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A Comparative Evaluation of the Peri-Implant Strain Transmitted Through Splinted and Non-Splinted Cement Retained Prostheses on Implants of Two Different Lengths: An In-Vitro Study

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***Abstract*---**Aim - The aim of this study was to evaluate and compare the peri-implant strain transmitted through splinted and non-splinted prostheses cemented on implants of two different lengths (8mm and 11.5mm) when subjected to an axial load. Method – The study was conducted on two polypropylene models on which implants of 8mm and 11.5mm length were placed in the molar region. Splinted and non-splinted prostheses were cemented to the implant abutments placed on the implants. Metal jig simulating the anatomy of the opposing tooth was casted and adapted to the prostheses. An axial

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load of 400N was applied to the assembly using Universal testing machine. The peri implant strain transmitted through these prostheses was recorded using strain gauges attached to Wheatstone bridge circuit. RESULT – The observations showed that implant length and splinting of the prostheses, both significantly affect the peri implant strain as analysed by one way ANOVA statistical test. [$F(3,36) = 1882.81$ $P<0.05$]. Lowest peri implant strain was observed in splinted prosthesis cemented on implant with 11.5mm length followed by non-splinted prosthesis on 11.5mm length implant followed by splinted prosthesis on 8mm length implant followed by non-splinted prosthesis on 8mm length implant.

***Keywords*---**biomechanics implants, implant length, implant supported prostheses, micro strain, splinting.

Introduction

Implant supported prosthesis is considered as one of the best predictable treatment options for rehabilitation of edentulous patients. The clinical success of rehabilitation by implant prostheses is predominantly related to the way that mechanical stresses are transferred from the implant to the surrounding bone without generating tensions that could endanger the longevity of the implants and prostheses (1). Peri- implant strain more than 4000 micro strain leads to pathologic fracture of the bone (2). The structure and design of the implants and prosthesis are important factors that affect the stresses generated in its surrounding bone consequently affecting peri- implant strain and implant stability (3). Hence, estimation of such effects gives a sense of correct geometry of implants for a successful treatment. There are varied range of options in front of the implantologists which should be analyzed biomechanically in relation with the individual's biological and anatomical conditions. There are different sizes of implants available in the market. Nowadays, short implants (i.e. length less than 10mm) have become the choice of implant in cases with well-rounded resorbed ridge due to the presence of important anatomical landmarks as these require advanced surgical techniques such as bone augmentation or inferior alveolar nerve in mandibular posterior region repositioning when used with standard sized implants. Natural teeth are splinted in order to decrease the stress and increase the stability of prostheses they receive; Similarly, the implant prosthesis can also be splinted to attain a better prognosis. The purpose of this study was to determine and compare the peri-implant strain transmitted through splinted and non-splinted cement retained prostheses on implants of two different lengths (8mm and 11.5mm) using strain gauge analysis.

Methodology

This study was carried out in the Department of Prosthodontics and Crown & Bridge in Bharati Vidyapeeth (Deemed to be University) Dental College and Hospital, Navi Mumbai. Two mandibular models of polypropylene material were 3D printed and labeled A and B. Four implants of diameter 4.2mm were placed in the molar region in these models using milling machine such that two implants

were adjacent to each other in both the quadrants (Figure 1). The distance between the 2 implants was calculated to be 5.5mm when the mesio distal dimension of the prosthesis was chosen to be approximately 9mm (Figure 2). Model A had implants of length 8 mm, model B had implants of length 11.5mm.



Figure 1. Mandibular models with implants

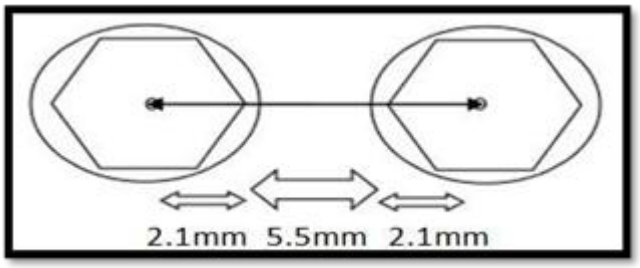


Figure 2. Schematic representation of the inter implant distance

Open tray implant level impressions of the models were made using addition silicone impression material with Coridentimplant impression tray (Figure 3). Implant analogues were attached to the impression copings and then the impressions were poured using die stone to obtain working casts of the models.

