In Vivo Load Measurement for Evaluating the Splinting Effects of Implant-Supported Superstructures: A Pilot Study

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The purpose of this in vivo study was to evaluate the biomechanical effects of splinting of implant-supported superstructures using piezoelectric transducers to measure the three-dimensional forces exerted on implants supporting fixed superstructures. Measuring devices were set into the implant fixtures at the mandibular right second premolar and first molar. During clenching, force magnitudes were allocated more evenly to the two implants if they were splinted compared with the unsplinted control implants. However, this equalization of load distribution was not apparent during wax biting. Splinting of implant-supported fixed superstructures affects the force exerted on implants, especially during clenching. *Int J Prosthodont 2013;26:143–146. doi: 10.11607/ijp.3223*

Clinical complications with implant-supported dental prostheses, such as screw loosening or fracture of the screw or superstructure, are thought to result from an overload on the implants. In addition, some studies have identified an association between overload and resorption of peri-implant bone.[1] These associations highlight the importance of controlling the load experienced by implants and preventing resorption of peri-implant bone to obtain long-term implant success. When fixed prosthodontic treatment supported by multiple implants is applied in a partially edentulous area, either splinting or unsplinting of the superstructures can be selected. In vitro studies comparing splinted and unsplinted superstructures have shown that a splinted prosthesis reduces the stress on bone surrounding the implants.[2] However, the input loads applied in those simulation studies were too simplistic to model the complicated loads actually exerted on an implant in vivo. A study by Mericske-Stern et al[3] used piezoelectric transducers to measure and evaluate the three-dimensional (3D) load on implants supporting an overdenture in vivo. Recently, an improved version of the transducer that is much smaller and able to record in vivo time series measurements was developed. Using these transducers, 3D force exerted on teeth was measured in vivo and force changes occurring during function were observed.[4] The present study applied the improved transducers to measure the functional loads on implants supporting fixed prostheses in vivo and evaluated the effect of splinting on the implant-supported superstructure.

Materials and Methods

The subject was a 62-year-old woman who had two standard regular-neck implants (Straumann) inserted at the mandibular right second premolar (implant 1) and first molar (implant 2). The functional loads exerted on the implants were recorded using a 3D piezoelectric transducer (Type Z18400, Kistler Instruments).[4] A transducer was set into each implant, and the experimental superstructure was attached using titanium screws (Fig 1). Two tasks were then used to impart force through the implants: maximum voluntary clenching (MVC, n = 8) and biting with paraffin wax (5 mm^3) (wax biting, n = 4). The loads were first measured for a splinted superstructure, which was then removed and cut into two sections between the first molar and second premolar. Interproximal contact was achieved by brazing with a gold alloy. These superstructures were then set on their respective implant supports, and the loads were again measured during performance of the same tasks. By using this method, the occlusal contacts were comparable in both the splinted and unsplinted superstructures, which enabled the authors to reliably investigate the

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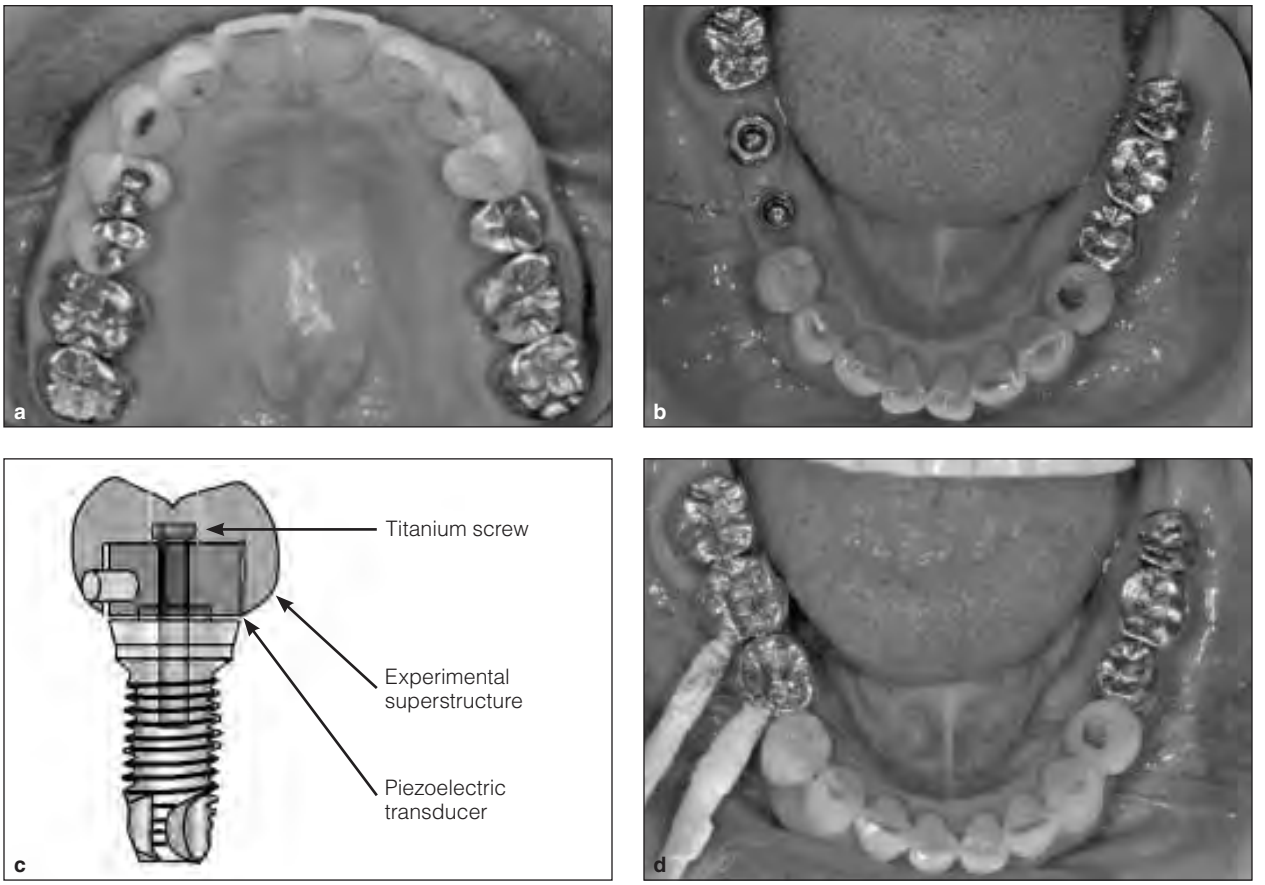


