To assess fit at the implant-abutment interface – a comparative in vitro study

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Abstract:

Background and Aim: The implant abutment interface is a site where the fixture connects to the abutment as well as the prosthesis. It is a very crucial feature to be considered when choosing an implant system. The accuracy of fit at this interface is vital for the successful outcomes of implant supported prosthesis. The purpose of the present study was to evaluate the microgap at the interface of prefabricated and castable abutments of two compatible brands.

Material and methods: The study consisted of 80 samples which were categorized into 8 groups. The components of two brands Adin and Alpha- Biocare were included in the study. The implant abutment interface was evaluated with a scanning electron microscope. Specimens were arranged so that all possible combinations were assembled. Each sample was mounted on an acrylic support for evaluation from four different sides. The data was compared with parametric test one way ANOVA followed by multiple comparison Bonferroni test.

Result: The results showed that the marginal gap at the interface of casted straight Adin abutment and Alpha-Biocare implant analog was the highest among all groups amounting to a mean of 7.490 µm and the least microgap was observed to be 1.324 µm at the interface of prefabricated straight Adin abutment and Adin implant analog.

Conclusion: The prefabricated abutments showed less microgap at the implant abutment interface than the castable abutments.

Keywords: implant, abutment, interface.

1. Introduction:

In recent years, dental implantology has become a part of mainstream dentistry. The implant restorations are mainly comprised of three tier assembly the titanium fixture, abutment and the prosthesis. [1]The Abutment is mechanically attached to surface of implant and should be fixed throughout the life of the implant to prevent any complications. It is very important to maintain the stability of the implant abutment connection for the success of the prosthesis. A large number of factors govern the stability of implant abutment interface like design, precision of fit, materials used, geometry of screw, amount of friction, preload and the shape of the abutment. [2]

The Implant Abutment Interface has either external or internal connection. Now a days, implants with internal type of connection are more commonly manufactured and marketed. [3-6]The implant abutments are classified as screw in, friction fit or cement retained.[7] Each of these types of abutments may be further sub classified as straight or angled abutments depending on the axial relationship between the implant body and the abutment. In addition, these abutments can be further classified into either prefabricated or custom abutments.[8]The custom abutments provide an ideal support for the peri-implant soft tissue and also allows for

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an optimized emergence profile.[9] Also, despite of the moderate cost, they can shorten treatment time and simplify treatment protocols.[10-12]

The implant systems are most commonly used are with a three tier assembly in which one component is clamped with another component. This may result in microgap at the implant abutment interface which provides a site for the colonization of microorganisms which leads to inflammatory reactions in the surrounding soft and hard tissues. [13] It provides a passage for the fluids and bacteria. These bacteria form a reservoir that allows the micro-organisms to seep in or out perpetuating a peri-implantitis disease. [14-16] The prevention of microleakage at implant abutment interface in case of two piece implant is necessary to decrease the inflammatory reactions. The type of the implant abutment connection and their sealing capacity both affect the infiltration of bacteria at the implant abutment interface. [17, 18]

Optical microscopy and scanning electron microscope are the main two dimensional methods used to evaluate the fit at the implant abutment interface.[19] Development of more reliable internal connections and progress in material science and precision manufacturing have improved abutment design and more reliable alloys for the abutment screws, significantly reducing the incidence of technical complications.[20]

2. Material and methods:

In this study, components of two brands Adin and Alpha-Biocare were tested. In order to assess the marginal accuracy at the implant abutment interface, one sample of implant with its respective abutment was evaluated and used as a control. Since the gap at the implant abutment interface was not significantly different from the microgap at the implant analog and abutment interface, all the samples were made by using implant analog of that particular brand.

Two types of abutments prefabricated and castable were included in the study and a total of eight groups were assessed. The following components were used to make samples-prefabricated Adin straight abutments, castable Adin straight abutment, Adin implant analogs, prefabricated Alpha-Biocare straight abutments, castable Alpha-Biocare straight abutments and Alpha-Biocare implant analogs. Eight groups were made by using the mentioned components.

