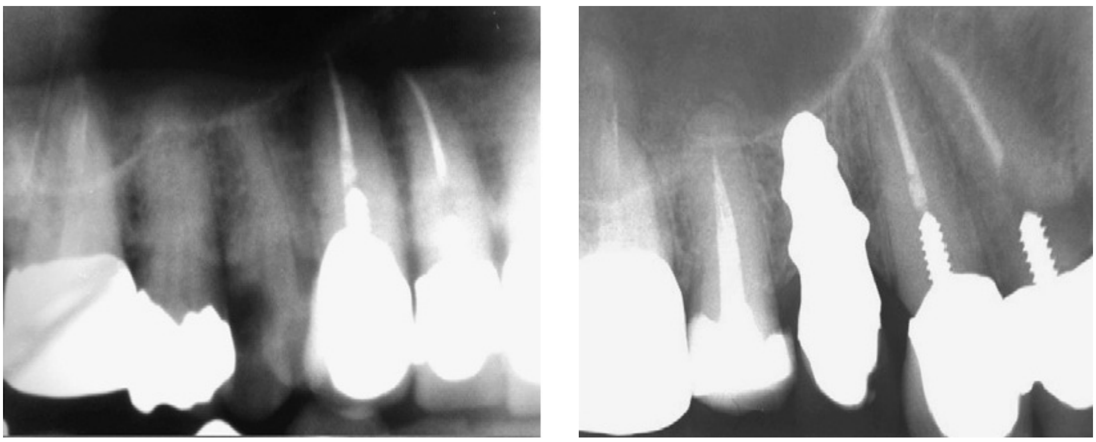

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Fig. 2. (a) X-ray of the partial mouth of a patient before the implant treatments. (b) X-ray of the partial mouth of a patient at 1-year follow up control after the implant treatments [4].

2. QUANTITATIVE CHARACTERISATION OF NON-TECHNICAL STRUCTURES FOR MEDICAL IMPLANTS

Clinical results achieved from successful placement of dental implants have a critical determinant called osseointegration. It is maintained by esthetic and functional stability of the implantation without any complications [4].

The anatomically specific macro retentions and micro retentions of the analogue tooth is the key to the successful osseointegration that must be individually measured, analysed and evaluated due to specific anatomic properties. The reason of choosing the dental surfaces was to see the differences between the methods, which are tactile and optical. Hence the differences are significant particularly when such non-technical surfaces are being measured.

Stylus profilometer and digital microscope are commonly used instruments in the field of precision metrology. The contact-stylus profilometer while measuring a dental sample is represented in Fig. 3.

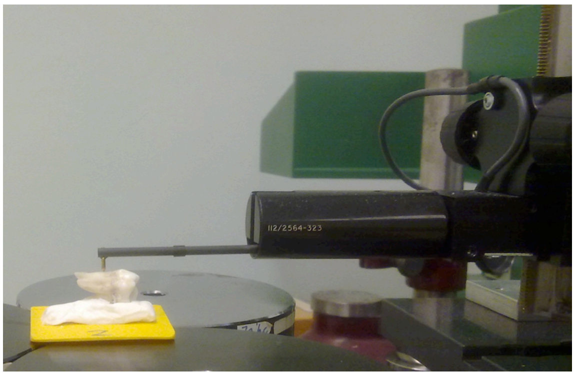

Fig.3. Schematic diagram illustrating Form Talysurf Intra 50 profilograph during the contact measurement of dental sample used in this study

Talysurf Intra 50 profilograph [5] with µltra software (FTS Iµ) represented in the Fig.3 according to the ISO 4287 and ISO 4288 [6, 7]. In the measurements of the stylus profilometer, 60 mm stylus arm length, 2 µm radius conisphere diamond stylus tip size and 1 mN force (speed=1 mm/s) were selected. Table 1 denotes the specifications of the contact stylus profilometer.

