Optimization of preload and torsion by using a unique abutment screw design for each EV connection size

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Abstract

When an abutment screw is tightened a preload (axial stress) is created securing the seating of the abutment in the implant. The tightening also induces torsion (shear stress) to the screw shaft, increasing the risk for screw loosening. Hence, it is important to achieve sufficient preload while at the same time minimizing the amount of torsion in the screw.

The results indicate that the design of the EV connection (now present on EV Implant Family implant lines) creates a preload of 270–390 N and a utilization factor of 37–70% while maintaining a ratio between shear stress and axial stress of 0.7–1.3. Providing the prerequisites for low risk of screw loosening and screw complications for the EV connection.

Background and aim

To justify an implant system where a unique abutment screw design applies to each implant size and where the same insertion torque applies for all abutments.

Methods and materials

Implants tested were OsseoSpeed EV 3.0, 3.6, 4.2, 4.8 and 5.4 with corresponding color-coded abutment screws; M1.4 (Green), M1.6 (Purple), M1.8 (Yellow), M2.0 (Blue), M2.0 (Brown) (Dentsply Sirona, Mölndal Sweden) [fig 1]. The corresponding TiDesign abutments were connected with a speed of 2 RPM to a torque of 55 Ncm.

The torque and preload were continuously recorded at a frequency of 100 Hz, using Instron 55 MT torsion testing device [fig 2]. For the specific preload, the ratio between shear and tensile stress and a utilization factor was calculated [Eq1-Eq3].

Methods and materials, continued

$$\tau = \frac{M_t * 16}{\pi * d_o^3}$$

$\tau =$ Shear stress
$M_t =$ Thread torque
$d_0 =$ Screw diameter

Eq 1

$$\sigma = \frac{F_{ax}}{A_0}$$

$\sigma =$ Tensile stress
$F_{ax} =$ Axial preload
$A_0 =$ Screw area

Eq 2

$$ut = \frac{\sqrt{\sigma^2 + 3 * \tau^2}}{\sigma_{yield}}$$

$ut =$ Utilization factor

Eq 3

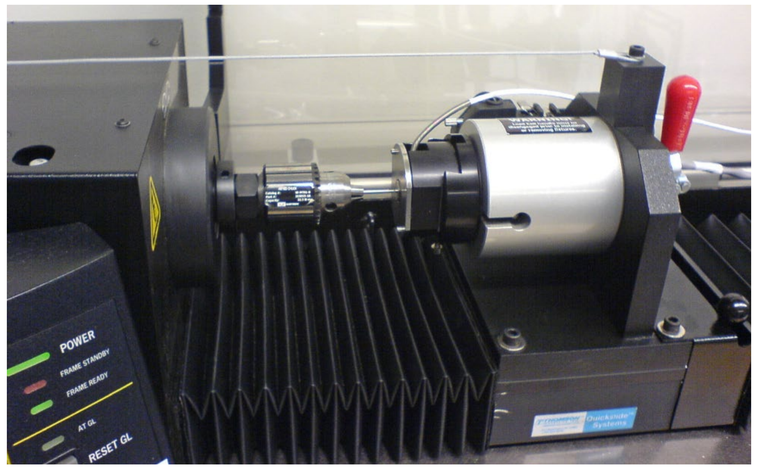

Figure 2. Testing device for preload and torque measurement.

Results

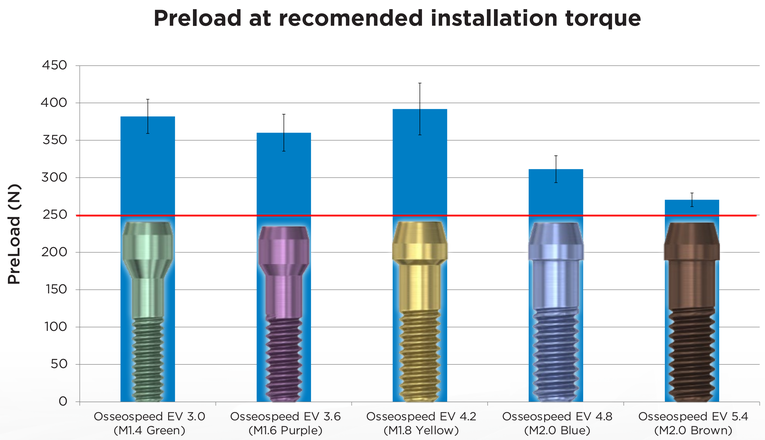

Figure 1. Preload of tested abutment screws. Red indicates a preload of 250 N.

Results, continued

The preload at the recommended installation torque of 25 Ncm were in the range of 270–390 N and the utilization factor [Eq 3] ranged between 37–70% [fig 3] depending on the abutment screw size. Furthermore the ratio between shear stress [Eq 1] and axial stress [Eq 2] ranged between 0.7–1.3 [fig 4].

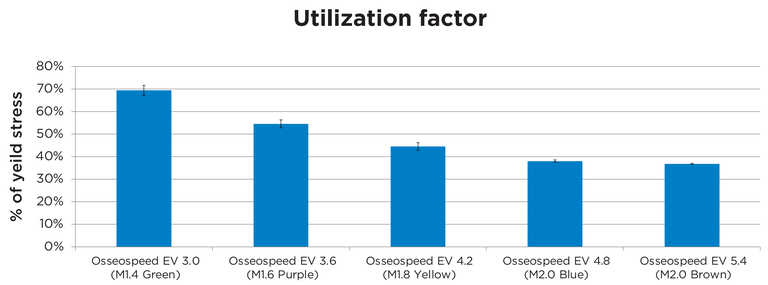

Figure 3. Theoretical yield utilization factor ± SD, representing how much of the screw yield strength that is used at recommended installation torque. Calculated according to Eq 3. 100 % represents that yield limit is obtained and plastic deformation occurs in the screw.

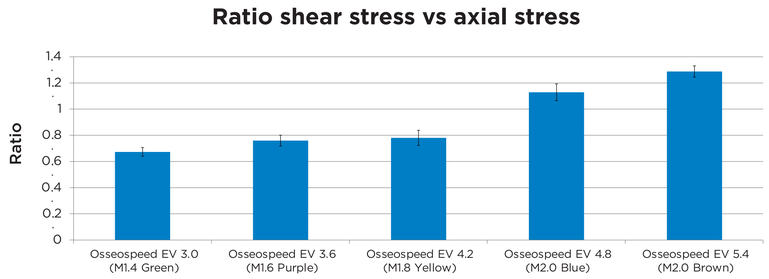

Figure 4. Theoretical ratio between shear stress and axial stress, representing how much of the screw is subjected to shear stress vs axial stress.

Conclusions

At recommended torque of 25 Ncm, all abutment screws exhibited an appropriate preload, adequate utilization factor and stress ratio. This data presents low risk for screw loosening and screw complications for the EV connection, due to the individual abutment screw design.

References

[1] Handbook on screw mechanics (http://handbok.sfnskruv.se)

[2] Halldin A, Dahlström M. Optimization of preload and torsion by using a unique abutment screw design for each implant platform size (P332). Clin Oral Implants Res 2013;24((Supplement 9)):162-63