The customized abutments of both brands were casted together under similar conditions as per the manufacturer's guidelines in cobalt chrome alloy. Each group consisted of 10 samples making a total of 80 samples. Specimens were arranged so that all possible combinations were assembled. The groups formed were arranged in the following sequence:

Group I - Prefabricated standard Adin abutments attached to Alpha-Biocare implant analogs

Group II - Prefabricated standard Adin abutments attached to Adin implant analogs

Group III- Prefabricated standard Alpha-Biocare abutments attached to Alpha-Biocare implant analogs

Group IV- Prefabricated standard Alpha-Biocare abutments attached to Adin implant analogs

Group V- Casted Adin abutments attached to Adin implant analogs

Group VI- Casted Adin abutments attached to Alpha-Biocare implant analog

Group VII- Casted Alpha-biocare abutments attached to Alpha-Biocare implant analogs

Group VIII- Casted Alpha-Biocare abutments attached to Adin implant analogs

The accuracy of the interface was quantified by the vertical discrepancy between the surface of the implant and the abutment. The components were initially submerged, cleaned in an ultrasonic bath thoroughly and finally mounted with a digital torque meter (fig 2) at 20 N/cm preload. [21]The implant analogue abutment set was mounted on an acrylic support which defined four assessment positions.(fig 3) By using the carbon tape, these blocks were mounted on a stub of around 13 mm and then placed under scanning electron microscope (JSM 6510LV 15 kV, JEOL, Japan) for evaluation.(fig 1) The images were made at ×1,000 magnification. Measurements were taken directly on the microscope at four selected locations. The highest value of microgap for each sample was considered as the representative gap measurement at the implant abutment interface for the statistical assessment of data.

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3. Results:

Table 1 shows the normality test of data. By Shapiro Wilks test, the data was normally distributed. Table 2 shows the mean and standard deviation of the microgap of eight groups. It was found that the mean of the microgap was the highest in group VI (fig 4) in comparison to the other groups which was formed by assembling the casted straight Adin abutments with the Alpha-Biocare implant analog. However the lowest amount of microgap was observed in group II which was formed by assembling the pre-fabricated straight Adin abutments with Adin implant analogs amounting to 1.324 µm. From table 3; on applying one way ANOVA the micro gap between eight groups was highly significant, $p<0.001$. Table 4 shows that by Bonferroni multiple comparison test, the mean difference of Group I versus Group II, Group I versus Group III, Group I versus Group IV, Group II versus Group III, Group II versus Group IV , Group III versus Group IV, Group V versus Group VIII and Group VII versus Group VIII were not significant, $p>0.05$.While between Group I versus Group V, Group I versus Group VI, Group I versus Group VII, Group I versus Group VIII, Group II versus Group V, Group II versus Group VI, Group II versus Group VII, Group II versus Group VIII, Group III versus Group V, Group III versus Group VI, Group III versus Group VII, Group III versus Group VIII, Group IV versus Group V, Group IV versus Group VI, Group IV versus Group VII, Group IV versus Group VIII, Group V versus Group VI, Group V versus Group VIII, Group VI versus Group VII and Group VI versus Group VIII, was significant $p<0.05$.

Tests of Normality							
		Kolmogorov-Smirnova			Shapiro-Wilk		
	Group	Statistic	Degree of freedom	P value	Statistic	Degree of freedom	P value
Micro gap	Group I	.124	10	.200	.979	10	.961
	Group II	.229	10	.146	.951	10	.679
	Group III	.311	10	.007	.844	10	.050
	Group IV	.222	10	.177	.852	10	.061
	Group V	.124	10	.200	.966	10	.852
	Group VI	.267	10	.042	.881	10	.134
	Group VII	.121	10	.200	.965	10	.838
	Group VIII	.203	10	.200	.946	10	.621

Table 1: Normality test of data

Groups	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Group I	10	1.491	.1316	.0416	1.396	1.585	1.3	1.7
Group II	10	1.324	.1438	.0455	1.222	1.427	1.1	1.6
Group III	10	1.477	.1624	.0513	1.361	1.593	1.2	1.6
Group IV	10	1.698	.1666	.0527	1.579	1.817	1.5	1.9
Group V	10	6.706	.3504	.1108	6.455	6.957	6.1	7.2
Group VI	10	7.490	.2413	.0763	7.317	7.662	7.0	7.8
Group VII	10	6.254	.6378	.2017	5.798	6.711	5.3	7.2
Group VIII	10	6.721	.9381	.2967	6.050	7.392	5.0	8.2

Table 2: Distribution of mean and standard deviation of micro gap (µm) of eight groups

