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STRESS ANALYSIS OF MANDIBULAR FULL FIXED PROTHESIS SUPPORTED BY THREE IMPLANTS WITH DIFERENT DISTAL TILTED IMPLANTS

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Abstract. *This study evaluated the stresses induced in periimplant mandibular full fixed prosthesis by distinct designs. Six photoelastic models with 5 or 3 implants were fabricated, simulating edentulous mandible. Control group (C) received 5 upright implants and other models received 3 implants ranging the distal abutment straight (S) or angled (A) and the distal tilt implant 0°, 17° or 30°. Vertical loads were applied at two points of the framework: the distal implant and the final of cantilever. Twenty points were determined around near implant of the loading for stresses calculation. Statistical analysis was performed by ANOVA and Tukey's B test (α = 0.05). For the cantilever loading was not found statistical difference between groups (p = 195). Under distal implant loading the groups S17 and S30 were significantly higher than the group C (p = 0.000). The angled abutments not showed higher stress during the distal implant loading and the final of cantilever loading. The shear stress is at the cantilever loading than distal implant loading.*

Keywords: *edentulous, photoelastic, dental prosthesis, tilted implants*

1. INTRODUCTION

Full fixed prosthesis (FFP) rehabilitation with supported by 5 implants gained modifications over the years in order to facilitate the indications for each patient second Rivaldo et al. (2012), such as decreasing the implants number, the inclination of the distal implant, the prosthetic components type, the infrastructure type, the welding process and the prosthesis material.

The success of these alternative protocols depends of the mechanical behavior of the loads transferred from the joint prosthesis, prosthetic components and framework of the implants. Factors such as region (bone type), implants tilted, interface abutment / implant have been reported as influential in peri-implant tensions. Using distal implants tilted splinted in FFP with reduced cantilever showed lower stress in the prosthesis / implant Bevilacqua et al. (2008).

The cantilever arm is hanging in the balance with just a foothold. Full fixed prosthesis cantilever size has been associated with major clinical peri-implant that could increase the marginal bone loss according to White et al. (1994).

The purpose of this study was to investigate the peri-implant FFP supported by 3 implants with different configurations of the distal implant. The null hypothesis is based on that study that there is no difference between the groups in the loading of the implant and the distal end of the cantilever loading.

2. MATERIALS AND METHOD

Six photoelastic models were fabricated simulating an edentulous mandible (Tab. 1).

Table 1. Groups description
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Models	Numbers of Implants	Distal Tilted Implant	Distal Prosthetic Component	Cantilever Size
C	5	0 °	Micro-unit reto	15 mm
S	3	0°	Micro-unit reto	15 mm

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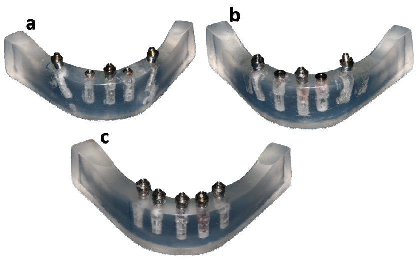
S17	3	17°	Micro-unit reto	9,7 mm
A17	3	17°	Micro-unit angulado 17 °	11,2 mm
S30	3	30°	Micro-unit reto	5,6 mm
A30	3	30°	Micro-unit angulado 30 °	7,8 mm

2.1 Metal framework procedure

The frameworks were made with prefabricated titanium bars welded to copings installed on the abutments of master models fig. 1. The TIG (Tungsten Inert Gas) welding was used.

Figure. 1. Master Models.



2.2 Stress analysis

The 6 photoelastic models were underwent two load conditions: the distal implant and the cantilever end. In order to standardize fringe order reading and shear stress calculation, was used a program called *FRINGES*, developed in FEMEC / LPM. A grid of 20 points was designed at the implant region closest to the load fig. 2.

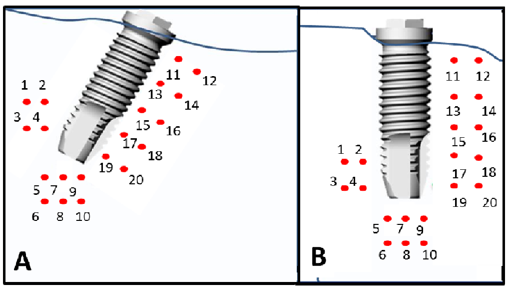


Figure 2. A- distal tilted implants to groups A17 and A30; B- distal upright implants to groups C, S, S17 and S30.

2.3 Statistical analysis

In order to check the differences between the shear stress value between models of each loading was carried out statistical analysis ANOVA followed Tukey's B conducted by SPSS, the significance level α = 0.05.

3. RESULTS

3.1. Distal implant loading

Qualitative analysis shows the order fringe behavior (Fig. 3).