Table 1. The specifications of contact stylus type profilometer

Measurement Method	***Spatial resolution***	***Z Resolution***	***Range Z***
Stylus Profilometer (SP)	1-2 µm	3 -16 nm	0.2-1 mm

The digital microscope (Keyence VHX-1000) and 3D laser scanning microscope was used to observe, measure and record stabilized, fully-focused, uniformly illuminated image of dental samples (Fig.4) [8] . In this study, the technical structures are investigated using a digital microscope (Keyence VHX-1000) with a high resolution CCD camera based system with a high intensity halogen lamp that integrates observation, recording, and measurement functions.

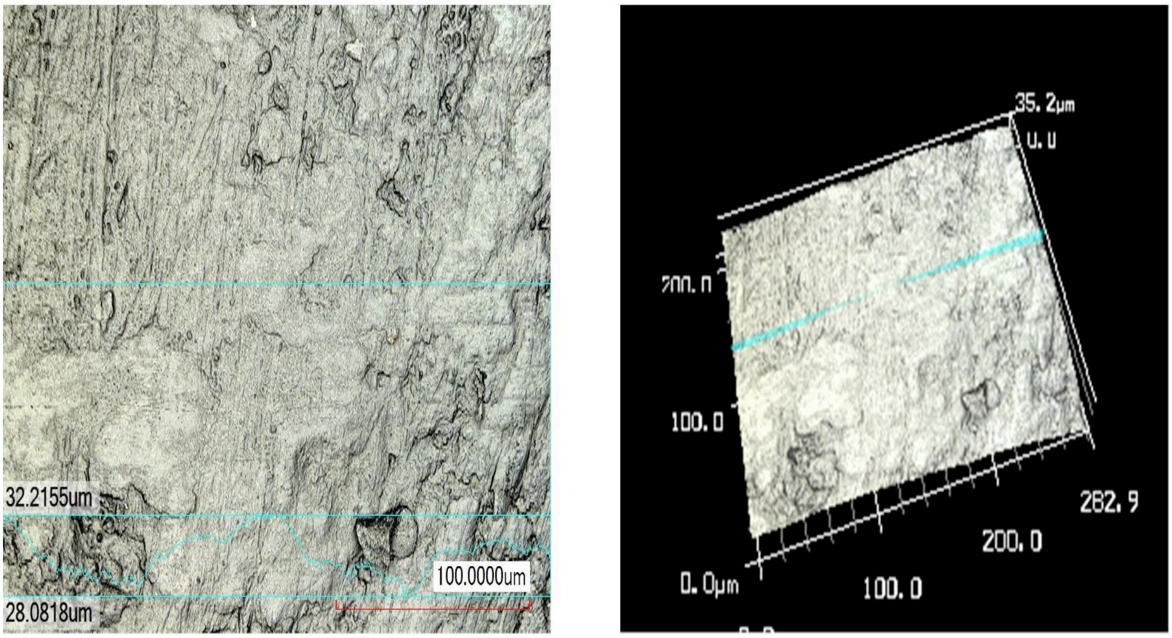

Fig.4. The original tooth sample surface topography using a 3D laser scanning microscope

The Olympus LEXT4000, the scanning type confocal laser microscope, is used to evaluate the surface topography as presented in the Fig.5 captured using a collimated laser beam with 408 nm laser diode (LD) laser and white light emitting diode (LED) illumination [9]. The measured area is 0.933192 mm2 and the radius is 0.545mm.