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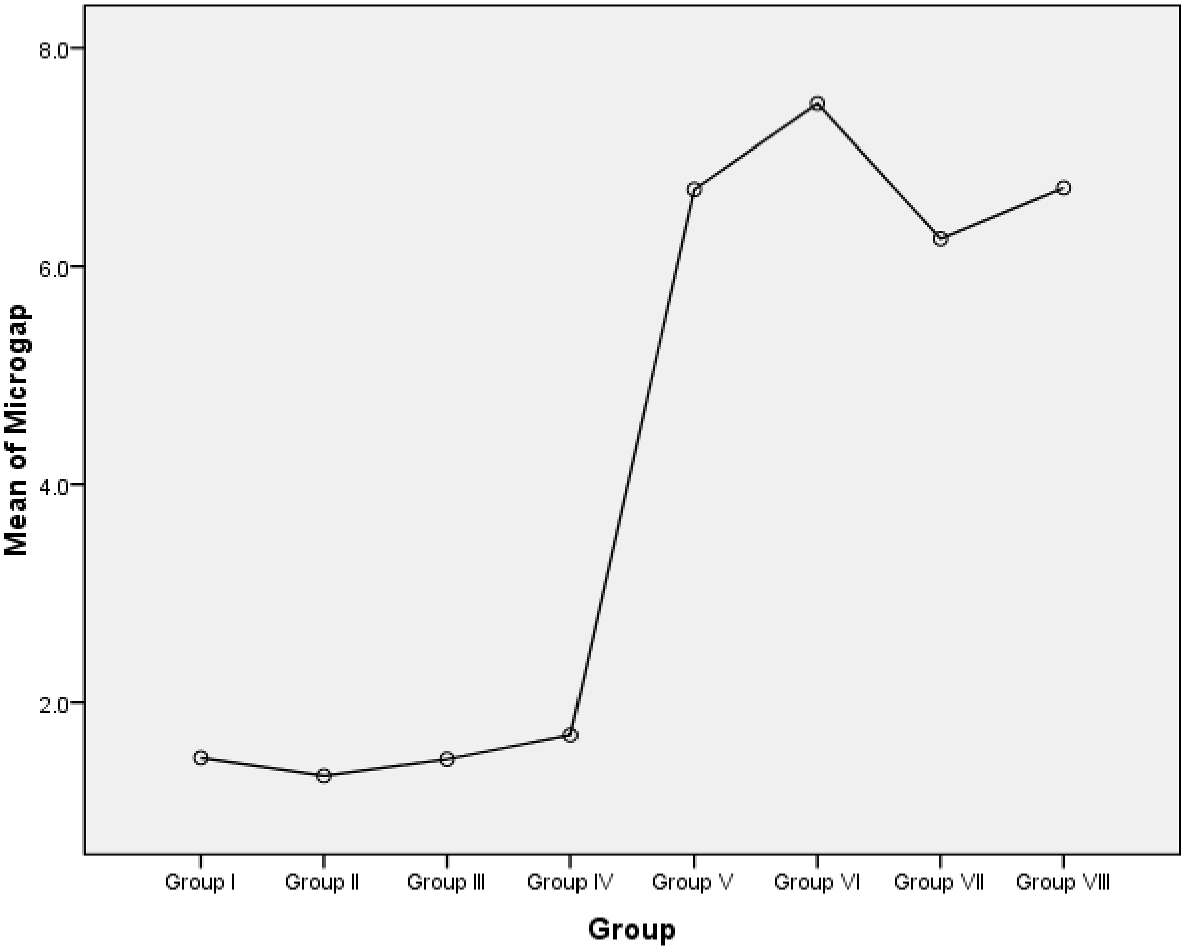
ANOVA					
Microgap	Sum of Squares	Df	Mean Square	F	P value
Between Groups	569.329	7	81.333	417.092	.000**
Within Groups	14.040	72	.195		
Total	583.369	79			

Table 3: Comparison of micro gap (µm) between eight groups by one way ANOVA

*Significant $p<0.05$, ** Highly Significant $p<0.001$, ^{NS} Not significant $p>0.05$