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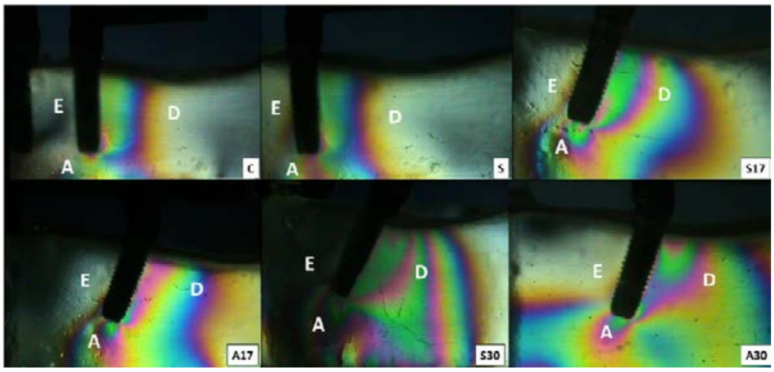

Figure 3. The group C and group S had similar stress concentration on regions A (apex) and D (right) the fringe order were between 1 and 2. For group S17, A17, A30 and S30 the standard stress concentrations were in regions A and D of the implant and the near marginal bone right too. In group S17 fringe order were among 1, 2 and 3. For the group A17 the order fringes were among 1, 2 and 3. For the group S30 the order fringes were among 1, 2, 3 and 4. For the group A30 the orders fringe were among 1, 2 and 3.

The distal implant loading Tab. 2 shows the mean and standard deviation (SD) in 20 points on the distal implant contour.

Table 2. Mean and SD of the shear stress (Kpa) during distal implant loading.

Groups	Mean (SD)
C	10.36 (3.74)[a]
S	11. 03 (2.06)[a,b]
A17	12.23 (2.85)[a,b]
A30	14.95 (3.08)[a,b]
S17	15.60 (4.89)[b]
S30	19.25 (4.37)[c]

[a,b,c] Different letters represent statistical significance

3.2. Cantilever end loading

Qualitative analysis shows the behavior orders fringe (Fig. 4).

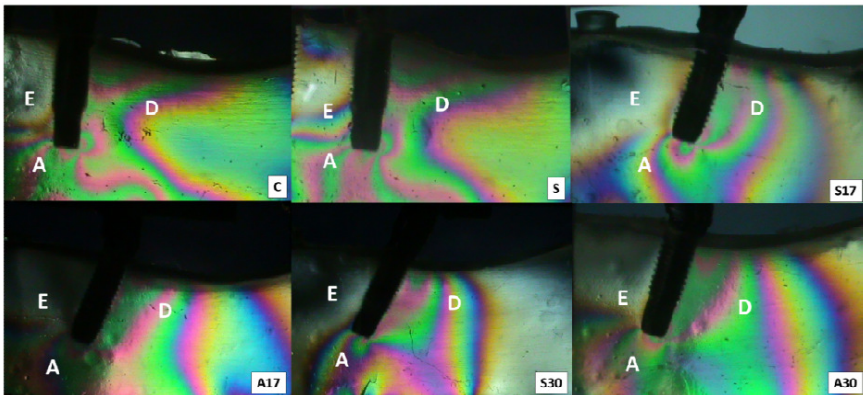

Figure 4. The group C and S had the similar stress concentration in the regions A (apex), D (right) and left (E) the order fringes were among 1, 2, 3 and 4. In the group S17 the order fringes were among 1, 2, 3 and 4. For the group A17 order fringes were among 1, 2 and 3. For the group S30 the order fringes were among 1, 2, 3 and 4. For the group A30 the order fringes were among 1, 2, 3 and 4.

The cantilever end loading Tab. 3 shows the mean and standard deviation (SD) in 20 point on the distal implant contour.

Table3. Mean and SD of the shear stress (Kpa) during distal implant loading.

Groups	Mean (SD)
C	19.68 (8.47)

S	22.78 (6.22)
A17	20.80 (9.61)
A30	20.74 (9.04)
S17	19.44 (8.49)
S30	15.99 (7.01)

4. DISCUSSION

The study hypothesis was partially accepted because during the cantilever end loading no differences statistics between groups C, S, S17, A17, A30 and S30 ($p = 0.195$). During the distal implant loading among models C, S, A17, A30 were no differences. Between groups S17 and C, between groups S30 and C and between groups S17 and S30 there were statistical differences ($p < 0.05$) Table 2. Standard abutments can be used when the tilted implants are splinted with the framework but have clinical difficulties when the tilted distal implants distal are used, due to the hole access to the abutment screw loosening and tightening with the wrenches, molding procedure and interocclusal record difficulty, interference bar fit and expending more clinical time. Angled abutments may offer clinical solution besides correcting the angulation path of the implant according to Kim et al. (2011). In addition to that during the distal implant loading the abutments upright had worst behaviors that angulated abutments.

No statistical difference was found between models when applied the cantilever end loading ($p = 0.195$), the mean and SD are shown in Table 3. The cantilever decrease with the implant inclination in some finite element analysis studies showed a decrease stress accordingly the inclination increase of the distal implants and decreased cantilever from 15 to 5 mm in the compact bone second Bevilacqua et al. (2008). When only the cantilever length, without implants tilted, prostheses with shorter cantilever had lower stress according to White et al. (1994). According to Kim et al. (2011) using photoelastic method for evaluating protocols supported by 4 implants, the distal implant angulation at 30 ° decreasing the maximum stresses in the marginal distal ridge to the distal implant. Studies of the implant tilted and distal abutments may find a clinical protocol with optimal settings.

Regardless of the configuration and implants number it can be observed that the region of greatest stress is the area closest to the cantilever. Clinical accompaniments should be performed with prosthesis and protocol 3 supported by implants to indicate the success and failures of this biological system.

5. CONCLUSIONS

The Full Fixed Prosthesis with distal implants tilted supported by three implants is an alternative to reduce the cantilever length and angled abutments in distal tilted implants splinted may be used due to good results. Group C showed good results in both loading types.

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8. RESPOSABILITY NOTICE

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