Evaluation of the Mechanical Behavior and Marginal Accuracy of Stock and Laser-Sintered Implant Abutments

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Purpose: The aim of this study was to evaluate the marginal accuracy and mechanical behavior of implant-supported crowns restored with original stock abutments and nonoriginal computer-aided design/computer-assisted manufacture laser-sintered abutments. ***Materials and Methods:*** A total of 26 implants were divided in two groups (n = 13 each) as follows: implants connected to original stock abutments (OS) and implants connected to nonoriginal laser-sintered abutments (LS). Of these, 10 samples were cross-sectioned to measure the marginal accuracy under a scanning electron microscope. In addition, 16 samples were used to study the mechanical behavior. Two tests were performed: *(1)* static load and *(2)* dynamic load after thermocycling with artificial saliva. ***Results:*** OS exhibited the best marginal accuracy; however, the LS gap was within the clinically acceptable range of marginal discrepancy. No significant differences were found in the mechanical tests. ***Conclusions:*** Both abutments are acceptable alternatives to restore implants, although the original abutments showed better fit than nonoriginals. *Int J Prosthodont 2017;30:136–138. doi: 10.11607/ijp.5089*

Several procedures and materials are available to fabricate prosthetic structures. High precision in manufacturing results in lower degrees of abutment rotation and smaller gaps at interfaces, and therefore less bacterial colonization, tissue alteration, and tension on the retaining screws.[1,2] The main abutment manufacturing techniques are milling and laser sintering. The use of stock milled abutments is limited due to the standard shape of the piece. However, the connection of a stock abutment with the implant, known as friction fit, provides a perfect assembly between the components. On the other hand, laser sintering enables direct fabrication of prototypes for development of prostheses.[3]

The aim of this in vitro study was to compare the marginal accuracy and mechanical behavior of original stock versus nonoriginal laser-sintered abutments connected to the same implant system.

Materials and Methods

A total of 26 titanium dental implants, 3.7 mm in diameter and 13 mm in length (Tapered Screw-Vent, Zimmer), were selected. They were divided into two groups: original stock abutments (OS) provided by the implant manufacturer (Zimmer Hex-Lock Contour Abutment ZOA341S, Zimmer) and nonoriginal custom computer-aided design/computer-assisted manufacture (CAD/CAM) abutments manufactured using laser-sintering technology (LS) (Phibo Dental Solutions).

All abutments were torqued to 30 Ncm according to the manufacturer's recommendations using a torque control system (TW30, Zimmer).

A total of 16 metal-ceramic crowns were fabricated. Crowns were cast using cobalt-chromium (Co-Cr) alloy (Remanium, DENTAURUM) and veneered with feldspathic ceramic (IPS d.SIGN, Ivoclar Vivadent). Crowns were cemented using adhesive resin cement (Multilink Implant, Ivoclar Vivadent) to the samples selected for the mechanical tests.

Marginal Microgap Assessment

Five samples from each group were embedded in a transparent acrylic resin and sectioned in the longitudinal axis using a cut-off machine (Micromet M, Remet). The sectioned surface of each specimen was polished using SiC abrasive paper and then with a mixture of SiO_2 suspension and distilled water.

Marginal vertical gap was evaluated with a scanning electron microscope (SEM) (Phenom G2 pro SEM 5 Kv, PhenomWorld).

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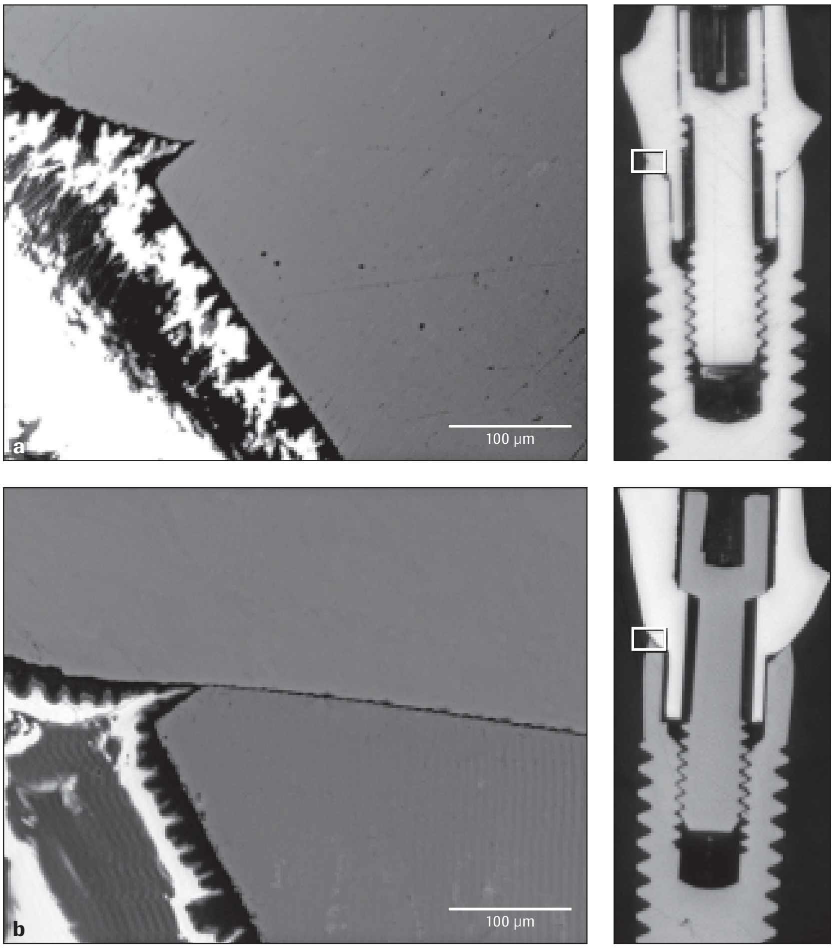

Fig 1 Representative cross-section SEM image of the two implant-abutment systems compared in the study. **(a)** Stock abutment sample. **(b)** Laser-sintered abutment sample.