Fig 1 The oral configuration and load-measuring device. **(a)** Maxillary oral cavity; **(b)** mandibular oral cavity; **(c)** schematic of the load-measuring device; **(d)** load-measuring device in the mouth.

effect of splinting (Fig 2). The 3D loads calculated from the outputs of the transducer were analyzed based on the Frankfort horizontal plane and sagittal plane.[4] Statistical comparisons were performed using the Mann-Whitney *U* test.

Results

The results of measurements during MVC showed that the maximum magnitude of the loads was distributed more evenly to the two implants through the splinted superstructure (Fig 3). However, during wax biting, this equalization of load distribution by the splinted superstructure was not apparent (Fig 3). The range of change in the load direction on implant 2 with the splinted superstructure was smaller than that with the unsplinted device during the load-increasing phase of MVC (Fig 4). However, there was again no difference between the splinted and unsplinted superstructures when measuring the range of change in the load direction during wax biting (Fig 4).

Discussion

The results of measurements during MVC suggest that superstructure splinting is a key factor in controlling the distribution of load forces exerted on implants supporting fixed prostheses. This finding is consistent with previous work.[5] Conversely, the distribution of load during food biting might depend on the position of the food between the teeth, since the first molar was the main biting point during wax biting. Although data were obtained from only one subject, the authors propose that splinting a superstructure supported by multiple implants can be an effective technique for eliminating the risk of occlusal overloads. Furthermore, in vivo load data can be very useful in improving the validity of experimental model simulation and finite element analysis, which are used to estimate the load stress experienced by the implants, superstructures, and surrounding bone. Such biomechanical evidence can help improve the reliability of treatment planning and the outcome of implant therapy.

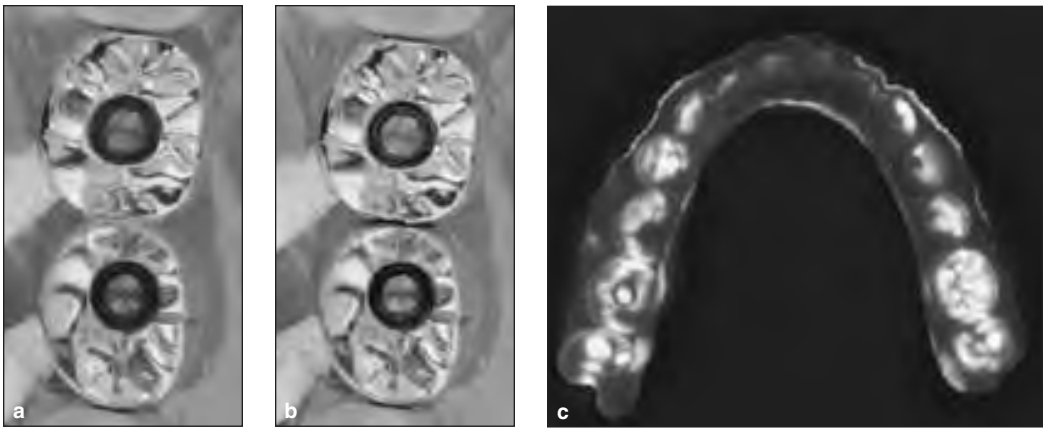


Fig 2 Experimental conditions. **(a)** Splinted experimental superstructure; **(b)** unsplinted experimental superstructure; **(c)** occlusal condition at clenching and **(d)** after biting with paraffin wax.

