LETTER TO THE EDITOR

STATIC AND FATIGUE RESISTANCE OF TWO TYPES OF IMPLANT/ABUTMENT CONNECTORS

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The aim of this study is to determine in an experimental way through mechanical tests the static, fatigue and torque resistance of two types of implant/abutment connectors with diameters of 3.4–5.2 mm.

To the Editor,

Modern implantology is based on the use of endosseous dental implants and on the study of osseointegration processes. The loss of marginal bone around a dental implant can be caused by many factors; the proper distribution of the masticatory loads is important and is closely dependent on the quality and quantity of bone tissue surrounding the implant. In fact, bone has the ability to adapt its microstructure through processes of resorption and neoformation of new bone matrix, as a result of the mechanical stimuli generated during the chewing cycles. The purpose of this study is to determine, through mechanical tests, the static, fatigue and the torque resistance of two types of implant/abutment connectors with diameters of 3.4–5.2 mm.

MATERIALS AND METHODS

Specimens

Tests were performed using the implant typologies above reported. The static and fatigue compression test specimens were composed of an endosseous screw-type component of two different diameters (3.4 and 5.2 mm) and a 25° angulated abutment: implants were mounted on cylindrical aluminum supports to mount the specimen on the testing machine as illustrated in Fig. I.

For static bending test, specimens were provided with the endosseous part already inserted into a custom-made aluminum cylinder for the testing machine grips.

Testing machine

Tests were performed on an MTS 858 Bionix servohydraulic testing machine (S/N 1014952, MTS, Minneapolis, MN) equipped by an axial - bending hydraulic actuator, with 25 kN axial capacity and 250 Nm bending 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 was measured by an MTS axial/bending load cell (model 662.20D-05, S/N 1007099, ±25 kN maximum axial load, ±250 Nm maximum bending load). The machine was driven by Test Star 790.01 digital controller.

Test procedure

Static tests criteria. The bending that arises when

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DISCLOSURE: ALL AUTHORS REPORT NO CONFLICTS OF INTEREST RELEVANT TO THIS ARTICLE.

masticatory loads act with an angle to the implant axis, is mostly responsible for implant failure; in this situation the stress state of the implant due to the load and the way of applying it is particularly severe and determines the implant specimen failure due to bending.

Test setup and configuration. All tests were carried out in monotonic compression under displacement control mode at a rate of 2 mm/min. Using the control software of test machine, the values of the displacement of the actuator and the force measured by the load cell were acquired. For the bending test, the implant is held between the lower jaws of the testing machine while the screwdriver is placed between the upper ones: a picture of the test is shown in Figure II.

*Test procedure***.** Tests were performed by increasing the load until specimen failure. All tests were 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 were acquired.

The bending test is run by rotating the upper head of the testing machine at the speed of 20°/min. The bending is stopped after specimen failure. Using the control software of the test machine the values of the angle of the actuator and the torque measured by the load cell were acquired (Fig. III).

Fatigue tests criteria. Tests were performed by applying the load in the same way as described for compressive static tests.

Test set-up and configuration For the fatigue test the same configuration used for the static tests was used. Tests were carried out at a temperature of 25±2°C and a humidity of 60±5%. and were conducted under force control, applying a sinusoidal waveform at 10Hz frequency.

Test procedure was conducted at the maximum frequency compatible with the control capabilities of the testing machine and, eventually not higher than 10Hz. A zero value for the displacement was set, when the actuator camein contact with the spherical head placed on the top of the abutment; a 0.3 mm displacement limit was then set so that the machine automatically stopped if such value was reached, thus indicating a failure of the implant.

