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Original Article

Microdeformation of Infrastructure for Implant-Supported fixed Dental Prosthesis by Strain-Gauge Method: Influence of Technique and Material Impression

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Abstract

Objective: To verify the structural microdeformation by strain gages, around implants that have metal infrastructure, obtained by different materials and techniques impressions. **Material and Methods:** Three internal hexagon implants in polyurethane block (master model) with abutments were taken the impression with differents materials and techniques impression (n=4): addition silicon and transfer for open tray technique (Group I), condensation silicon and transfer for closed tray technique (Group II); and polyether and transfer for open tray techniques (Group III). Impressions were poured with type IV stone. Metallic infrastructure were made and installed in the master model by an aid of a manual ratchet wrench. A torque of 20N was used to install the metallic infrastructure. Microdeformation analysis was performed around the implants by strain gauge method. Two gauges were inserted into the polyurethane base, and three measurements were taken for each infrastructure. Data were analyzed using descriptive statistics and inference. Kruskal-Wallis test was used to verify association between materials and impression techniques and deformation around the implants, at 5% confidence. **Results:** Microdeformations around the implants showed no statistically significant difference ($p = 0.123$) between the experimental groups, Group I (215.8 $\mu\varepsilon$), Group II (194.9 $\mu\varepsilon$) and Group III (297.4 $\mu\varepsilon$). **Conclusion:** The use of different materials and techniques impression to made of infrastructures for fixed implant-supported dental prosthesis did not present difference in microdeformation values around implants.

Keywords: Dental Implantation; Dental Impression Materials; Dental Prosthesis.

Introduction

Oral rehabilitation with osseointegrated implants has increasingly been performed in the day to day of the dental office. The longevity of implant-supported dental prostheses is obtained by stability, passive fit of prosthetic infrastructures on the implant connections [1-3]. The absence of satisfactory fit induces the irregular distribution of masticatory loads, resulting in deformation of the adjacent bone tissue3 and of the prosthetic components [4-5], compromising the therapeutic success of the implant and its components [6]. Factors that influence the passivity of infrastructures of fixed implant-supported dental prosthesis are the precision of impression [7], adequate insertion of the components transferred, quality of the casting, as well as the variables related to accuracy of the impression techniques of the implants position [8-10].

The impression technique of implants and abutments is a crucial step in rehabilitation with implants. From performing this step, analogs - replica of the abutments for fabrication of the prosthetic infrastructure - are obtained8. There is no defined protocol to follow for obtaining a working model, and the techniques for transferring the position of implants and impression most commonly used are the indirect, direct, and direct splinted types [11-13]. The literature has related that direct impression with square transfers, retaining screw splinted with acrylic resin Duralay, GC or pattern, precisely records the relationship between the implants by means of a rigid impression, without distortions[14], resulting in more precise prosthetic parts, in comparison with prosthetic structures obtained by indirect impression with conical transfers [7,13,15-18].

Elastic impression materials are widely used in impression transfers in implant dentistry [7]. Elastomers, as also called, deform when removed from the tray, due to the presence of retentive areas of the part of which the impression is taken, and after this go back to their original position, and become elastic after their final setting. Polyether, sulphide, addition silicones and condensation silicones are classified as elastomer [7-19]. Addition silicones and polyethers are the materials that present the highest linear dimensional stability [20], greater rigidity after polymerization and higher resistance to transfer rotation within its tray [16] making it possible to obtain efficient working models, in addition to more precise and stable fit of implant-supported dentures [7].

Among the technological devices to observe simulation of bone deformation in vitro, electrical strain gauges, finite elements and photoelasticity are outstanding methods. Electrical strain gauges are used to determine stress and deformation measurements in relation to the forces exerted on implants, and their transfer to the supporting structures [21-25]. The method is based on the use of electrical strain gauges, small electrical resistances that change the resistance to low intensity current, which detects the slightest deformation in the structure evaluated. This electrical signal captured is sent to a data acquisition board to be transformed into digital signals, enabling them to be read by a microcomputer [25].

The Pub-Med database presented only three studies that used the electrical strain gauge method to evaluated impression transfer techniques, when the key words transfer impressions and strain gauges were used in the search. Because of the scarcity of studies that deal with microdeformation of the prosthetic infrastructure, by means of the variables materials and techniques impression in implant-supported dental prostheses, the aim of this study was to verify, by means of strain gauges, the structural microdeformation occurring around implants with metal infrastructures for fixed dental prostheses, obtained by different materials and techniques impression. The hypotheses to be tested were impression with addition silicone, and with polyether, both by the direct splinted impression technique would present the lowest values of microdeformation around implants, in comparison with impression-taking with condensation silicone by the indirect technique. In addition, there would be no difference in the microdeformation values between the addition silicon and polyether materials, both by the direct splinted impression-taking technique.