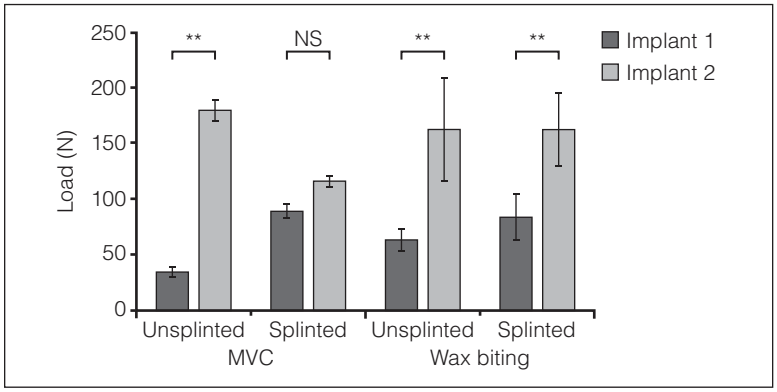
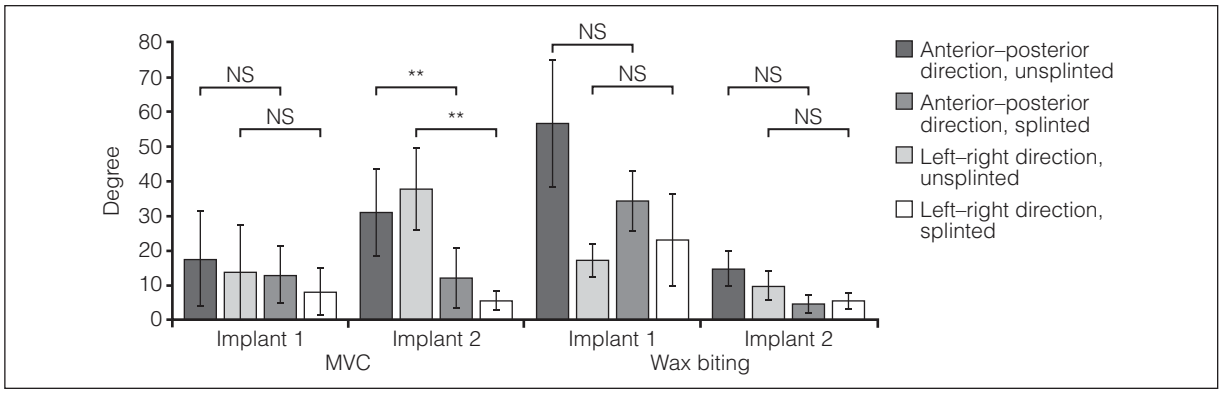


Fig 3 *(right)* Maximum magnitude of load exerted on each implant. NS = not significant; MVC = maximum voluntary clenching.

Fig 4 *(below)* Range of change in load direction during function. NS = not significant; MVC = maximum voluntary clenching.



However, the present findings must be replicated in a larger group of patients before definitive extrapolations are made from these results.

Conclusion

Within the limitations of an in vivo study measuring only one patient, the authors suggest that splinting a superstructure might be advantageous in eliminating the risk of occlusal overload in implant treatments.

Acknowledgments

The authors reported no conflicts of interest related to this study.

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Literature Abstract

Dental x-rays and risk of meningioma

Ionizing radiation (IR) is a consistent and modifiable environmental risk factor identified for meningioma, which is the frequently reported primary brain and central nervous system tumor in the United States. This population study aimed to examine the correlation between dental radiographs and the risk of intracranial meningioma. This case-control study included 1,433 patients between the ages of 20 to 79 years who were diagnosed with intracranial meningioma. A group of 1,350 controls was frequency matched on age, sex, and demographics. The main outcome measure for the study was the correlation between a diagnosis of intracranial meningioma and self-reported frequency of bitewing, full-mouth, and panoramic dental radiographs received. Over a lifetime, patients with intracranial meningioma were more than twice as likely as controls (odds ratio [OR], 2.0; 95% confidence interval [CI], 1.4–2.9) to report having ever had a bitewing examination. Regardless of the age at which the films were obtained, individuals who reported receiving bitewing films on an annual basis or with greater frequency had an elevated risk for ages < 10 years (OR, 1.4; 95% CI, 1.0–1.8), ages 10 to 19 years (OR, 1.6; 95% CI, 1.2–2.0), ages 20 to 49 years (OR, 1.9; 95% CI, 1.4–2.6), and ages ≥ 50 years (OR, 1.5; 95% CI, 1.1–2.0). Significantly increased risk of intracranial meningioma was correlated with panorex films taken at a young age or on an annual basis or with more frequent receipt of the films; and individuals who were aged < 10 years at the time of screening had a 4.9 fold of increased risk (95% CI, 1.8–13.2) of meningioma. No correlation was found between tumor location above or below the tentorium and dental radiographs. The authors concluded that exposure to some dental radiography performed in the past, when radiation exposure was greater than in the current era, may be correlated with an elevated risk of intracranial meningioma. As with all artificial sources of IR, efforts to moderate exposure to IR to the head region may be of benefit to patients.

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