RESULTS

The results of the static compression tests are

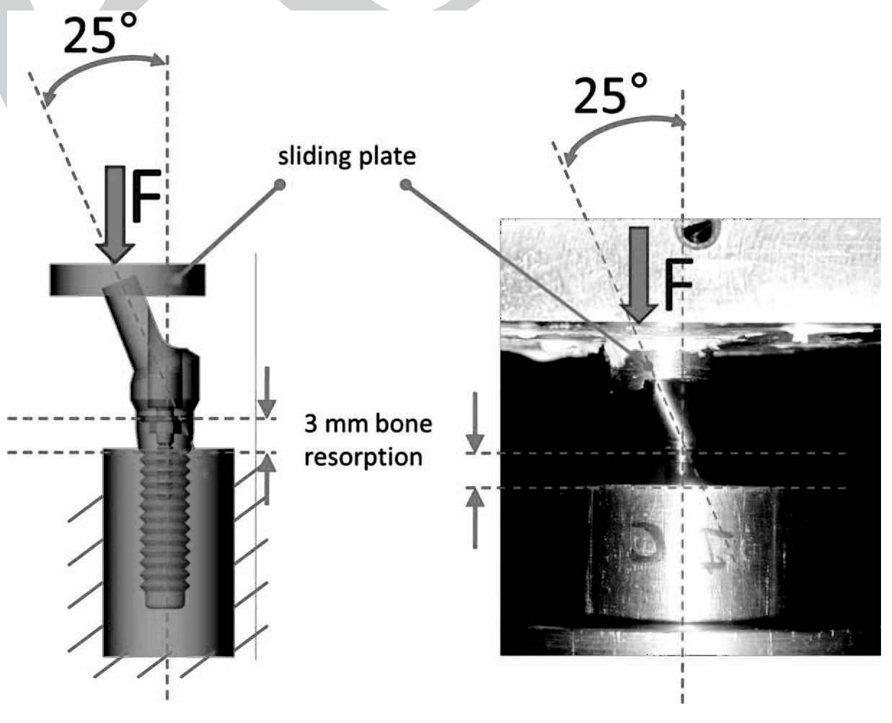

Fig. 1. *Testing machine.*

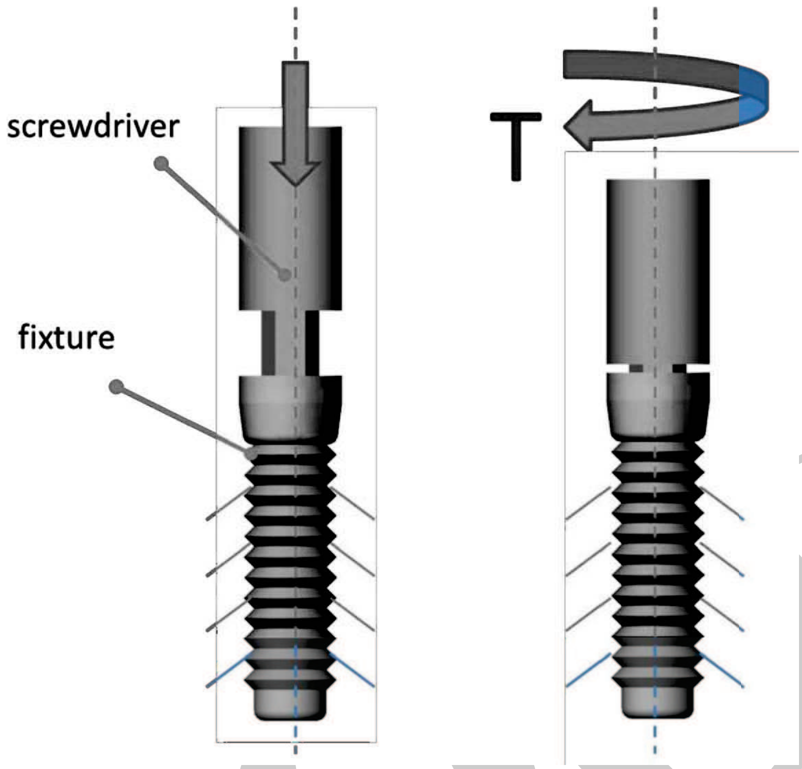

Fig. 2. *Picture of the test.*

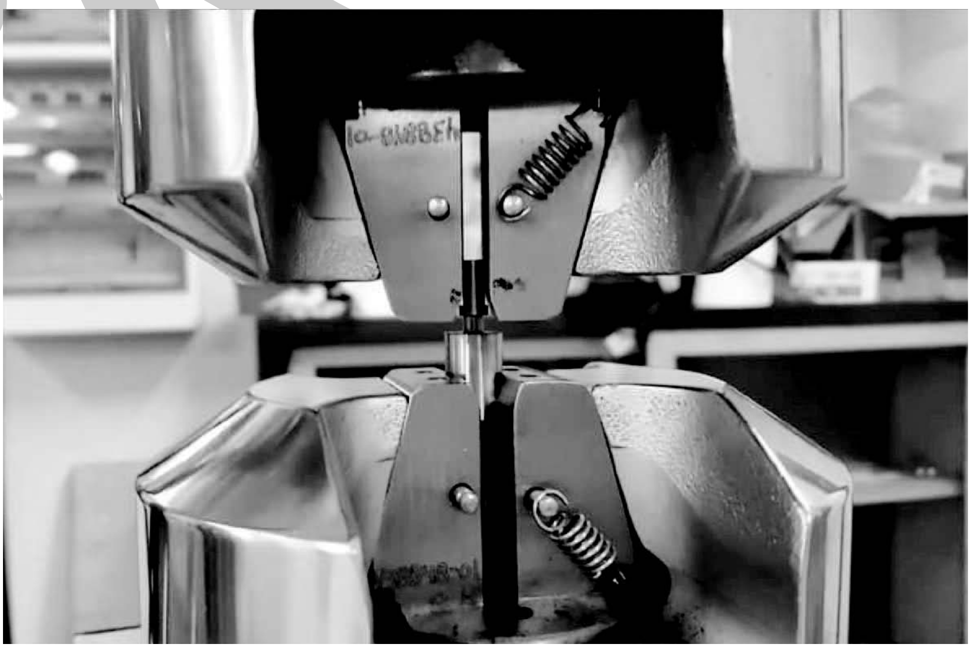

Fig. 3. *The torque measuring.*

Table I. *Results of the Static Compression Test.*

ID	Yield load [N]	Ultimate load [N]
3.4-1	1025	2265
3.4-2	970	2380
3.4-3	905	2359
3.4-4	950	2346
mean	**962.5**	**2337.50**
std. dev.	**49.75**	**50.32**
5.2-1	1170	1316
5.2-2	1133	1140
5.2-3	1214	1360
5.2-4	1198	1273
mean	**1178.75**	**1272.25**
std. dev.	**35.50**	**95.05**

Table II. *Results of fatigue Compression Test.*

ID	Applied load [N]	Cycles at failure
3.4-5	108-1080	>5.000.000
3.4-6	125-1250	395.935
3.4-7	125-1250	79.085
3.4-8	125-1250	78.257
mean		**1449297.67**
std. dev.		**971537.20**
5.2-5	108-1080	>5.000.000
5.2-6	125-1250	467.704
5.2-7	125-1250	1.469.733
5.2-8	125-1250	2.410.456
mean		**184425.67**
std. dev.	**1831**	**72.92**

reported in Table I. The two groups compared by Student's *t*-test resulted statistically and significantly different for both yield load ($p < 0.001$) and ultimate load ($p<0.001$). The results of the fatigue compression tests are shown in Table II. The two groups compared by Student's *t*-test resulted statistically and significantly different regarding the number of cycles at rupture.

Results of the static bending tests compared by Student**'s** *t*-test were not statistically different with regard to the ultimate torque ($p>0.05$).

DISCUSSION

For implant-supported fixed prostheses, the factors that affect bone-implant stress distribution and ultimately the success of the prostheses include implant inclination, implant number and position, the prostheses splinting scheme, the occlusal surface, framework material properties (1-8). Canay (9) compared vertically orientated implants with angled implants and found that the inclination of implants greatly influenced stress concentrations around the implant-supported fixed prosthesis. Many clinicians believe that a correct implant positions and the appropriate scheme of prostheses are critical for the long term success and stability of an implant-supported fixed