Graph 1:Mean Plot of microgap of eight groups

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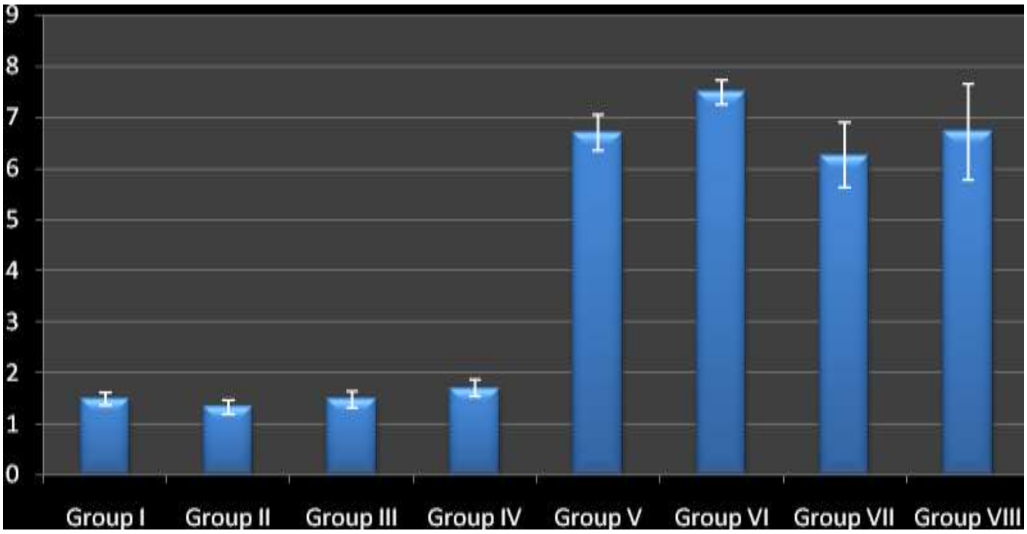
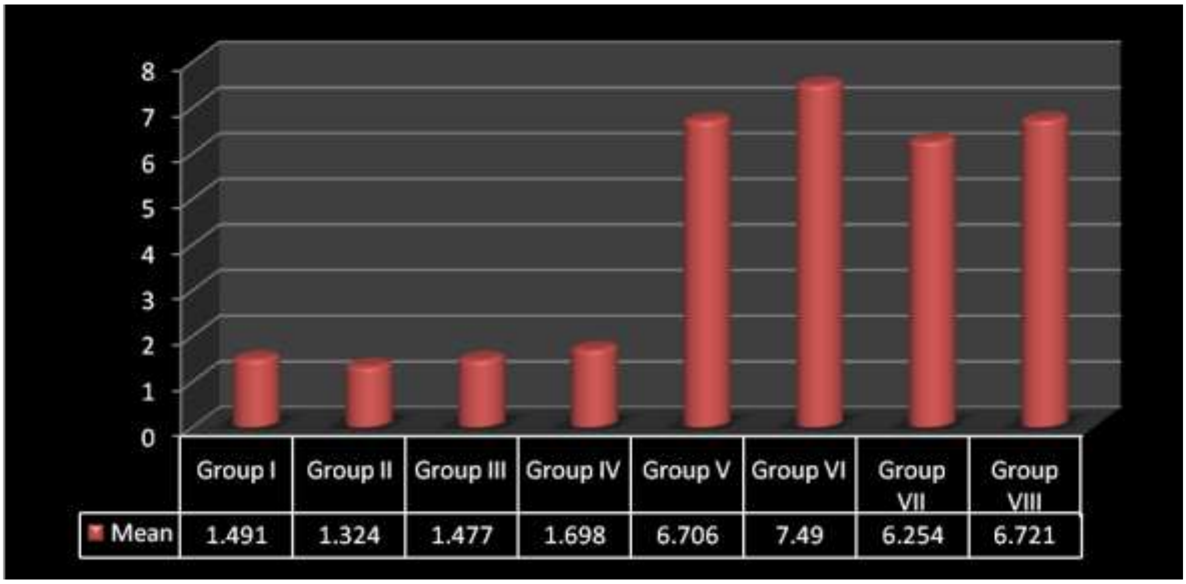


Graph 2: Distribution of mean and standard deviation of micro gap (µm) of eight groups (Error bars shows the mean ±standard deviation of micro gap (µm))