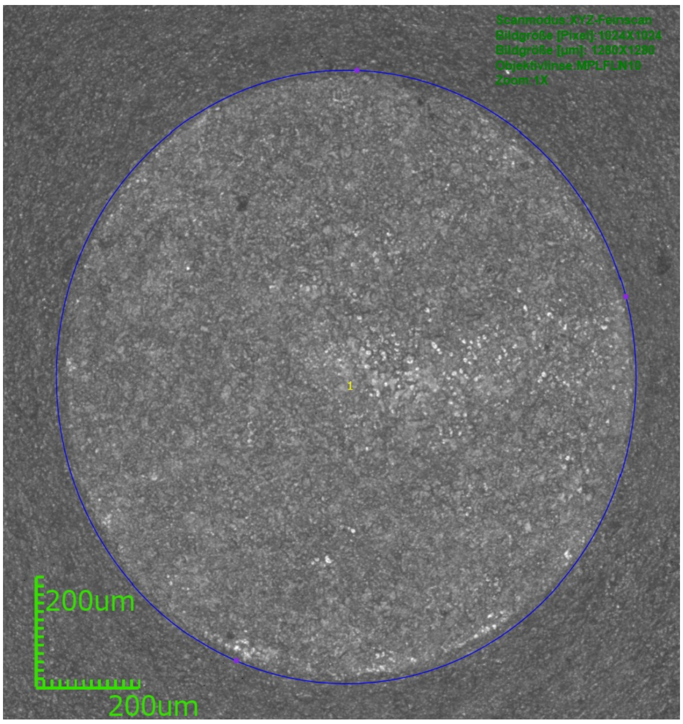

Fig.5. The surface topography of the dental implant using a scanning type confocal laser microscope (Scan-mode: XYZ-Feinscan, 1024x1024Pixel, 1280x1280µm, Zoom:1x)

3. MEASUREMENT RESULTS

In this research, the surface roughness measurements of three original teeth and four medical implants manufactured by different pressures were performed with a contact-stylus profilometer. The outcome was compared with each other and it is found that the difference between them is significant.

Table 2. R_a values belonging to three different teeth

	Roughness Measurement R_a(µm)					**Mean**	**Std.Dev.**
Original Tooth 1	6,1356	6,8910	7,8193	7,9923	8,0371	7,3751	0,8347
Original Tooth 2	7,1169	7,6722	8,4380	7,5274	8,4416	7,8392	0,5849
Original Tooth 3	7,0023	5,5159	6,5012	7,5831	6,1739	6,5553	0,7882

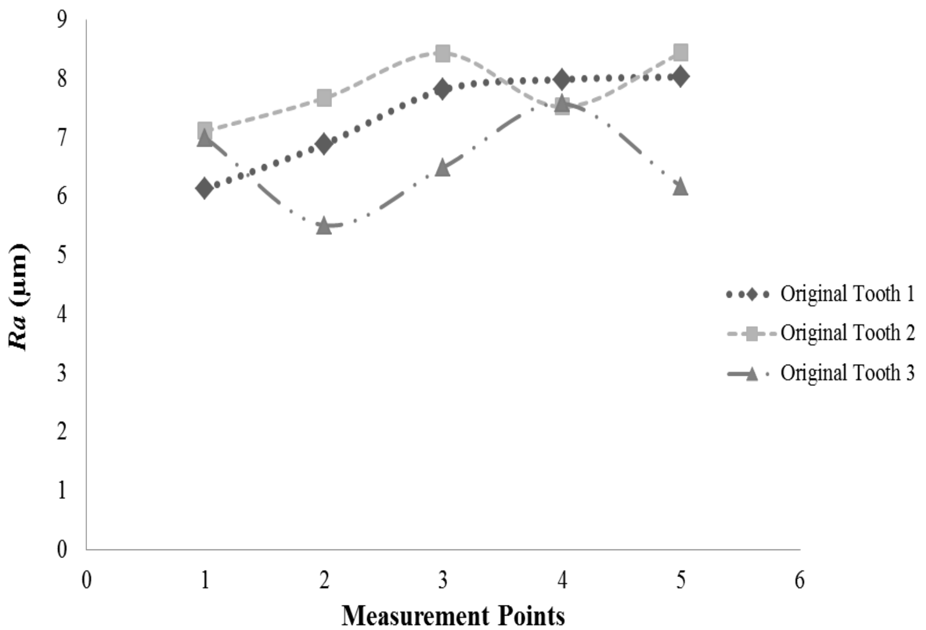

Fig.6. The roughness values belonging to three different teeth taken from the stylus profilometer in terms of the parameter R_a.

As seen in Fig. 6, the results for three different teeth characterize analogous surface topography in terms of R_a values. R_a values are around 6,5 µm to 7,8 µm for the original teeth samples.

