R E P O R T

DENTAL DYNAMIC ABUTMENT AND IMPLANT SYSTEM. RESULTS OF FATIGUE RESISTANCE TO COMPRESSION BENDING

On request of: **TALLADIUM ESPAÑA**

NOVEMBER 2008

SIGNATURES AND AGREEMENT CONDITIONS

Date: 03/11/2008

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C o n t e n t s

1. INTRODUCTION, ANTECEDENTS AND OBJECTIVES

This report presents the results related to fatigue tests of compression bending for a dental dynamic abutment and implant system, according to the standard ISO 14801:2007 *Dentistry – Implants – Dynamic fatigue test for endosseous dental implants*.

The tests have been requested by the company TALLADIUM ESPAÑA, S.L. sited in Avda. de Madrid, 17 - Altillo 1ª. 25002- Lleida (SPAIN).

2. MATERIAL AND METHODS

The description of the tested specimens is presented in Table 1.

Element	Reference	Description	Material	Measures
Abutment	PDINT	Dynamic abutment of internal connection	Tilite with Titanium	D 4.8 mm α 20º
Screw	TPDSYN	Synocta dynamic abutment screw	Grade 5 – Titanium alloy	Torque 30 N·cm
Transepithelial	EBRPL43	Dynamic abutment transepithelial for Replace internal connection	Titanium	Height 0.8 mm Torque 35 N·cm
Implant	29414	Dental implant Nobel Biocare Replace Select Tapered TiUnite RP	Titanium	D 4.3 mm L 13 mm

Table 1. Description of the tested specimens

The loading geometry for the tests (Figure 1) is described in section 5 of the standard ISO 14801:2007. Figure 2 shows some pictures of the test set-up.

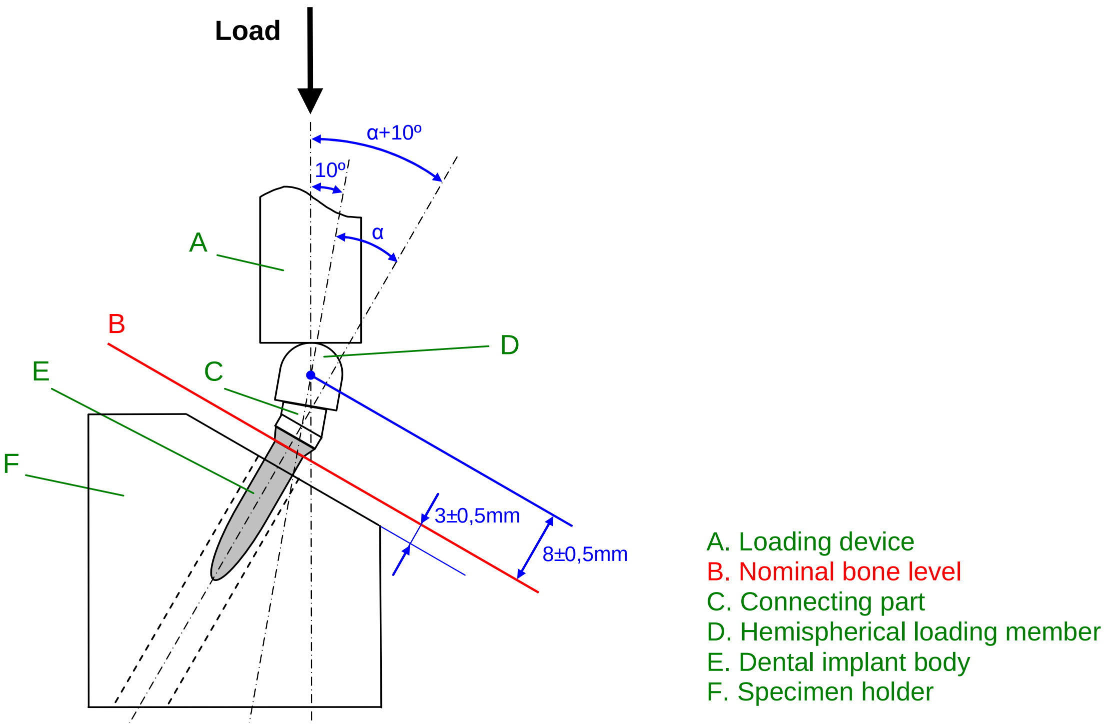

Figure 1. Loading geometry for the tests (α=20º) (ISO 14801:2007)