Material and Methods

Fabrication *of the master model*

A polyurethane block (Polyurethane F16 Axson, Cercy – France) was made in the metal matrix (95 x 45 x 20 mm^{3}), that similar to the matrix found in the literature[26]. Polyurethane has an elastic modulus of 3.6 GPa, which is similar to the elastic modulus of bone tissue. After final polymerization of the polyurethane, the block was flattened with water abrasive papers grain 220 to 600 to obtain a smooth and flat surface. After this, the block was fixed in a cutter (Fresadora 1000 – Bioart – São Carlos, São Paulo, Brazil) and 3 perforations of 10 mm deep were made, according to the surgical protocol for clinical use. Perforation began with a lance type cutter, followed by cutters 2.0; pilot, 3.0 and finalizing with the counter-sink type of cutter.

Three implants, 3.8 mm in diameter by 10 mm high, internal hexagon type (IH) (Implante ConectAR - 513710, Conexão Master - Conexão Sistemas de Prótese, Arujá, São Paulo, Brazil) duly aligned were inserted in a single polyurethane block, maintaining a center-to-center distance of 7 mm between each implant. The abutments (Micro Unit 3mm height - 132083, Conexão Master - Conexão Sistemas de Prótese, Arujá, São Paulo, Brazil) were installed on the implants. Master model was made of polyurethane block + implants + abutments.

Material and Technique Impression

The impression with transfer for open and closed tray technique of the abutments were performed with different materials impression. One single operator realized the impressions, in order to obtain a final working model in stone for fabrication of the metal infrastructure. The study had 3 experimental groups (n=4) (Table 1):

Table 1. Experimental Groups, Impression Technique and Material and Manufacturers of the study.

Experimental Group	Impression Technique	Impression Materials	Manufacturer
I.	Direct Impression (Open Tray)	Addition silicone	Elite, Zhermack - Badia Polesine, Italy
II	Indirect Impression (Closed Tray)	Condensation silicone	Optosil e Xantopren, Heraeus-Kulzer – São Paulo, São Paulo, Brazil
III	Direct Impression (Open Tray)	Polyether	Impregnum, 3M ESPE AG, Seefeld, Germany

Group I: The impressions were realized with addicional silicon and the splinted direct impression technique or open tray technique. Square transfers (Transfers - 094000, Conexão Master - Conexão Sistemas de Prótese, Arujá, São Paulo, Brazil) were inserted in the abutments, that were connected by chemically activated acrylic resin (Duralay, Polidental - Cotia, São Paulo, Brazil). The individual tray was made of Chemically Activated Acrylic Resin (VIPI - Pirasununga, São Paulo, Brazil), with an opening in the region corresponding to the implants and abutments. For each new impression, the transfers were separated and then united again. The fluid pastes of material impression were placed in a pistol that automatically mixes them when activated. The fluid material was injected around the transfers, concomitantly equal portions of the two dense masses were manipulated. The tray was filled with the elastomer material and placed in position.

Group II: The impressions were realized with condensation silicon and the indirect impression technique or closed tray technique. Conical transfers (Transfers - 103000, Conexão Master - Conexão Sistemas de Prótese, Arujá.São Paulo, Brazil) were inserted in the abutments. The individual closed tray was fabricated of Chemically Activated Acrylic Resin (VIPI -Pirasununga, São Paulo, Brazil). The material impression was used by the dual impression technique; first impression with dense material and finally with the fluid material on the first impression, until final polymerization occurred.

Group III: The impressions were realized with Polyether and the splinted direct impression technique or open tray technique. The impression techique, transfer and tray were the same of group I. Before the impression the adhesive specifically for this material was applied in the internal area of the tray. The polyether was spatulated, filling the tray and syringe for impression. The material was applied around the transfers by means of the syringe, thus the tray was placed in position.

The transfer was chosen according to the impression technique to be used. The conical transfer was used for the indirect impression technique, because its conicity allowed it to remain in the oral cavity after the tray is removed [17], and also when the tray is reposition afterwards, by means of grooves or bevels present on its surface [7]. Whereas, the square transfer was used for the open impression or direct impression technique, because these components have parallel walls and retentive areas, so that the impressions are captured inside the tray without moving about at the time the tray is removed from the mouth [7,17].