Mechanical Behavior

Static Load Test. A total of 10 samples (n = 5 per abutment group) were embedded in epoxy resin (Epoxicure Resin, Buehler) following ISO Norm 14801[4] and mounted in a steel holder in a universal testing machine (Shimadzu AG-X Series, Shimadzu). The maximum force (Fm) before failure was regarded as load-bearing capacity. Additionally, the presumed onset of notable plastic deformation (Fp) was determined.[5]

Thermocycling and Dynamic Load Test. Six samples (n = 3 per group) were aged by thermocycling with 10,000 cycles at 5°C and 55°C in artificial saliva for 20 seconds each with 10 seconds between baths for thermal stabilization.

After thermocycling, dynamic load test was conducted using an electromagnetic testing machine (EMT-1KNV-30, Shimadzu) operated under load control at 2 Hz. The cyclic forces selected for the fatigue test were between 30 and 300 N, simulating forces generated in the oral cavity. The maximum force selected for test was 300 N, since the lowest value in the elastic limit of the static load test (Fp) was slightly higher than this value. Fatigue life of specimens was determined according to ISO 14801 for implant abutments,[4] and the test was carried out until the specimens showed failure or signs of deformation (2 mm).

Statistical Analysis

Statistical analysis was performed using SPSS software (version 21.0, SPSS). LS and OS abutments were compared using independent *t* test at a confidence level of $P < .05$ to assess differences between both groups under static and dynamic load.

Results

Marginal Accuracy

The cross-section of representative polished samples is shown in Fig 1. Only nonmeasurable gaps were found in the OS group (Fig 1a). The mean gap in the LS group was 2.5 ± 1.0 μm (Fig 1b).

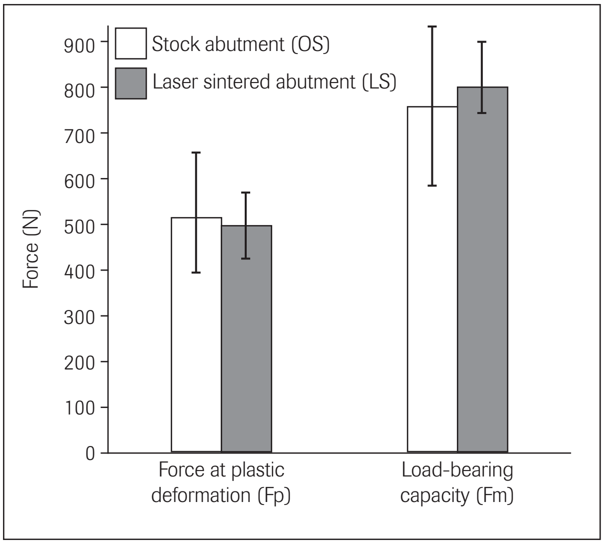

Fig 2 Load bearing capacity (Fm) and force at plastic deformation (Fp) for the different implant-abutment configurations.

Table 1 Mean Number of Cycles to Failure Under Fatigue Load Test and Approximate Chewing Equivalence In Vivo Time

Abutment	Cycles to failure (n)	Chewing equivalence in vivo time (mo)
Stock abutments (OS)	423.225 ± 69.520	10–11
Laser-sintered (LS)	416.069 ± 85.392	9–10

Mechanical Behavior

Static and fatigue mechanical results are shown in Fig 2 and Table 1, respectively. No significant differences were found in the mechanical behavior under static and dynamic loading conditions among OS and LS abutments ($P > .05$).

Discussion

When the marginal gap between the implant-abutment surfaces was analyzed, OS abutments showed better fit between components. These results agree with a study by Fernández et al,[2] where the authors compared milled, laser-sintered, and cast abutments.

Both groups showed similar results in mechanical tests under static and dynamic load after thermocycling. Although no significant differences were found, the mean maximum force (Fm) registered in the LS group was higher. However, the OS group needed higher forces to suffer irreversible deformation of its pieces (Fp) (Fig 2). This difference could be explained by the composition of the abutment and not by the manufacturing process or the fit. OS abutments were composed of a Ti_6Al_4V alloy, while LS abutments were made from Co-Cr alloy. Dynamic load test results were similar in both groups; a slightly but not significantly higher number of cycles to failure was registered for the OS abutments (Table 1).

Conclusions

Both OS and LS abutments showed similar results in mechanical tests under static and dynamic load after thermocycling. However, the friction fit obtained with OS was not achieved by LS abutments connected to the same implant system.

Acknowledgments

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