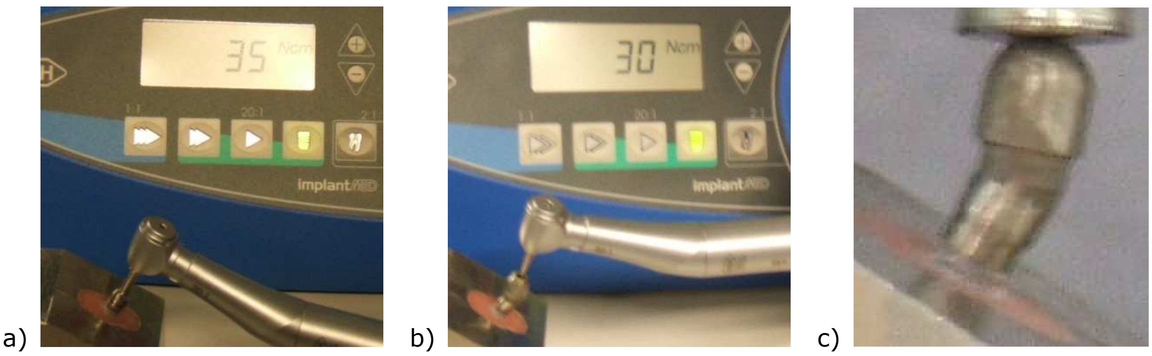

Figure 2. Test set-up for the dental dynamic abutment and implant system:
a) Tightening the transepithelial, b) Tightening the screw, c) Testing the specimen.

Fatigue resistance to compression bending of the dental abutment and implant system has been evaluated by building a load-cycle diagram (S-N curve or Wöhler curve). The devices have been tested at cyclically varying loads of predetermined amplitude and the number of load cycles until failure occurs has been recorded. Results have been summarized by representing in a diagram the number of load cycles endured by each specimen (on a logarithmic scale) and the corresponding peak load (on a linear scale) (Figure 3). From the load-cycle diagram the fatigue limit (L_F) of the object can be determined, being the maximum peak load for which fatigue does not occur at an infinite number of loading cycles or at a number of cycles n_F selected for termination of the test.

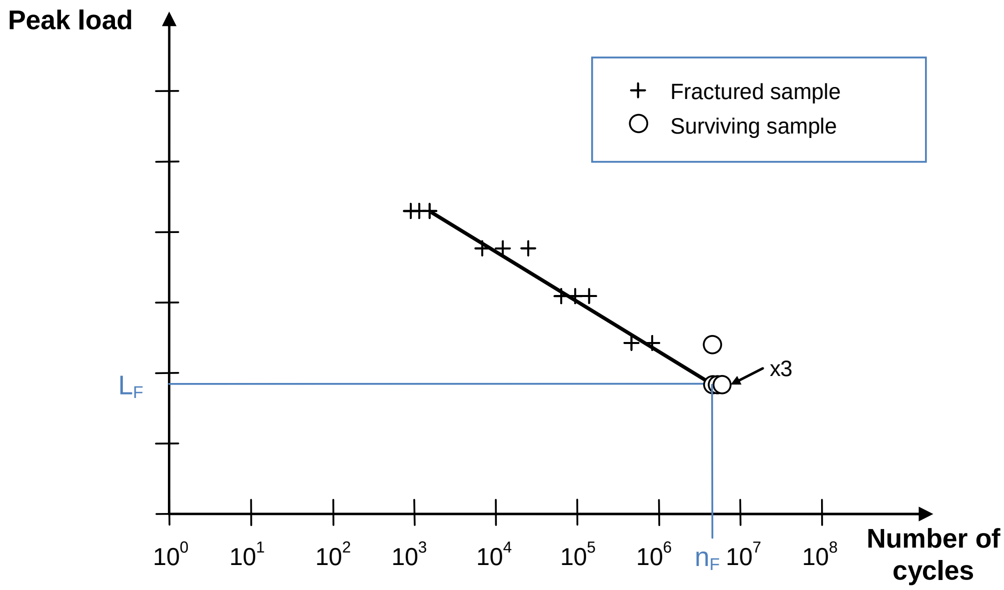

Figure 3. Load-cycle diagram for tests run until $5x10^6$ cycles

With the aim of generating a load-cycle diagram for the dental abutment and implant system, the standard ISO 14801:2007 recommends to test the specimens at a series of loads until a lower limit is reached at which at least three specimens survive and none fails in the specified number n_F of $5x10^6$ cycles for testing conducted in air at frequencies between 2 Hz and 15 Hz. An appropriate starting load is 80% of the load to failure reached in a previous static test performed using the same test geometry and environmental conditions. The standard recommends to test the devices in at least four load levels and to carry out at least two, and preferably three, repetitions at each level, being necessary that at least three specimens survive at the maximum endured load.