The materials impression were manipulated in accordance with the recommendations of each manufacturer. After impression in all the groups, the analog (Micro Unit analog - 147000 Conexão Master - Conexão Sistemas de Prótese, Arujá. São Paulo, Brazil) were fixed in the tray in their respective positions. Impressions were poured with type IV stone (Durone type IV, Dentsply – Petrópolis, Rio de Janeiro, Brazil) immediately, for Groups II and III, and after one hour for Group I. For each experimental group, four stone model were obtained, resulting in 12 stone model and 12 metallic infrastructure.

Casting alloy and Insertion of metallic infrastructure

The plastic cylindrical (Cylindrical acrylic 144001, Screw 157004, Conexão Master - Conexão Sistemas de Prótese, Arujá.São Paulo, Brazil) were placed on the analogs and waxing was performed for casting of the infrastructure. The cobalt-chrome alloy (Litecast B Will-Ceram / USA), measuring 52 x 8 x 2 mm^3 was used.

The prosthetic infrastructure were inserted in master mold, following the screw fastening sequence from the center to the margins of the part, beginning with the central implant and then the lateral implants. Initially the titanium screws were manually threaded by an aid of a manual ratchet wrench, until offered resistance. A torque of 20N was used to install the metallic infrastructure. The torque was realized by a single operator.

Electrical strain gauges

Two electrical strain gauges were bonded on the polyurethane base with cynoacrylate adhesive, but before bonding the surface of the block was cleaned with isopropyl alcohol. Three measurements were taken (with each strain gauge) for each of the samples (infrastructures), totaling 36 measurements. The microdeformation(με) were taken during insertion of the prosthetic bars, after attaining the torque for fixation of the screws. Monitoring was performed for a maximum time of 50 seconds, while the strain gauges remained connected to a signal amplification machine (ADS 2000 - Lynx Tecnologia Eletrônica Ltda.– São Paulo, São Paulo, Brazil) which amplified the signals captured by the strain gauges, and transformed them into digital signals sent to the computer that provided the microdeformation values obtained, in the AqDados program (Lynx Tecnologia Eletrônica Ltda. - São Paulo, São Paulo, Brazil). The microdeformation values obtained were submitted to the AqAnalysis program (Lynx Tecnologia Eletrônica Ltda. – São Paulo, São Paulo, Brazil), which provided the mean values of these readouts. (Figure 1).

Figure 1: Prosthetic infrastructute on the master model and the two electrical strain gauges inserted in the polyurethane base.

Analysis of Results

The data were analyzed by means of descriptive statistics and inference. The Kruskal-Wallis test was used to verify the association between material and type of impression with the deformation around implants, adopting a 5% level of confidence.

Results

Group II (Condensation Silicone and Indirect Impression Technique) presented the lowest microdeformation values (με) in comparison with the other experimental groups. However, technique and impression material presented no statistical difference for the microdeformations of the infrastructure on implant (kw = 4.192). (Table 2) (Figure 2).

Table 2. Descriptive distribution of results of microdeformations in experimental groups.

Experimental Groups	Mean (με)	Median	Standard Deviation	Coefficient of Variation	*p*-value
Group I[A]	215.8	191.7	66.9	31.00	
Group II[A]	194.9	190.8	72.3	37.11	0.123
Group III[A]	297.4	289.7	37.11	29.33	

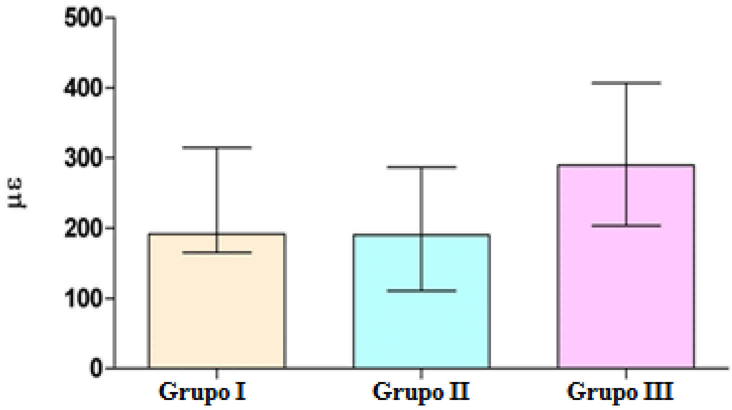

Figure 2. Microdeformation values corresponding to materials and impression techniques.

Discussion

The stresses on implants result from mastication and excessive occlusal contacts, that are due to prosthetic misfit and poor placement [27]. These problems with implant-supported dental prostheses may be reduced or eliminated by means of efficient impression and casting procedures [28].

