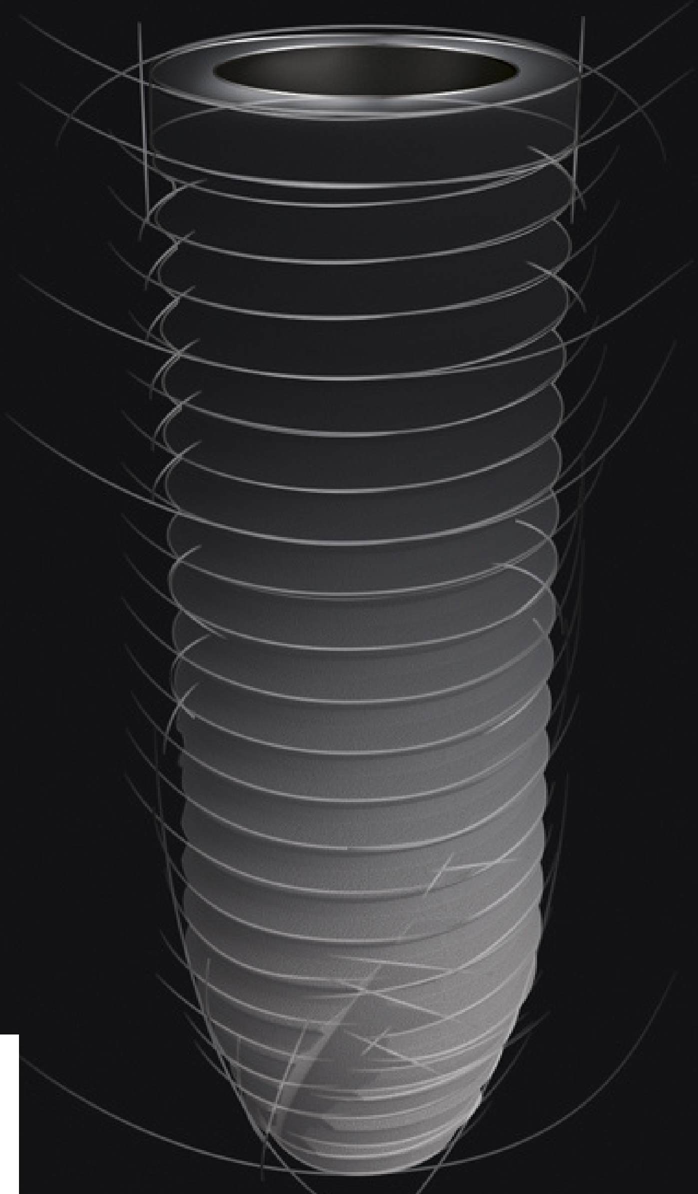
Mechanical and Stress Test on AISER Dental and Zygomatic Implants

DEPARTMENT OF CHEMISTRY, MATERIALS AND CHEMICAL ENGINEERING "GIULIO NATTA"
LABS - LABORATORY OF BIOLOGICAL STRUCTURE MECHANICS



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AISER

Test goal

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DIPARTIMENTO DI CHIMICA,
MATERIALI E INGEGNERIA CHIMICA
GIULIO NATTA

MECHANICAL TEST ON AISER SA M30D35VH2 – THD35V DENTAL IMPLANTS

The test goal is to evaluate and measure the static and fatigue mechanical resistance of Aiser SA dental implants connected to angled abutments.

Tests have been performed according to ISO standard 14801 – 2016 “Dentistry - Implants - Dynamic loading test for endosseous dental implants”.

MATERIALS

M30D35VH2 – THD35V DENTAL IMPLANTS

Test specimens

Tests have been performed on dental implants composed of an endosseous implant with transmucous screw and a 30° angled abutment.

The implants have been supplied mounted in cylindrical Titanium supports properly custom-made for the testing machine grips.

The different parts of the implant were assembled by the manufacturer. According to the configuration proposed in ISO 14801: 2016, the implant long axis was inclined as reported in Figure 1, simulating an undercorrection of 10°; the implant was supported 3 mm below the anticipated crestal bone level, simulating 3 mm of bone resorption. A total of 3 specimens were used for the static tests and 16 for the fatigue tests.

The reference numbers, as well as the internal names given by Politecnico di Milano, are reported in Table 1.