3. RESULTS

Table 2 presents the results of static tests of the dental abutment and implant system which were carried out previously to the fatigue tests and with the same test geometry and environmental conditions. The values of this table correspond to the mean and standard deviation of the five specimens tested.

System	Stiffness (N/mm)	Load at the yield point (N)	Displacement at the yield point (mm)	Load at the rupture point (N)	Displacement at the rupture point (mm)
Dynamic abutment system	**4207 ± 654**	**1833 ± 528**	**0,51 ± 0,10**	**2182 ± 318**	**0,79 ± 0,13**

Table 2. Results of static tests

According to the recommendation of the standard ISO 14801:2007, the starting load level for the fatigue tests of the dental abutment and implant system has been defined as 80% of the load to static failure. Depending on the results obtained for each load level, the following procedure has been followed: if the system has withstood $5x10^6$ cycles at a specified load level then the next level load has been increased, otherwise it has been decreased. The total number of load levels applied has been four, and two specimens have been tested at each level except for the fatigue limit at which three specimens have been tested. Therefore, the total number of specimens tested has been nine.

Table 3 shows in chronological order the testing procedure followed, and Figure 4 presents the resulting load-cycle diagram for the dental dynamic abutment and implant system. Results, as well as mode of failure of the specimens, are described in detail in the ANNEX. From the results obtained it can be concluded that the fatigue limit of the tested system is **436,4 N**, at which three specimens have survived.

Load level	Peak load (N)	Specimen	Number of cycles
1	1091	1	597.059
		2	1.325.883
2	763,7	3	727.025
		4	768.896
3	436,4	5	5.000.000
		6	5.000.000
		7	5.000.000
4	1418,3	8	15.194
		9	6.486

Table 3. Procedure followed in the fatigue tests of the dental dynamic abutment and implant system

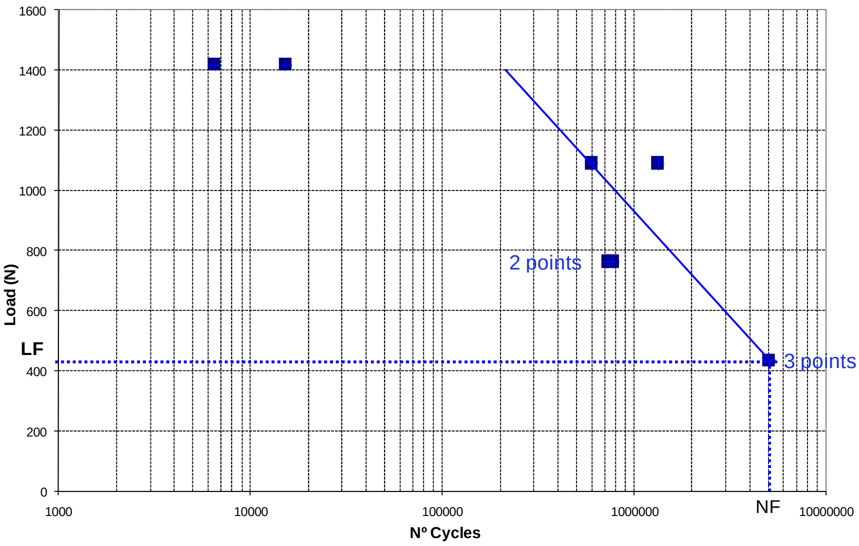

Figure 4. Load-cycle diagram for the dental dynamic abutment and implant system

4. ANALYSIS OF RESULTS

Fatigue limit of the dental dynamic abutment and implant system has been **436,4 N**, with the test geometry indicated in the standard ISO 14801:2007.

The tested systems are used in anterior and posterior teeth. Scientific studies about masticatory forces with natural teeth in several materials have been found, which have observed peak values between **5 and 54 N** for incisive and canine teeth (Gay *et al.*, 1994; Dan *et al.*, 2003; Kohyama *et al.*, 2004a, 2004b, 2005; Johnsen *et al.*, 2007; Xu *et al.*, 2008) and peak values between **50 and 284 N** for premolar and molar teeth (Morneburg and Pröschel, 2003; Kohyama *et al.*, 2004a, 2004b; Johnsen *et al.*, 2007). The fatigue limit obtained in the performed tests of fatigue resistance widely exceeds these peak load values.