Table 3. R_a values belonging to four medical implants manufactured by different pressures

	Roughness Measurement R_a(µm)					**Mean**	**Std. Dev.**
Implant 1	6,1169	5,8697	5,8274	5,9571	6,1674	5,9877	0,1496
Implant 2	9,4074	9,5551	9,8005	9,7558	10,2517	9,7541	0,3200
Implant 3	13,2140	13,6919	12,6261	14,0001	14,0685	13,5201	0,6028
Implant 4	20,5499	19,3169	19,6167	21,2405	20,9839	20,3416	0,8425

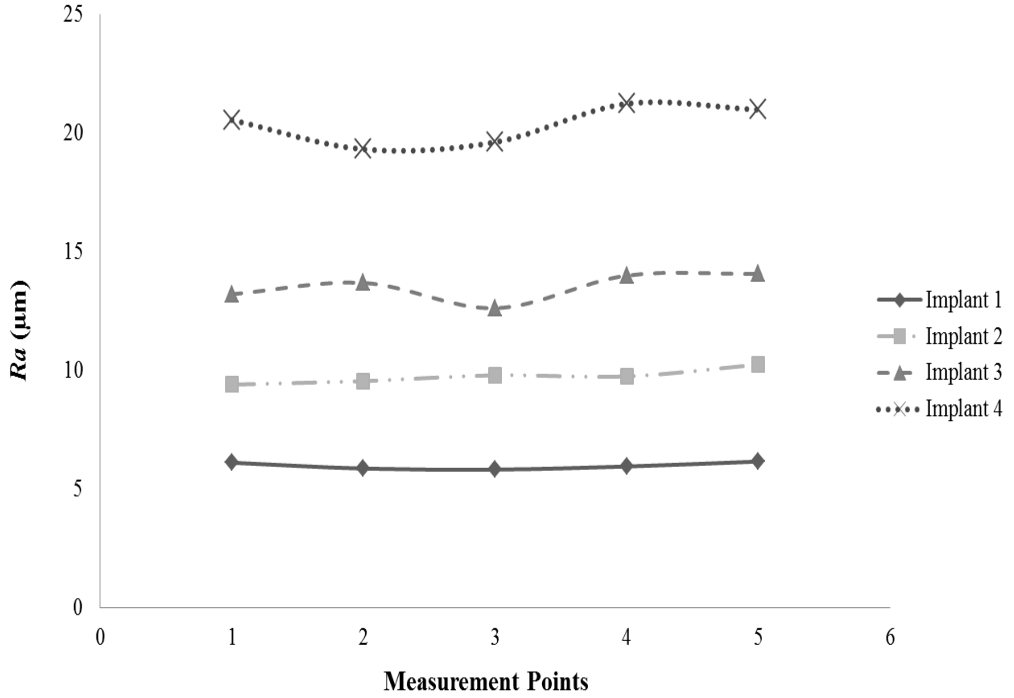

Fig.7. The roughness values belonging to four medical implants manufactured by different pressures taken from the stylus profilometer in terms of the parameter the parameter R_a. (Implant1 : 1,5 bar, Implant2 : 2 bar, Implant3: 2,5 bar, Implant4 : 3 bar)

The R_a values of the implant samples are measured to be in the range of 5,9 µm to 20,3 µm as presented in the Fig.7. The roughness values resulting different surface topography are caused by different pressure values while manufacturing.

4. CONCLUSION

In this study, the measurement and evaluation of the non-technical dental structures have been investigated and the measurements have been evaluated using a contact-stylus profilometer, a digital microscope, a 3D laser scanning system and a scanning type confocal laser microscope. The quantitative results of the measurements were used to characterize the roughness levels of the surfaces that describe the effect activity of the samples.

The R_a values are measured in the range of 6,5 µm to 7,8 µm for the original teeth samples. Whereas R_a values of the implant samples are in the range of 5,9 µm to 20,3 µm. The roughness values resulting different surface topography are caused by different pressure values while manufacturing. The best solution is sought by the clinical experience to advance the health quality of the patients using this study in a long term project.

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