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BASIC RESEARCH

Stability of diameter reduced one-piece zirconia implants. An investigation in the chewing simulator

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Abstract

The purpose of this investigation was to assess the effects of hydrothermal aging and mechanical fatigue on the long-term stability of zirconia implants. The aging/fatigue of the implants was performed in a chewing simulator through hydrothermal and/or dynamic loading. Subsequently, all implants that survived the aging and/or loading procedure, were submitted to a static loading test until fracture. Aging and simultaneous loading had a negative effect on the stability of one-piece diameter reduced zirconia implants and led to a reduced fracture resistance. However, within the limits of this in vitro investigation, it can be concluded, that the investigated implant system will withstand functional loading over an extended time period.

Group		Fracture strength (N)	Bending moment (Ncm)
A loaded/ aged	mean	512	283
	sd*	47	28
B loaded/ not-aged	mean	569	314
	sd	30	18
C not-loaded/ aged	mean	588	324
	sd	39	22
D not-loaded/ not-aged	mean	516	285
	sd	67	38

Table 1: Fracture strength and bending moment – mean values; * = standard deviation

Background and Aim

Yttria-stabilized tetragonal zirconia (Y-TZP) is known as a ceramic material with high fracture strength and long-time stability. Therefore, oral implants made from Y-TZP represent an available alternative to titanium implants. However, Y-TZP is prone to low-temperature-degradation (LTD), a spontaneous phase transformation in the presence of water molecules in low temperatures, which can result in reduced strength and reduced long-term stability especially with reduced diameter implants (Sanon et al. 2013).

The aim of the present in-vitro study was to evaluate the long-term stability of one-piece diameter reduced zirconia oral implants under the influence of loading and artificial aging in a chewing simulator as well as the fracture strength in a static loading test.

Methods and Materials

32 one-piece zirconia implants (ZIBONE; Ø: 3.6 mm) were embedded according to ISO 14801 (embedding angle: 30º, lever arm: 5.5 mm) (Figure 1).

Figure 1: Embedded implant

The implants were divided into four groups @ 8 implants (group A: loaded/aged; B: loaded/not-aged; C: not-loaded/aged; D: not-loaded/not-aged). All samples of groups A and B were loaded in a chewing simulator with 10^7 cycles and with a force of 98 N. Hydrothermal aging of the samples of groups A and C occurred in a hot water bath at 85 °C. Loading and aging of group A took place simultaneously. One sample of each group was microstructurally evaluated (not part of this poster). All implants that survived the chewing simulation (n=27; specimen A4 fractured during simulation) were statically loaded to fracture in a universal testing machine. A one-way ANOVA was applied to evaluate group differences onto the fracture stability and bending moments. The method of Bonferroni was used to correct for multiple testing after pairwise comparisons. The level of significance was set to $p < 0.05$.

fracture strength	one-way-ANOVA	p = 0,016	
	pairwise comparison	p-value	significance
	A vs B	0.266	not significant
	A vs C	0.053	not significant
	A vs D	1.000	not significant
	B vs C	1.000	not significant
	B vs D	0.304	not significant
	C vs D	0.058	not significant

Table 2: Fracture strength - comparison

Results

Groups B and C had a survival rate of 100% after loading or aging. Group A showed a survival rate of 87.5% after loading/aging. In the static loading test, group C showed a fracture strength (mean ± SD) of 588 ± 39 N, group B of 569 ± 30 N and group D of 516 ± 67 N. Group A revealed with 512 ± 47 N the lowest fracture strength (Figure 2). A one-way ANOVA revealed a statistically significant difference between the groups (p = 0.016) (Table 2). The pairwise comparisons between group C and group A showed a large difference of 76.5 N (p = 0.053), as well as between group D and group C with 72.6 N (p = 0.058). They were, however, not significant due to the Bonferroni correction. The calculation of the average bending moments (the lever arms in all groups were 5.5 mm) revealed the following values (mean ± SD): Group A: 283 ± 28 Ncm; B: 314 ± 18 Ncm; C: 324 ± 22 Ncm; D: 285 ± 38 Ncm (Table 1). These values were not statistically significant different.

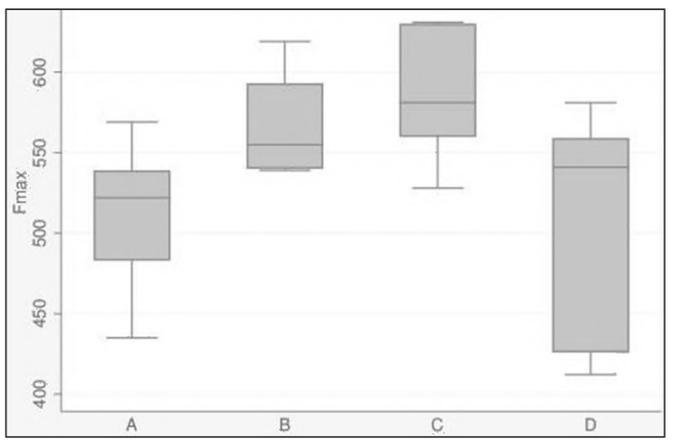

Figure 2: Fracture strength - boxplots

Conclusion

Hydrothermal aging and simultaneous loading had a negative effect on the fracture stability of one-piece diameter reduced zirconia implants. Although, the bending moment values are small compared to other investigations, it has to be mentioned that reduced diameter implants were evaluated. Within the limits of this investigation, it can be concluded, that the investigated implant system is able to resist physiological chewing forces long-term.

References

1. Sanon C, Chevalier J, Douillard T, et al. Low temperature degradation and reliability of one-piece ceramic oral implants with a porous surface. Dent Mater. 2013;29(4):389-397.

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