Graph 3: Distribution of mean of micro gap (µm) of eight groups

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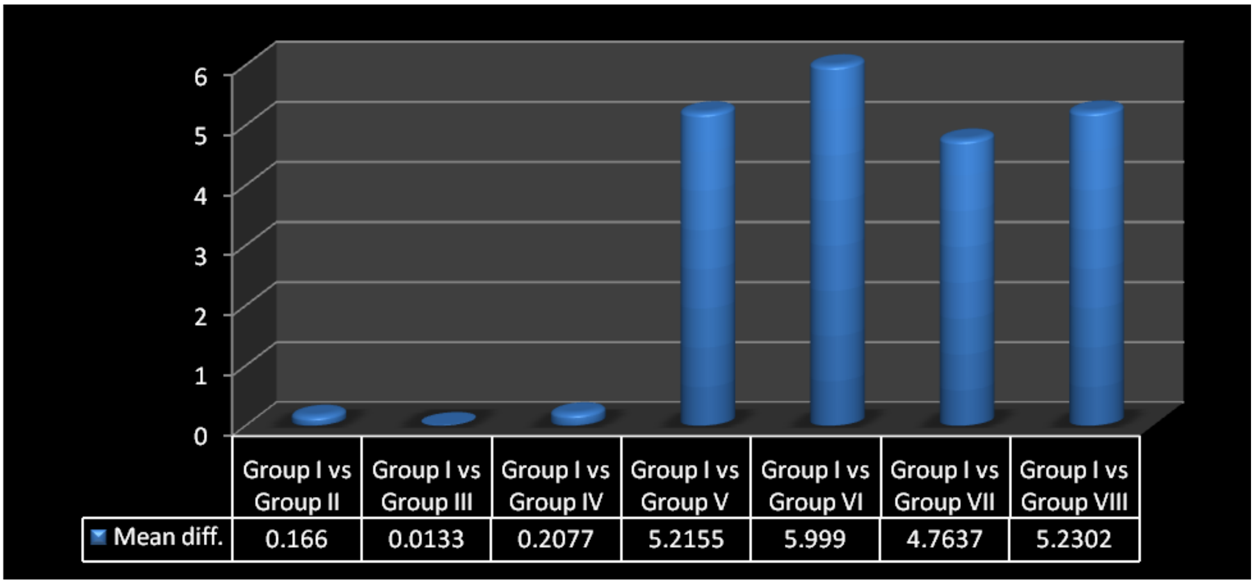
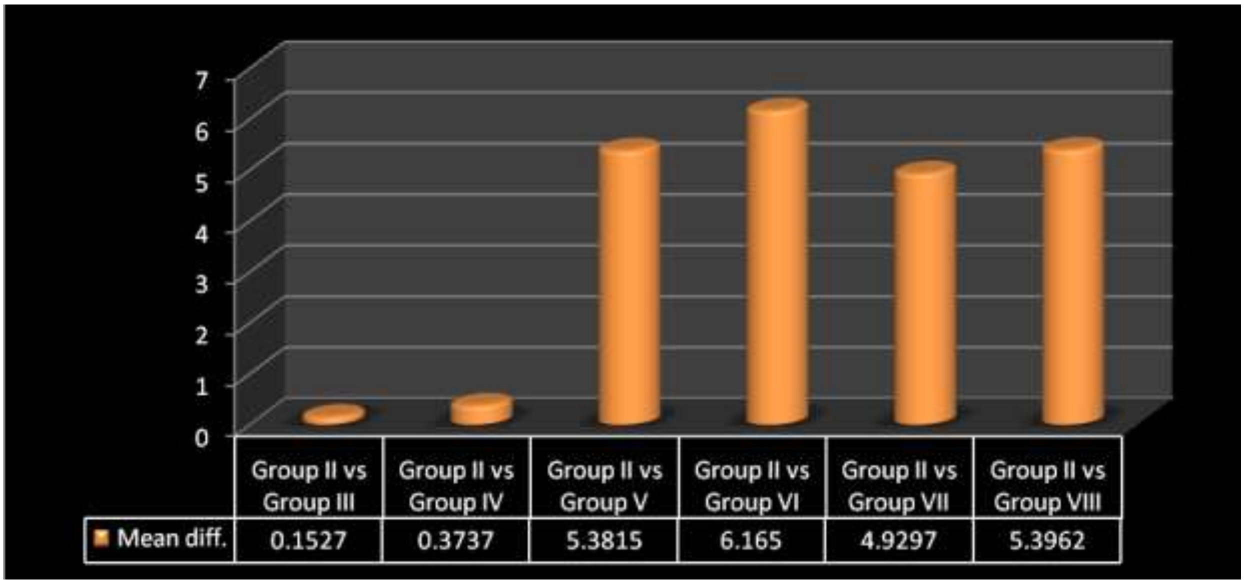