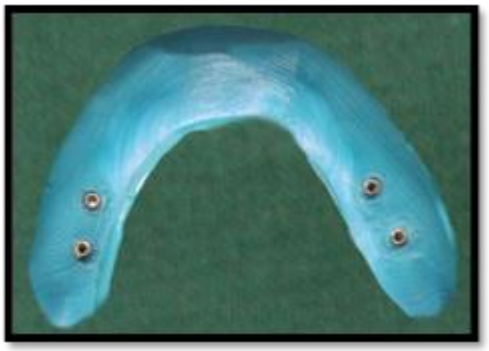


Figure 3. Open tray implant level impression

Abutments were screwed to the implant analogues and scanning of the models was done. CAD/CAM designing of the prostheses was done so that all the

prostheses were uniform dimensionally (Figure 4). On the left side of both the models splinted prostheses were designed and on the right side non splinted prostheses. The prostheses were milled and further finished and polished to obtain the final prostheses (Figure 5). The abutments were removed from the working cast and screwed to the implants and the access holes of the abutments were sealed using Teflon tape and composite. The final prostheses were cemented to the abutments placed on the implants in the polypropylene model using zinc poly carboxylate cement.



Figure 4. Designing of the prostheses using computer aided software



Figure 5. Finished and polished final prostheses

The study groups (Figure 6) were defined as follows:

- A1: Splinted prostheses cemented on implants with 8mm length
- A2: Non splinted prostheses cemented on implants with 8mmlength B1- Splinted prostheses cemented on implants with 11.5mmlength
- B2: Non splinted prostheses cemented on implants with 11.5mm length



Figure 6. Study groups

A metal jig was fabricated by casting its wax pattern so as to imitate the opposing occlusal surface and contact (Figure 7). Strain gauge chips were bonded to the buccal and lingual peri implant area. The terminal leads of the strain gauges were connected to a Wheat stone bridge circuit for measuring peri implant strain. A static axial load of 400N was applied to all the prostheses through metal jig using universal testing machine. The load application was done 10 times and the mean of the peri implant strain transmitted through each prostheses was recorded (Figure 8).

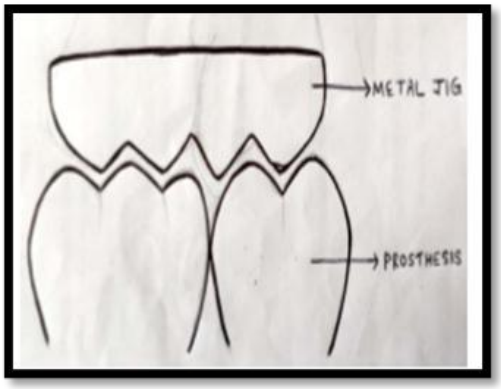


Figure 7. Diagrammatic representation of contact of metal jig with the prostheses



Figure 8. Load application and peri implant strain calculation

Observations and Result

Table 1
Mean of the peri implant strain transmitted through all the types of prosthesis in first molar region (in microstrain)

Type Of Prosthesis	Number Of Observations	Mean (μ)	Standard Deviation	Standard Error
A1	10	640.3	14.94	4.7
A2	10	761.7	16.46	5.2
B1	10	365.3	17.54	5.5
B2	10	493.3	10.78	3.4
F=1882.81	P<0.05			

There was a statistically significant difference in mean between the peri implant strain transmitted through different type of prostheses in first molar region as analysed by one way ANOVA statistical test. [$F(3,36) = 1882.81$ $P<0.05$] (table 1)

Table 2
Mean of the peri implant strain transmitted through all the types of prosthesis in second molar region (in microstrain)

Type Of Prosthesis	Number Of Observations	Mean (μ)	Standard Deviation	Standard Error
A1	10	505.5	23.13	7.3
A2	10	658.5	19.36	6.1
B1	10	264.7	13.72	4.3
B2	10	381.6	10.84	3.4

F =938.5 P<0.05

There was a statistically significant difference in mean between the peri implant strain transmitted through different prostheses in second molar region as analysed by one way ANOVA statistical test. [F(3,36) = 938.5 P<0.05] (table 2)

Thus, the results of this study can be summed up as follows:

- The peri implant strain transmitted through the prostheses included in the study were statistically different from each other.
- The highest peri implant strain was observed in case of non-splinted prosthesis fabricated on implant of 8mm length.
- The lowest peri implant strain was observed in case of splinted prosthesis fabricated on implant of 11.5mm length.
- Amongst the prosthesis fabricated on implants of 8mm length, the peri implant strain transmitted through non splinted prosthesis was higher than splinted prosthesis.
- Amongst the prosthesis fabricated on implants of 11.5mm length, the peri implant strain transmitted through non splinted prosthesis was higher than splinted prosthesis.

