Biomechanical Rationale for Short Implants in Splinted Restorations: An In Vitro Study

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Seven implants provided with strain gauges were placed in an acrylic block to evaluate the biomechanical performance of short implants in splinted restorations. Two 7-mm-long implants with the same diameter (3.8, 4.4, or 5.0 mm) were splinted together (short-short implant splinted restoration [SS]) or individually with a 4.4 × 12.0-mm implant (short-long implant splinted restoration [SL]), and a 50-N oblique load was applied to both restorations. The strain decreased significantly with an increase in implant diameter in both the SS and SL restorations, and the observed strain was identical between splinted implants of the same diameter and those splinted with the long implant, suggesting that splinting of two short implants has the same biomechanical effectiveness as splinting with a single long implant. *Int J Prosthodont 2011;24:130–132.*

The use of short implants (≤ 8 mm)[1] in areas of severe bone resorption may reduce use of advanced surgical bone grafting procedures. Similar survival rates have been reported for short–wide diameter implants when compared with long–standard diameter implants.[1] ten Bruggenkate et al[2] recommended the use of short implants splinted with longer implants to reduce biomechanical risks. However, the biomechanical aspects of short implants have not been evaluated fully. The aim of the present study was to evaluate the biomechanical performance of short implants supporting fixed restorations.

Materials and Methods

A model with seven titanium implants (SETiO, GC) was used and consisted of six 7-mm-long and one 12-mm-long implants (Fig 1). Two 7-mm-long implants were 3.8 mm in diameter, two were 4.4 mm, and the remaining two were 5.0 mm; the 12-mm-long implant had a 4.4-mm diameter. Abutments of 13 mm in height were connected to all implants, and 20 N of torque was applied to each abutment screw. All implants were embedded in a polymethyl methacrylate (PMMA) resin block (50 × 50 × 50 mm; Palapress Vario, Heraeus Kulzer), simulating a maxillary edentulous region with low-density bone.[3] Because of the external-hex implant-abutment connection, each abutment was engaged to the external-hex assembly on the platform as an antirotational feature. A miniature strain gauge (KFR-02-120-C1-11L1M2R, Kyowa) was attached 1 mm below the platform on the external surface of each implant, which was coated with a 0.2-mm-thick layer of PMMA resin using strain gauge cement (CC-30A, Kyowa). Short implants were located at the apices of a 15-mm regular hexagon, while the 12-mm-long implant was positioned at the center (Fig 1).

Each implant was calibrated using 0-, 10-, 20-, 30-, 40-, and 50-N loads initially, and a strong linear relationship was confirmed using regression analysis ($P < .05$, $r > 0.9$). A 30-degree oblique static load of 50 N, simulating occlusal force,[4] was applied 10 times on the occlusal surface of each abutment connected to a 7-mm-long implant. This application represented the control group, which was simulated as a non-splinted restoration to differentiate the influence of splinting and the implant diameter. Within the PMMA resin superstructure (22 mm long, 8 mm wide, 12 mm high), two 7-mm-long short implants with the same diameter (3.8, 4.4, or 5.0 mm) were splinted together (short-short implant splinted restoration [SS]) or with a 12-mm-long implant (short-long implant splinted restoration [SL]) (Fig 1). The same loading procedure was applied on the occlusal table of the superstructure with each SS or SL configuration (Fig 2).

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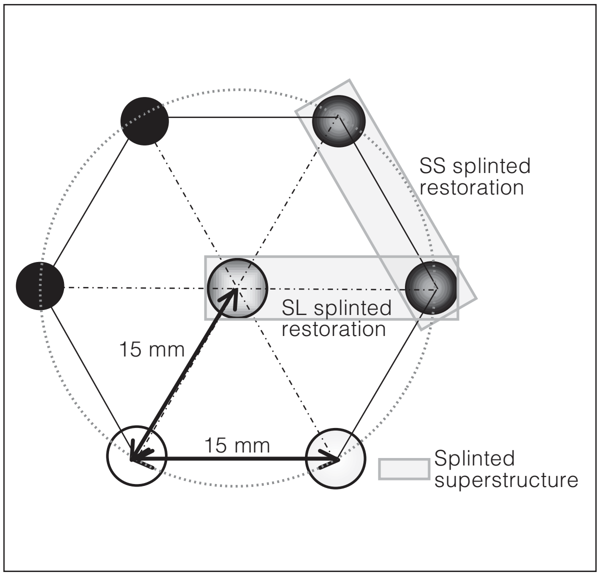


Fig 1 Illustration of the test model configuration: 7-mm-long implants (short) of diameters 3.8 mm *(black)*, 4.4 mm *(gray)*, or 5.0 mm *(white)* were arranged at the apices of a regular hexagon. In the center of the hexagon was a 4.4 × 12.0-mm implant. Because it was a regular hexagon, the length of each superstructure in the SS and SL splinted restorations were the same.