Table 1 – Specimen and test description

LaBS ID	Description of the specimen	Lot	Test
18/27/THD 30°- S 01 … 03	M30D35VH2 (Multi Unit Abutment Violet 30°) THD35V(Themys Implant Violet)	B7K08-R 00B7L80-K	static
18/27/THD 30°- F 01 … 16	M30D35VH2 (Multi Unit Abutment Violet 30°) THD35V(Themys Implant Violet)	B7K08-R 00B7L80-K	fatigue

Testing machine

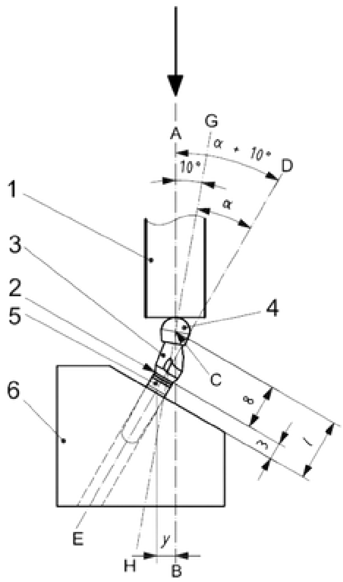


Figure 1. Implant configuration according to ISO 14801

The tests have been performed either on: - a MTS 858 Bionix servohydraulic testing machine (S/N 1014952, MTS, Minneapolis, MN). The MTS testing machine is equipped by an axial - torsional hydraulic actuator, with 25 kN axial capacity and 250 Nm torsional capacity, a ±100 mm range LVDT displacement transducer and a ±140° range ADT angular transducer mounted on the actuator.

The load applied to the test sample is measured by a MTS axial/torsional load cell (model 662.20D-05, S/N 1007099, ± 25 kN maximum axial load, ± 250 Nm maximum torsional load).

The machine is driven by Test Star 790.01 digital controller or on - a MTS 858 MiniBionix servohydraulic testing machine (S/N 1014952, MTS, Minneapolis, MN). The MTS testing machine is equipped by an axial - torsional hydraulic actuator, with 15 kN axial capacity and 150 Nm torsional capacity, a ±100 mm range LVDT displacement transducer and a ±140° range ADT angular transducer mounted on the actuator.

The load applied to the test sample is measured by a MTS axial/torsional load cell (model 662.20D-04, S/N 1011239, ± 15 kN maximum axial load, ± 150 Nm maximum torsional load). The machine is driven by Test Star 790.01 digital controller.

Testing procedure

Criteria

The bending that rises when masticatory load acts with an angle to the implant axis, and not parallel to it, causes the worst loading situation for dental implants. In order to achieve that situation, the implants have been mounted on the testing machine with a total 10° angle to the vertical axis.

The stress state in the implant due to that load and the way of applying it is particularly severe and determines the implant specimen failure due to bending.

Test setup

A sketch of the set-up is shown in Figure 2 while in Figure 3 a picture of a specimen during the test is reported. Between the spherical head of the abutment and the load plane a greased metallic plate able to slide in lateral direction is interposed so that the lateral constraint that may arise due to bending is minimized (see Figure 3).