The peri implant strain transmitted through non splinted prosthesis fabricated on implants with 11.5mm length was lower than splinted and non-splinted prosthesis fabricated on implants with 8mm length in the second molar region.

Discussion

Any biomechanical stress which is induced on the implants is transmitted to the peri implant area4. This results in a deformation of the peri implant tissue, which is termed as peri implant strain5. When the force on the bone crosses its adaptive capacity, crestal bone loss, loss of osseointegration or even pathologic fracture of bone may occur leading to implant failure6. Hence the implantologist should have a thorough knowledge of all the factors that lead to these stresses and strain and should imbibe certain measures that decreases these forces on to the prostheses and peri implant tissue which in turn helps in prolonging the longevity of the treatment.

The present study aimed to compare two such factors, which were Implant length and Type of prosthesis (i.e., splinted or non-splinted) While, the remaining factors were kept constant to avoid any confounding effects. Short (8mm) and long

(11.5mm) implants were chosen for the study to compare the effect of the length of the implants on peri implant strain. Splinted and non- splinted cement retained prostheses were fabricated on implants with both the length to compare the effect of splinting of prostheses on peri implant strain. Based on the results of the present study, it was found that prosthesis fabricated on the longer implants transmitted lesser peri implant strain as compared to shorter implants. Also, splinting the prostheses helped in better distribution of the stresses and generated minimum strain.

The results of the study were in accordance to the studyconducted by Xi Ding (7) and Basile Georgiopoulos et al8, in which they concluded that with the increase in the implant length, there is decrease in the peri implant strain. While Cleidiel Aparecido Araujo Lemos et al using 3D finite element analysis documented that implant length had no influence on thestress distribution and peri implant strain (9). The study conducted by Chun Li Lin et al also indicated that peri implant strain increased with decrease in the density of the bone regardless of the implant length and suggested that bone quality and loading conditions are more influential factors, for determining peri implant strain, than implant length (10).

Short implants have now become the debatable topic amongst the dental professionals. The survival rate of short implants is found to be almost equivalent to that of a standard implant (11). Rather than opting for a complicated bone augmentation surgery, rehabilitation using short implants has become the preferred option. Literature suggests use of short implants, where the use of longer implants is limited due to anatomical consideration (12). Whenever possible the prostheses retained on these implants should be splinted with each other. Splinting implant supported prostheses is done to increase the retention and resistance form (13). Another rationale for splinting the prostheses is to distribute the non axial forces favourably and minimizing its transmission to the supporting hard and soft tissues. This practice of splinting is inspired by the concept of splinting natural periodontally compromised teeth, which believes that joining the units together improves the resistance of those units to the forces and stresses subjected to them (14).

The observations of the present study were reproducible to that of the study conducted by Guichet et al (15) and Ebadian Behnaz et al16, which was, that the peri implant tissues around cemented splinted restorations exhibited lesser strain than non- splinted restorations. Ipsha Rani et al also conducted a study to compare peri implant strain transmitted through different types of implants supported prostheses (17). They concluded that cement retained splinted prostheses generated the least strain amongst all the groups they studied. Further studies should consider evaluating the effect of other factors that affect the forces acting on peri implant tissue. These factors include bone density, implant diameter, implant angulation, number of implants, loading time of the implants, surface treatment of the implants, occlusal material used for prosthesis, etc.

Conclusion

Thus, within the limitations of this in-vitro study, it can be concluded that-:

- Both the parameters included in the study, i.e. implant length and type of prostheses (splinted or non-splinted) affect the peri implant strain. Prostheses cemented on longer implants transmit lesser peri implant strain as compared to prostheses cemented on shorter implants. Splinting the adjacent prostheses distributes the forces applied to the prostheses favourably resulting in a much lesser peri implant strain as compared to non splinted prostheses.
- Implants with longer length should be used whenever possible clinically after evaluating crown to implant ratio.
- Prostheses fabricated on shorter implants should be splinted so as to reduce the peri implant strain generated.

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