prostheses. Kregzde (10) reported that induced stresses in bone are sensitive to the scheme of prostheses splinting and implant positions. Stress distribution in implant-supported fixed prostheses has been shown by FEA (11) to be influenced in various ways by implant inclination, implant number and position, the prosthetic framework, material properties. The bending that arises when masticatory loads act with an angle to the implant axis is mostly responsible for implant failure; in this situation, the stress state of the implant due to the load and the way of applying it is particularly severe and determines the implant specimen failure due to bending. In has been shown (12) that stress distribution in cortical bone does not seem to be greatly influenced by thread form configuration and that stress difference is also not affected greatly by the load inclinations and cortical bone properties. However, in the trabecular bone–implant interface, stress distribution is influenced greatly by thread form configurations. Rieger et al. (13) stated that v-thread (V) threads are better than threads in cylindrical or tapered implant. Other studies (14, 15) showed that square threads are better for compressive load transmission than a standard v-thread or a cylindrical implant. Both v-thread and large square thread configurations appear to be suitable for use in a screw implant design but thin thread form should be strongly avoided and small square thread form is not satisfactory. Stress distribution in cortical bone does not greatly affect thread form configurations. Stress difference in cortical bone does not seem to be greatly influenced by support type constraint positions among various thread models. However, minimal support constraints allow clearer differentiation of the stress picture between the different screw types at the trabecular bone-implant interface. The fatigue strength of implants is influenced by occlusal masticatory forces. These residual stresses are redistributed by cyclic loading, and the bending momentum that arises when masticatory loads act with an angle to the implant axis is mostly responsible of implant failure.

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