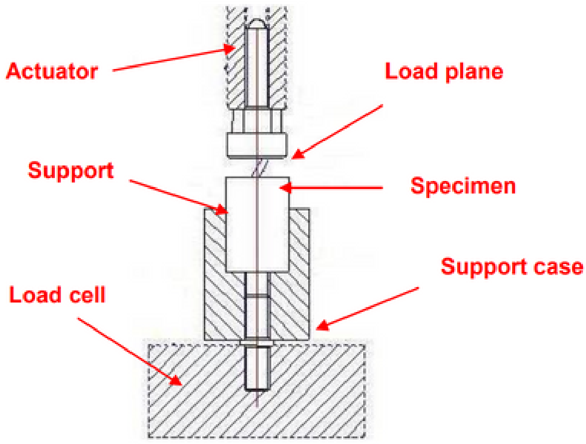


Figure 2 – Sketch of the experimental set-up for fatigue tests

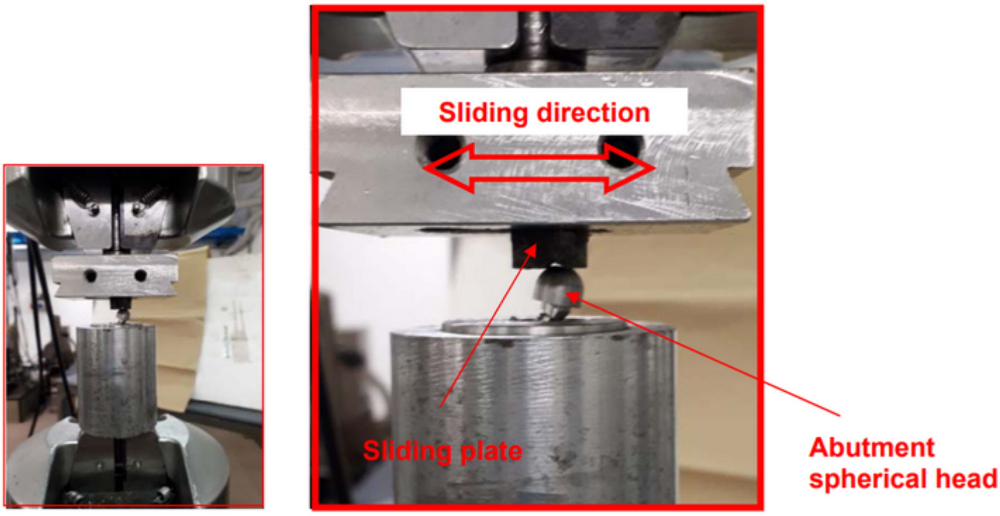


Figure 3 - Specimen during the test

Testing procedure

Static test procedure

Tests have been performed by increasing the load until specimen failure. The tests have been carried out in monotonic compression under displacement control mode at a rate of 2 mm/min. Using the control software of the test machine the values of the displacement of the actuator and the force measured by the load cell have been acquired. The applied moment has been calculated by multiplying the applied force by the moment arm (y in Figure 1): y value has been calculated according to the formulas reported in Appendix 1. The values of the applied bending moments have been reported in Table 2.

Table 2 – Results of static tests

LaBS ID	Maximum load [N]	Maximum bending moment [Nmm]	Figure
18/27/THD 30°- S 01	537	1890	Figure 4
18/27/THD 30°- S 02	626	2204	Figure 4
18/27/THD 30°- S 03	595	2094	Figure 4

Fatigue test procedure

In order to build the Wöhler fatigue curve for a dental implant, ISO 14801 standard prescribes to test some specimens until rupture and three further specimens that must withstand 5 million cycles without failure. The choice of the load levels is based on the results of the static tests. Tests have been conducted under force control, applying a sinusoidal waveform ranging between a maximum value (reported in Table 3) and a minimum value, with a ratio equal to 0.1 (minimum value = 10% maximum value). The applied moment has been calculated by multiplying the applied force by the moment arm (y in Figure 1): y value has been calculated according to the formulas reported in Appendix 1. The values of the applied bending moments have been reported in Table 3. Tests have been conducted at the maximum frequency compatible with the control capabilities of the testing machine and, in any case, not higher than 15 Hz

A zero value for the displacement is set at the beginning of the test, when the actuator comes in contact with the spherical head placed on the top of the abutment; a 0.3 mm displacement limit is then set so that the machine automatically stops if such value is reached, thus indicating a failure of the implant.

Results

The results of the static test are reported as follows: - maximum load and maximum bending moment (reported in Table 2) - load – displacement curve The results of the fatigue tests are reported as follows: - cycles withstood by each specimen: if the specimen reaches 5.000.000 cycles without rupture the test automatically stops;

Table 2 reports the maximum value for the load registered during the static tests; the load displacement plots are given in the annexes (Figure 4). In all the cases, the failure was due to yielding and plastic deformation of the neck of the implant: images of the yielded implants are reported in Figure 6.

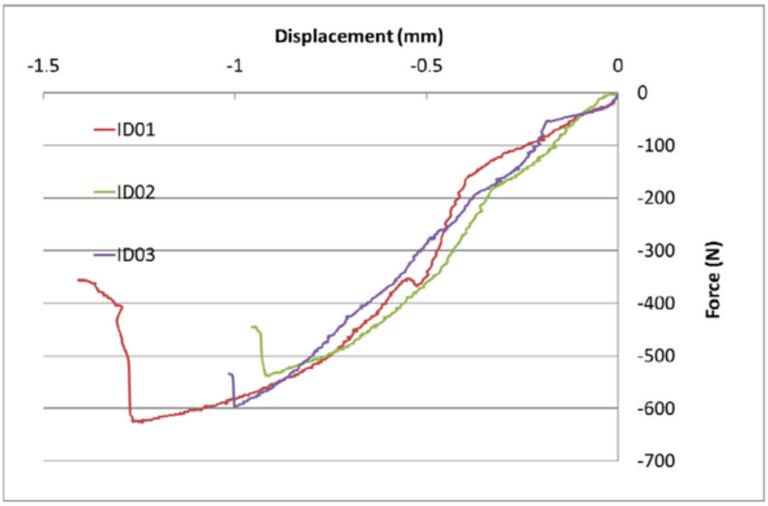


Figure 4

Figure 6

Results

Table 3 reports the applied maximum value and the withstood number of cycles for each specimen.