5. CONCLUSIONS

In conclusion it can be stated that the results obtained in the fatigue tests for the dental dynamic abutment and implant system are satisfactory, as the fatigue limit obtained is higher than the usual masticatory forces.

In the fatigue tests, the dental dynamic abutment and implant system has reached a fatigue limit of 436,4 N. The masticatory peak load with incisive and canine teeth ranges from 5 to 54 N and the masticatory peak load with premolar and molar teeth ranges from 50 to 284 N. Therefore, results of the fatigue tests are satisfactory because the fatigue limit obtained is higher than the loads expected during the usual activity of the dental abutment and implant system.

6. REFERENCES

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ANNEX

REPORT. Dental implants. Evaluation of fatigue resistance to compression bending

R E P O R T

DENTAL IMPLANTS. EVALUATION OF FATIGUE RESISTANCE TO COMPRESSION BENDING

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SIGNATURES AND AGREEMENT CONDITIONS

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Date: 30/10/08

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C o n t e n t s

1. INTRODUCTION AND OBJECTIVES

The objective of this test is to evaluate the fatigue resistance to compression bending of a dental dynamic abutment and implant system.

The tests have been requested by the company TALLADIUM ESPAÑA, S.L., sited in: Avda. de Madrid, 17 - Altillo 1ª. 25002- Lleida (SPAIN).

2. MATERIAL AND METHODS

The test sample and its codification appear in the following table:

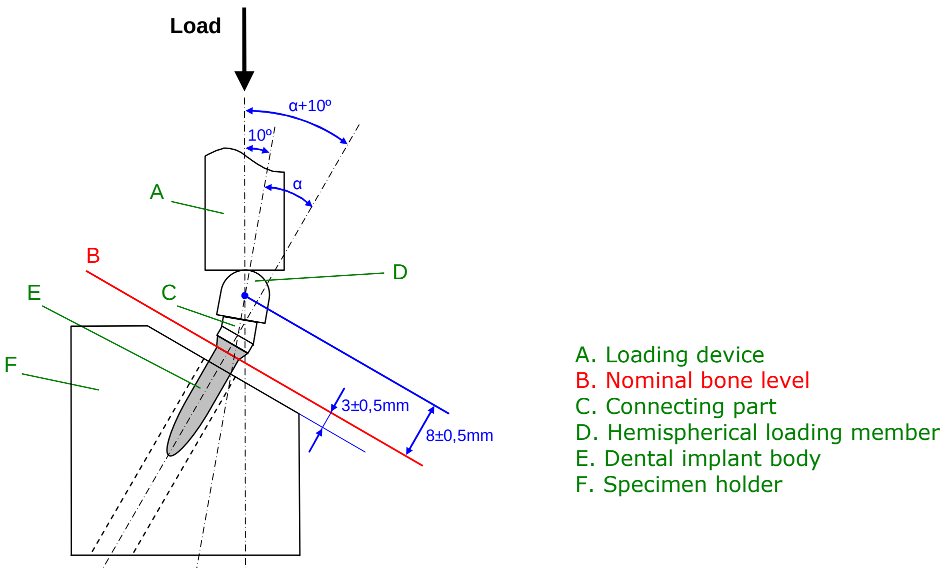
CODE	DESCRIPTION	UNITS
MU08-0742	Dynamic abutment systems formed by: one dynamic abutment of internal connection D4.8 (PDINT), one screw (TPDSYN), one transepithelial for Replace internal connection D4.3 (EBRPL43) and one dental implant Replace Select Tapered TiUnite RP D4.3xL13 from Nobel Biocare (29414).	9

The test samples will be given back to the client after the tests.

The tests have been performed using an INSTRON 8872-8874 universal testing device.

The tests have been done from 22nd September 2008 to 21st October 2008, with an ambient temperature of 20-23ºC and humidity of 45-64%.

For the test, the implant is inserted between the actuators of the testing machine and cyclically varying compression loads are applied as shown in the following picture.



The conditions of test for each sample have been:

- The cyclically varying compression loads have been applied as a haversine with the values of amplitude, preload, peak load and order indicated in the table.

PEAK LOAD (N)	AMPLITUDE (N)	PRELOAD (N)	ORDER
1418,3	1276,5	141,8	4
1091,0	981,9	109,1	1
763,7	687,3	76,4	2
436,4	392,8	43,6	3

- The loading frequency has been 7 Hz.
- The test has been finished, for each load value, when the specimen failure has occurred or when the sample has reached $5x10^6$ cycles with no failures.