Graph 4: Distribution of mean difference of micro gap (µm) of between groups I with other groups



Graph 5: Distribution of mean difference of micro gap (µm) of between groups II with other groups

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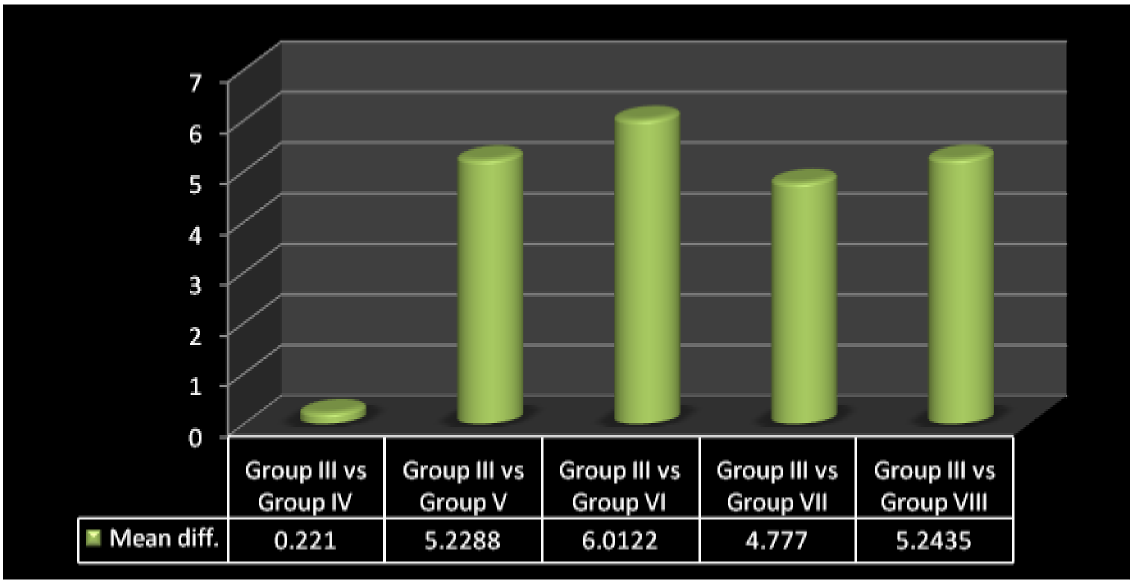
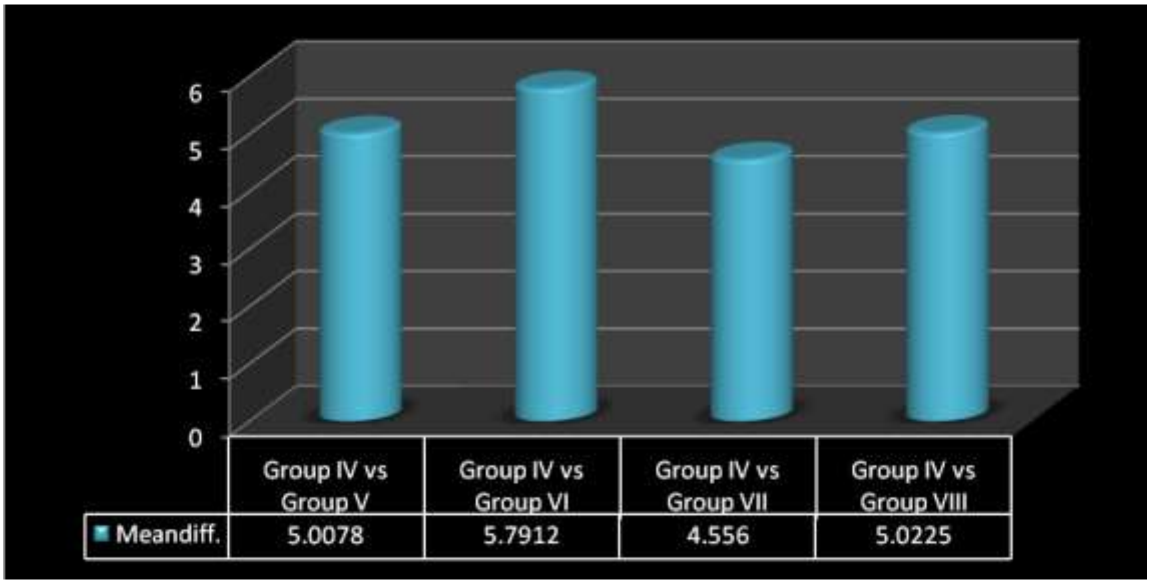
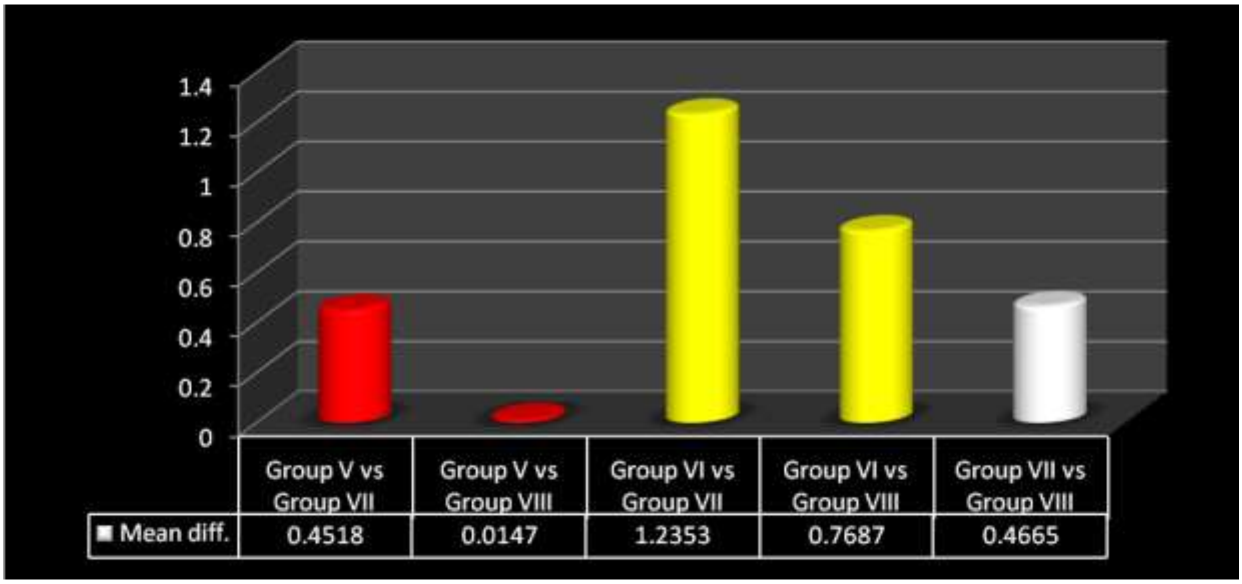