Table 3 – Results of fatigue tests

LaBS ID 18/27/THD 30°- F	Load level [N]	Bending moment [Nmm]	Number of cycles	Figure
1	600	2112	36125	5
2	600	2112	15379	5
3	500	1760	854226	5
4	500	1760	680025	5
5	450	1584	271972	5
6	450	1584	772613	5
7	450	1584	812038	5
8	400	1408	1452354	5
9	400	1408	196123	5
10	350	1232	5000000	5
11	350	1232	5000000	5
12	350	1232	753623	5
13	300	1056	3292083	5
14	250	880	5000000	5
15	250	880	5000000	5
16	250	880	5000000	5

Figure 5 reports the Wohler curve.

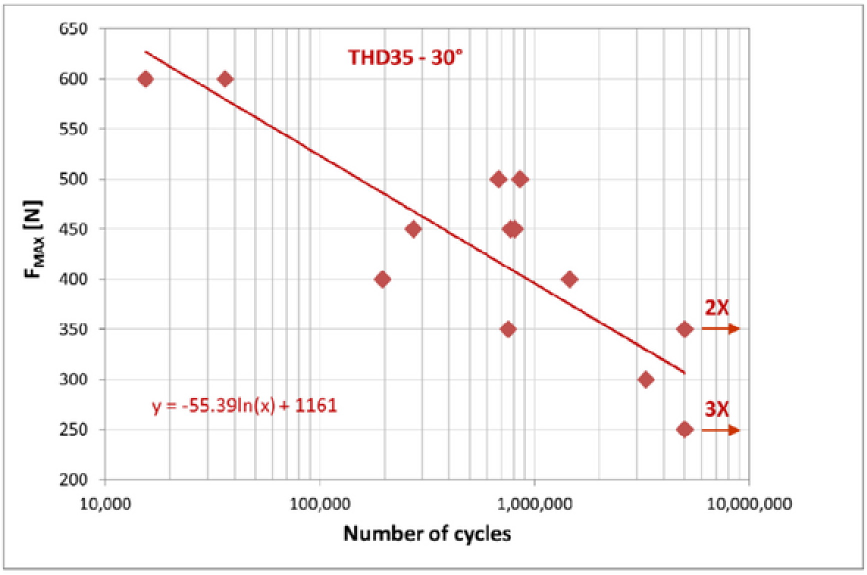
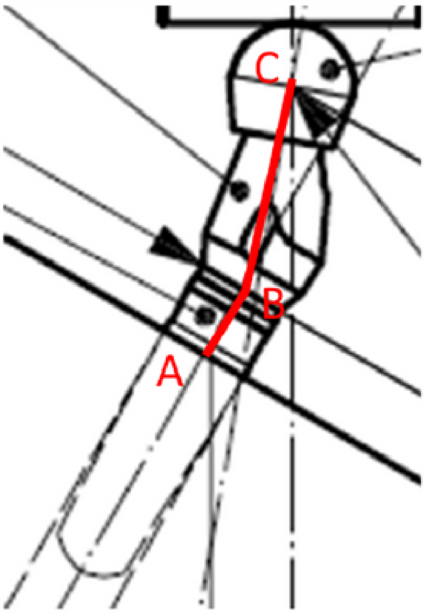
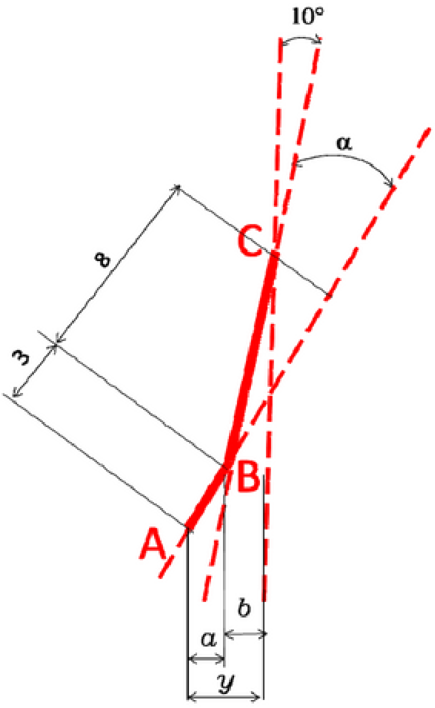


Figure 5

Appendix 1





Referring to the above figure the following calculations permit to found the value of y

$\propto = 30°$

$\beta = 10°$

$BC = \dfrac{8}{\cos \propto}$ $\quad BC = 9.23\ mm$

$b = BC\ \sin\beta$ $\quad b = 1.60\ mm$

$a = AB\ \sin(\propto + \beta)$ $\quad a = 1.92\ mm$

$y = a + b = 3.52\ mm$

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