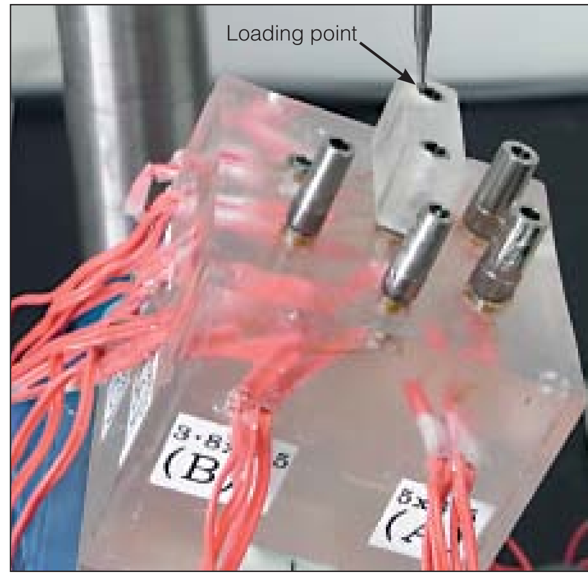
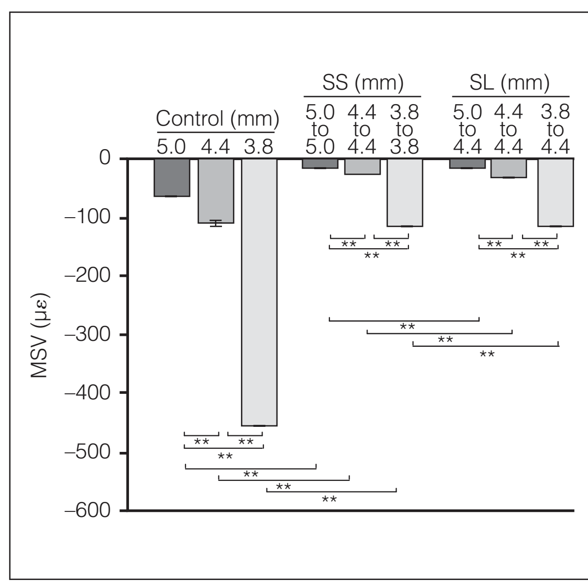


Fig 2 Loading point and test on the splinted restoration (SL: 4.4 × 7.0 mm to 4.4 × 12.0 mm).

Fig 3 Decrease in MSVs seen with increasing implant diameter. MSVs from nonsplinted restorations (control) are presented on the left, SS splinted restorations are presented in the middle, and SL splinted restorations are presented on the right. **$P < .05$.



Mean strain values (MSVs) obtained from an average of the output from the strain gauges were compared using analysis of variance and post hoc analysis ($P < .05$; SPSS 11.0, IBM).

Results

In the nonsplinted control group, MSVs decreased significantly as implant diameter increased ($P < .05$; Fig 3). For splinted restorations (SS, SL), the MSVs decreased more than the nonsplinted restoration. In the SS splinted restorations connecting two short implants, MSVs decreased significantly with an increase in implant diameter ($P < .05$; Fig 3). In the SL splinted restorations, MSVs also decreased significantly with an increase in the short implant diameter ($P < .05$). Comparing SS and SL splinted restorations, the actual value difference was less than 4 με with statistical differences, which was within experimental fluctuations and considered to be identical (Fig 3).

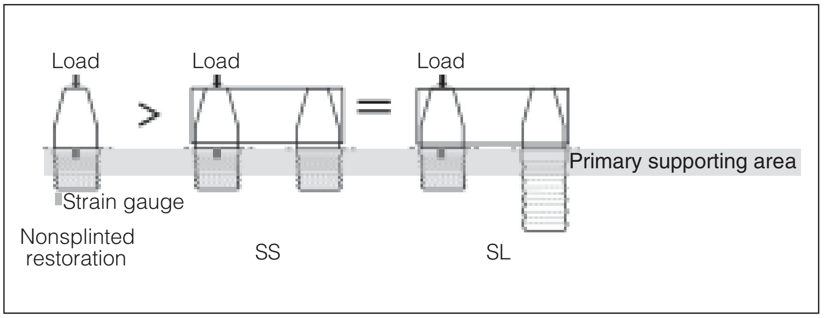


Fig 4 Strain in the nonsplinted restoration was significantly larger than that in the splinted restorations under the same load. The strain was identical in SS and SL splinted restorations. The primary supporting area was identified below the platform and around the neck of the implant, which influenced the strain around the implant under loading.

Discussion

A splinted implant restoration may reduce MSVs around implants under loading more than a nonsplinted restoration. In this study, reduced MSVs were observed in SS and SL splinted restorations with larger implant diameters, which may be a result of the biomechanical influence of the implant diameter rather than the implant length on reducing stress in bone and around the implant. The difference in MSVs between SS and SL splinted restorations was nearly identical when the short implant was splinted with a short or a longer implant of the same diameter. Pierrisnard et al[5] also indicated that maximum bone stress was almost constant and independent of implant length and bicortical anchorage.

According to these findings, it may be inferred that there is a critical area below the platform of an implant where the majority of the stress/strain is concentrated under loading. This area may act as the primary support for the implant, thus influencing the stress/strain distribution around the implant under loading (Fig 4). Therefore, even when connecting with a longer implant, the length of the implant beyond this area seems to have little influence on strain distribution. The most important factor in strain transfer is to use this area effectively, such as using a wide-diameter implant instead of a long one with a small diameter. A more thorough approach will be needed to evaluate this issue.

The use of a homogenous acrylic model and the limited area attached with only one strain gauge on each implant, which enables strain measurement in only one dimension under occlusal force, may be limitations of this study. Thus, the entire stress/strain distribution around an implant should be evaluated for different clinical situations, such as the number and distribution of implants, different superstructure materials, and stronger loads within the physiologic range, in further studies.

Conclusion

Within the limitations of the present study, identical biomechanical performance (ie, MSV) was found when comparing two short splinted implants with a short and a long splinted implant.

References

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