Graph 6: Distribution of mean difference of micro gap (µm) of between groups III with other groups



Graph 7: Distribution of mean difference of micro gap (µm) of between groups IV with other groups



Graph 8: Distribution of mean difference of micro gap (μm) of between groups V, VI VII with other groups

4. Discussion:

The objective of the present study was mainly focused on raising awareness among clinicians in terms of the marginal fit and microgap at the implant-abutment interface. This is very important because it is highly possible that the colonization of microbes is either obstructed or abetted by the proper marginal fit of the implant-abutment interface. The inescapable microgap at the interface of implant-abutment has been shown to cause microbial leakage which further results in inflammatory reaction in peri-implant hard and soft tissues. [22-25]

For the external hex joint-type of implants, few similar in vitro studies have been reported on the marginal fit and size of micro gaps at the implant abutment interface. For example, for the Branemark implant including the rounded edge of the abutment, Binon et al reported a marginal error of 49 μm.[26] Mean vertical discrepancies that ranged from 79.3 to 24.3 μm were reported by Dellow et al.[27] Additionally, Byrne et al. reported that external vertical discrepancies ranged from 36 to 86 μm, and horizontal discrepancies ranged from 66 to 11 μm.[28] Most of the previous studies used the technique of direct measurement from scanning electron microscope images to evaluate marginal fit and size of micro gaps. In the present study also direct evaluation of the interface was done to determine the marginal discrepancy.

