Short Communication

Influence of Connection Geometry on Dynamic Micromotion at the Implant-Abutment Interface

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The aim of this study was to evaluate dynamic micromotion at the implant-abutment interface for 3 different implant neck designs. Five samples each from 3 implant types with different neck designs were subjected to 1×10^6 cycles under simulated oral conditions. Load magnitudes varied from 10 to 250 N at 15 Hz. The results revealed a significant main effect for type of implant ($P < .0001$). The main effect for level of cycles proved to be nonsignificant ($P = .9999$), as did the interaction between type of implant and level of cycles ($P = .9989$). Differences in neck design among the 3 implant types resulted in differences in micromotion at the implant-abutment interface under simulated oral conditions. *Int J Prosthodont 2007;20:623–625.*

Single-tooth implant prostheses have a documented history of complicating mechanical factors, among which screw loosening is the most problematic and most often correlated to implant-abutment interface design.[1] Two mechanisms of screw loosening are *(1)* excessive bending: the plastic permanent deformation occurring when a load larger than the yield strength of the screw is applied; and *(2)* settling: when external loads applied to the screw interface create micromotion between 2 surfaces. As surfaces wear, they "settle" closer together.[2]

The external neck design and internal interface geometry of the Straumann dental implant has evolved: standard, synOcta, synOcta TE. To date, studies report no difference in the strength of the implant-abutment connection between the synOcta and standard design,[3] higher values for removal torque than placement torque for synOcta compared with lower values for removal torque than placement torque for the standard design,[4] and a hypothesized correlation of fewer favorable bending moments with smaller wall thickness.[5]

This study aimed to determine whether and how the dynamic micromotion and fatigue properties vary between the standard, synOcta, and synOcta TE implants as a result of internal and external mechanical design changes.

Materials and Methods

Three variations in implant external neck and internal interface geometry were evaluated. Five 4.1-mm-diameter Straumann implants (Institut Straumann) for each of the 3 implant types (RN standard 4.1, ref no. 042.278S/lot no. 2001; RN synOcta 4.1, ref no. 043.043S/lot no.1057; and RN synOcta TE 4.1, ref no. 043.763S/lot no. 1006) (Fig 1) were randomly mated to fifteen 5.5-mm solid abutments (ref no. 048.541). Implants were mounted vertically in acrylic resin per the manufacturer's surgical protocol. The abutments were torqued to 35 Ncm, and simulated cast crowns were luted over the abutments with zinc phosphate cement set for 24 hours at 37°C before load application. Each implant-abutment framework assembly was secured in a mounting column fixed in a custom-loading device (Fig 2). Randomized testing consisted of cyclic load magnitudes varying from 10 to 250 N at 15 Hz with

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Fig 1 Cross section of 3 implant neck designs. The following are the indicated wall dimensions for the standard 4.1 *(left)*, synOcta 4.1 *(middle)*, and synOcta TE *(right)* implants, respectively, as reported by Straumann: 0.49 mm, 0.32 mm, and 0.53 mm.

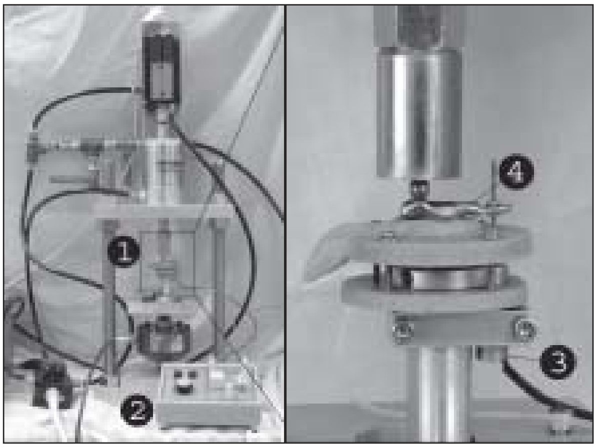

Fig 2 Loading instrument and implant assembly: 1 = implant mounting fixture; 2 = peristaltic pump used to circulate artificial saliva around the implant-abutment interface during testing; 3 = LVDT; 4 = simulated gold crown framework cemented onto the implant abutment to facilitate loading by the loading stylus and data acquisition with LVDT.