3. RESULTS

The following table presents the number of cycles that the implant has withstood for each of the loading values applied:

PEAK LOAD (N)	NUMBER OF SPECIMENS TESTED	NUMBER OF CYCLES	OBSERVATIONS
1418,3	2	15.194	[1]
		6.486	[1]
1091,0	2	597.059	[1]
		1.325.883	[1]
763,7	2	727.025	[2]
		768.896	[1]
436,4	3	5 Millions	-

[1] Failure is produced because of rupture of the transepithelial screw that joins the abutment and the implant. Some cracks are observed at both sides of the implant (Figure 1).

[2] Failure is produced because of rupture of the transepithelial screw that joins the abutment and the implant. No cracks are observed at the implant (Figure 2).

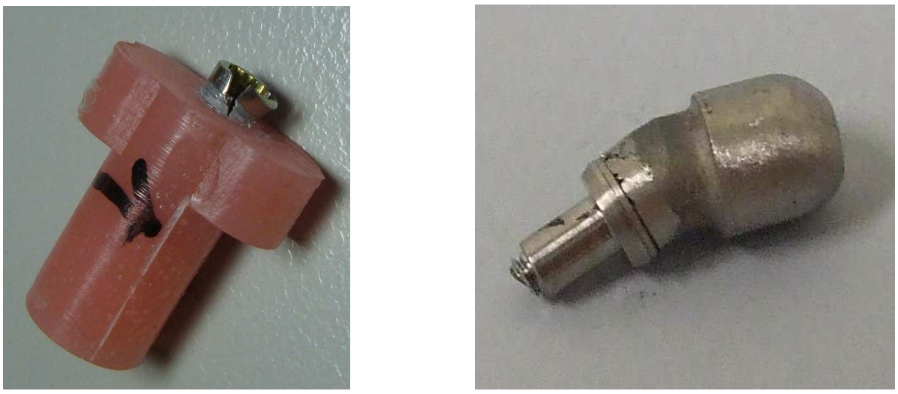
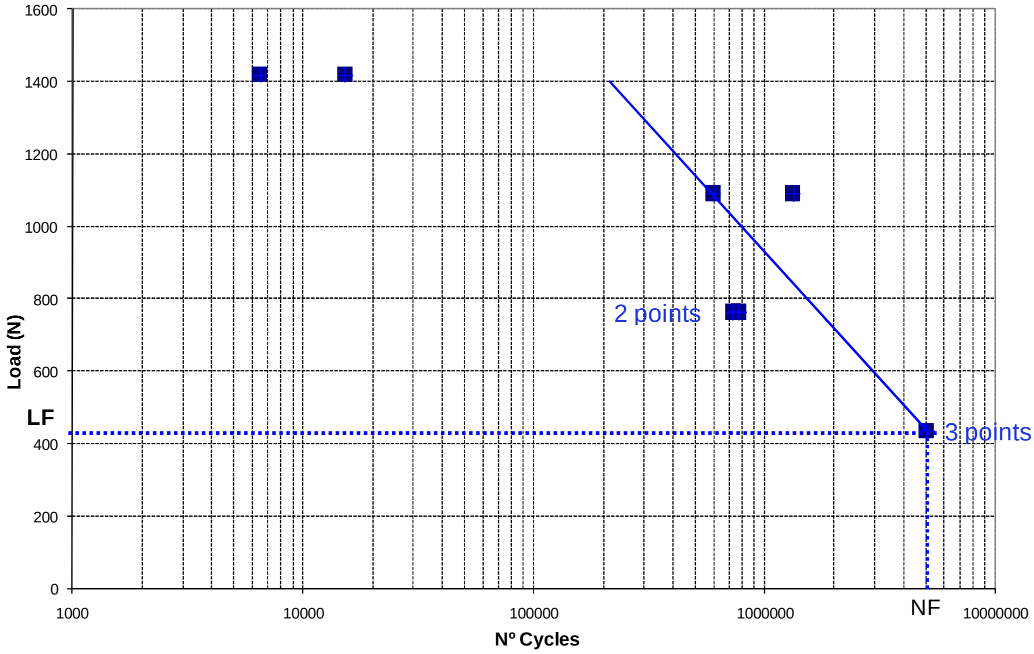


Figure 1

Figure 2

Next, the load-cycle diagram is included:



LF: Fatigue limit   NF: Number of cycles resulting in no failure