Lalithamma et al compared the marginal accuracy of prefabricated and cast abutments. [29] In this study they used prefabricated titanium, stainless steel, and gold abutments as the control groups. The casting of the plastic abutments was done cast in nickel-chromium, cobalt chromium and grade IV titanium. In this study it was concluded that the marginal gap for cast components obtained from plastic cylinders were statistically higher compared to the prefabricated cylinders made of gold and grade V titanium. [30]

In the present study, the normality of data was tested by Shapiro Wilks test, and found normally distributed data. The significance of micro gap between groups was tested by parametric test one way ANOVA followed by multiple comparison Bonferroni test. The 95% C.I. and 5% level of significance was used for analysis of data. The microgap at the interface of casted abutment and implant analog ranged from 4.47-8.25 μm and was the highest among all groups. However when casting abutments of different brands were interchanged the microgap further increased to a range of 4.47-10.20μm. The microgap at the interface of preformed abutments and implant analogs ranged from 1.02-2.57 μm and this microgap further increased to a range of 0.52-2.18 μm when the preformed abutments of Adin and Alpha-Biocare were interchanged.

Screw loosening may be an early warning of inadequate biomechanical design or occlusal overloading. Whenever there is a vertical microgap between the implant and the abutment, this can also result in decreased transfer of preload, thereby hastening the process of screw loosening. In addition to this, in implants using screws, the biting force lowers the pretension in the screw. A combination of non-uniform contact between implant-abutment interfaces, coupled with greater loading than the installed forces enhances the screw loosening.

In the present conducted study, comparison were made between the microgap at the interface formed by prefabricated and castable abutments of different brands. The study revealed significant microgap at the implant abutment interface of different groups however the microgap at the implant abutment interface formed at the interface of castable abutments was comparatively higher than that at the interface formed by prefabricated abutments. The conventional lost wax technique was used for the casting of the customized abutments in cobalt chrome alloy as per the manufacturer's guidelines. The larger microgap observed at the interface of castable abutments may be attributed to the fact that the contact surface of the cylinder as well as the internal cylinder surface are influenced by a variety of processing and handling conditions of the fabrication process and by the casting accuracy of the alloy.

Also when components of same brand are used the microgap is comparatively lower than at the interface formed by compatible abutments of other brand. Caution must be taken while using scanning electron microscope as a method to evaluate the fit of the joint because the variations in gap sizes have been shown to occur along the implant radius in cross-sectional observations of this interface. Also, the knowledge of the interface size allow the understanding of the potential of the bacterial colonization, but it is limited in providing more insight into the possibility of fluid passage through the implant-abutment interface. Imperfections that occur during the manufacturing related to machining of implants components, excessive torque during abutment placement (which may allow the distortion of its parts), and in addition the misfit between implant-abutment are factors that have been related to interface gap origin. Therefore, new studies are now focusing to assess the sealing capability of different connection systems along with fatigue testing which will help to evaluate the effect of misfit on systems mechanical performance and bring insight for the development of new connection designs.

Implications for clinical practice: Clinical significance of the study is useful in situations where sometimes the patient opts for implant placement and implant restoration from different clinicians. A descriptive knowledge of the compatible components helps to overcome the hurdles in treatment planning of such cases.

5. Conclusion:

The stability of the joint at the implant abutment interface is very critical for the long term success of the implant prosthesis and is directly influenced by the microgap present at the implant abutment interface.

A variety of studies have been performed on this interface and they are not easy to compare. In the present study, all the connections presented a certain amount of microgap at the interface but the components of the same brand were more compatible comparatively. The prefabricated abutments showed less microgap at the implant interface than the castable abutments. Also, when the abutments were interchanged the microgap between the components of same brand was less than of components of different brand. As only a limited numbers of brands with similar implant abutment connection geometry were included in the study, it is hard to conclude that which connections are more compatible than others.

The stability of the joint in the implant abutment interface is critical and needs appropriate attention. The design of the abutment connection is of utmost importance for the long-term success of implant prosthesis. Existence of such micro-gap may hamper the life expectancy of implant restoration in the patient. Reducing this micro-gap to an acceptable level should be the one of the set goal for a successful implant restoration. Further studies are needed to increase the evidence of which brands with similar implant abutment connection geometry are more compatible than the others.

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20- Differences in micromorphology of the implant abutment junction for original and third-party abutments on a representative dental implant. George Fokas, DDS, Dr med dent, Li Ma, DDS, PhD Vasilios Chronopoulos, DDS, MSc, PhD, Martin Janda, DDS, MSc, and Nikos Mattheos, DDS, MSc, PhD

21-Connecting accuracy of interchanged prosthetic abutments to different dental implants using scanning electron microscopy

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