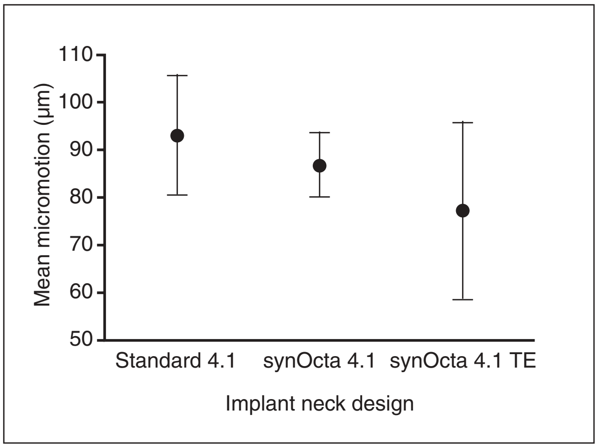

Fig 3 Mean implant-abutment interface micromotion (± SD) for 3 implant neck designs. Tukey test showed significant difference between all 3 means ($P < .0001$).

sinusoidal duty cycle for 1,000,300 cycles per sample, while submerged in artificial saliva at room temperature. Dynamic micromotion across the implant-abutment interface was recorded with a linear variable differential transformer (LVDT) strain gauge at 18 different cycle intervals. Data analysis included 2-way and 1-way analysis of variance (ANOVA) with post hoc comparisons using Tukey tests (honestly significant difference) when interactions were significant at $P < .05$.

Results

Mean dynamic micromotion at the implant-abutment interface for each of the 3 implant groups was as follows: standard, 93.15 ± 12.54 µm; synOcta, 86.81 ± 6.80 µm; synOcta TE, 77.07 ± 18.72 µm (Fig 3). Two-way ANOVA revealed a significant main effect for type of implant ($P < .0001$). The main effect for level of cycles was nonsignificant ($P = .9999$). Interaction between type of implants and level of cycles was also nonsignificant ($P = .9989$) (Table 1 and Fig 4).

Discussion and Conclusions

Adressing dynamic micromotion, the synOcta TE exhibited superior joint performance over the synOcta and standard implants when cyclically loaded and used in conjunction with the 5.5-mm solid abutment. Hypothetically, this is because *(1)* the synOcta TE possesses a greater wall dimension in its thinnest portion than the others, paralleling the findings of Akça et al[5]; and *(2)* the synOcta TE possesses an internal octagonal configuration that decreases the mating surface area, resulting in a seemingly more favorable internal connection and subsequently a greater amount of screw joint preload for a given tightening torque. The latter seemed to be more important for joint stability under the present parameters, and also explains the observed improved joint stability of the synOcta implant, despite its thinner wall, over the standard implant. Similar conclusions have been made by other examiners.[4,5]

Addressing dynamic fatigue (Fig 4), the micromotion at the implant-abutment interface remained constant through 1,000,300 cycles for each of the 3 implant types, indicating no loss of mechanical integration at the screw-joint interface. The initial variation in micromotion occurring in the first 40%, 10%, and 20% of loading cycles for the standard, synOcta, and synOcta TE, respectively, is indicative of the metal surface's macro- and microroughness, settling effects, and work hardening of the mechanical components at the implant-abutment interface during cyclic loading.

Table 1 Results of 2-Way ANOVA

Source of variation	*df*	Sum of squares	Mean square	% total variation	F	*P*
Interaction	32	2,669.84	83.43	19.05	0.39	.9989
Implant type	2	11,160.47	5,580.24	79.63	26.06	< .0001
Cycle interval	16	184.40	11.52	1.32	0.05	.9999
Residual	204	43,681.35	214.12			

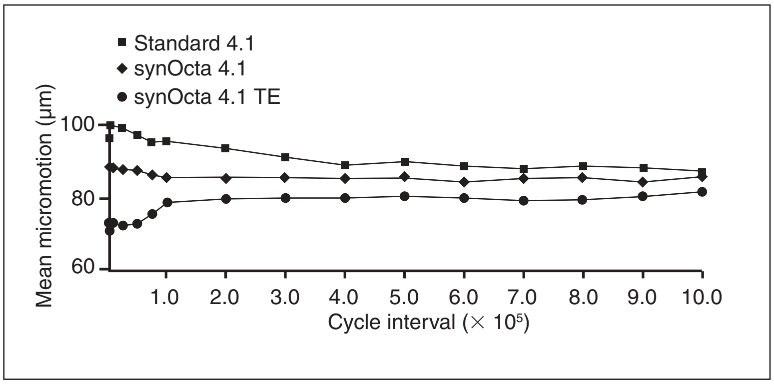

Fig 4 Implant-abutment interface micromotion for 1,000,000 cycles.

These observations suggest that variations in both implant intaglio and cameo surfaces affect the stability of the implant-abutment connection when used in conjunction with a direct/solid abutment system.

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