The impression stage of the abutments is extremely important in the fabrication of implant-supported fixed dental prostheses, because the original position and disposition of the abutments must be reproduced, in order to obtain the working model, and thus it is necessary for the dentist to use and apply the materials and impression techniques correctly [18,29].

In this research, the prosthetic infrastructure obtained by means of impression with condensation silicone and closed tray technique presented the lowest microdeformation values, among the other impression materials and techniques tested. However, the materials and techniques impressions were not statistically significant.

The results found corroborated with studies that related the absence of statistical difference between elastomer and the open and closed tray techniques for the observation of dimensional alteration [29]. Under conditions of indirect impression of straight and angled implants, condensation silicone was shown to be efficient in comparison with the irreversible hydrocolloids [30]. When the indirect impression technique (conical transfers) was compared with the direct technique without the union of square transfers, and direct technique with the union of square transfers by means of acrylic resin, no statistical differences were observed among them. The indirect technique presented better reproduction of the experimental points of the original metal model than the other techniques [31].

The findings in the literature are in disagreement with the results obtain, which showed the use of direct impression, the use of polyether and addition silicone presented better performance for impressions of angled and straight implants [16], with the lowest values of dimensional alteration [15,17]. Dimensional alterations were present in working models obtained for implant-supported dental prostheses, irrespective of the material and technique impression [15,17]. Although addition silicones and polyethers presented lower dimensional alteration values than condensation silicone [19].

The high mean microdeformation values of Group I and Group III may be justified by the low resistance to rupture of the polyether, and by condensation silicone being the elastomer most used in the fabrication of implant-supported dental prostheses. From a survey conducted in laboratories, it was observed that 41% of cases involve multiple prostheses and among the impression materials adopted, condensation silicone was used in 56% of the cases, performing both the direct and indirect technique [32].

As is the case with the affinity for the impression method used, the materials and techniques impression must be chosen in accordance with professional skill and affinity [18]. The difficulty with screw retaining the analog may cause displacement of the transfer, generating the lost adaptation of the prosthetic infrastructure, due this part occurring the union of the transfers with acrylic resin is indicated33. The indirect technique with the closed tray and conical transfers has the advantage of screw retaining the analog. The transfer is removed of the abutment and positioned in impression, and on the transfer the anlog is retaining. Thereby allowing better visualization between transfer and analog; in addition, it is easy for dentists to do, and is indicated in cases of limitation of mouth-opening [33].

The use of individual trays for both impression techniques is a factor that may explain the findings, because each impression situation was individualized, promoting homogeneity of the results. The rigidity and stability of the individual tray minimize the distortions of the impression and makes it possible to obtain homogeneous thickness [34,35].

Microdeformation analysis by means of strain gauges sought to obtain microdeformation records directly from the polyurethane, in a region adjacent to the cervical portion of the implants. This area must be considered as area of greatest distribution of the masticatory load[24,36]. There is the possibility of establishing legitimate correlations between the results obtained with artificial models and those found in clinical situations [6].

Studies that have used electrical strain gauges and transfer impressions of implants discuss microdeformation in the union of impression transfers [37,39]. Therefore, there are practically no studies that present the data obtained in this research to be compared, because in this study, linear analysis of microdeformation was used to observe the efficacy of the technique and material impression in the transfer of implants. Whereas, studies found in the literature used dimensional alteration or marginal adaptation for in vitro analyses. This methodological factor may also justify the results obtained. By means of the findings in this research, affirm that complementary analyses of the distortions in more than one direction are necessary, and not only linear analyses, in order to obtain more results of this condition of the prosthetic infrastructure on the implant.

The hypotheses tested of this research, the hypothesis that impression with addition silicone and with polyether, both by the direct impression technique would present the lowest values of microdeformation around implants, in comparison with impression with condensation silicone by the indirect technique was rejected, because there was no statistical difference between the impression materials and techniques tested. The hypothesis that there would be no difference in the microdeformation values between the addition silicon and polyether materials, both by the direct impression technique was accepted.

The limitation of this study is the use of only electrical strain gauge analysis and in prosthetic infrastructure made in monoblock; the microdeformation values might have been changed if isolated spot welds had been performed. Although the proposal of this research was to evaluate only the material and technique impression for implant-supported fixed dental prostheses. Further studies must be conducted using isolated welding and other complementary analyses.

Conclusion

The use of condensation silicone and the closed tray technique presented the lowest values of microdeformation around the implant.

The use of different impression materials associated with indirect and direct impression techniques, for the fabrication of infrastructures for implant-supported fixed dental prostheses presented no difference in the values of microdeformation around the implants.

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