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Original article

The effect of fatigue loading on the screw joint stability of zirconium abutment

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Abstract

Purpose: This study evaluated the effect of fatigue loading on the screw joint stability of a zirconium abutment connected to an external hexagon implant in vitro.
Materials and methods: Fifteen titanium and 15 zirconia abutments of 3 different heights (5, 8, and 11 mm) were connected to external titanium implants with titanium screws. A torque gauge was used to measure the reverse torque values before and after loading. An air cylindrical loading device was used to simulate mastication at a 45-degree angle to the longitudinal axis of the implant.
Results: There were significant differences ($P < 0.05$) before and after the loading of titanium (5 mm) and zirconia (5, 8, and 11 mm) abutments.
Conclusion: Zirconia abutments for external hexagon implants had durability rates similar to those of titanium abutments after repeating load on the reverse torque of the abutment screw, indicating that the zirconia abutment could be reliably used instead of the titanium abutment.

Keywords: Zirconia abutment; Screw; Implant; External hexagon

1. Introduction

Recently, implant-supported restorations have become increasingly popular, and patients are demanding a more natural-looking outcome in not only the anterior but also the posterior regions. Among the major concerns are darkness of soft tissue around the implant margin and unexpected soft tissue recession around the implant, results of the thickness of soft tissue and an inappropriate position or direction of implant placement. In such cases, the use of tooth-colored abutments and crowns without metal is recommended. To improve esthetic results, all-ceramic materials are frequently used for implants, abutments, and crowns. The abutment material has been changing from titanium to zirconia, which has high translucency and mechanical strength and could create an ideal emergence profile and crown margin.

Screw joint failures have been reported by many clinical researchers, especially in cases of single-tooth replacement using a titanium abutment with a titanium implant [1–5]. The introduction of the zirconia abutment based on CAD/CAM technology has provided new opportunities for esthetic implant restorations. The Dental CAD/CAM GN-I (GC, Tokyo, Japan), introduced to the market in 1999, can produce titanium, aluminum, and zirconia copings and abutments [6]. Kokubo et al. [7] have shown that the technology can fabricate clinically acceptable copings on the marginal fit to the natural teeth.

As far as the authors know, only six kinds of zirconia abutments are available from companies such as Nobel Biocare and Astra Tech. There have been no reports on the durability of zirconia abutments with titanium implants. Abutments connected with implants inherently receive high stress in the cervical area, where abutment screws apply high bending stress, the reported cause of prosthetic and osseointegration failure [8].

In this study, the effect of fatigue loading simulated in the oral environment and caused by masticatory movement on screw joint stability was analyzed. An air cylindrical cyclic loading device was used to simulate mastication.

The purpose of this study was to evaluate the stability of abutment screws connected to external hexagon implants and

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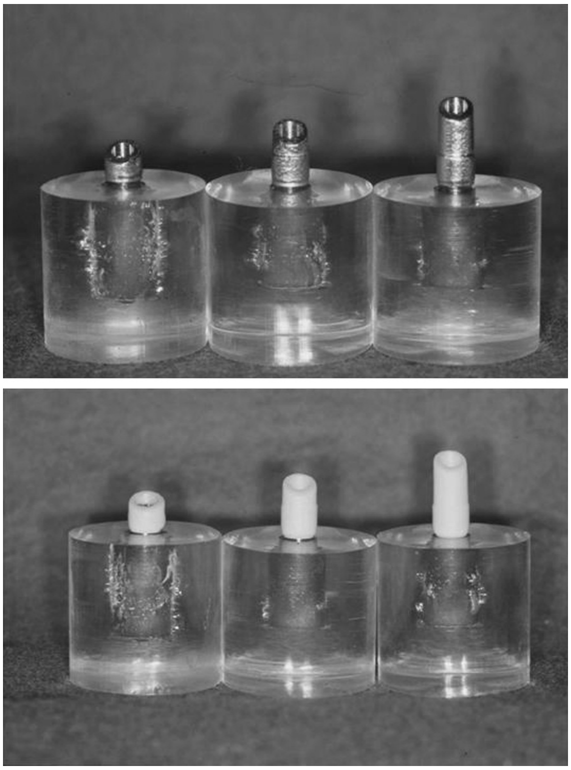

Fig. 1. Titanium and zirconium abutments used in this study.

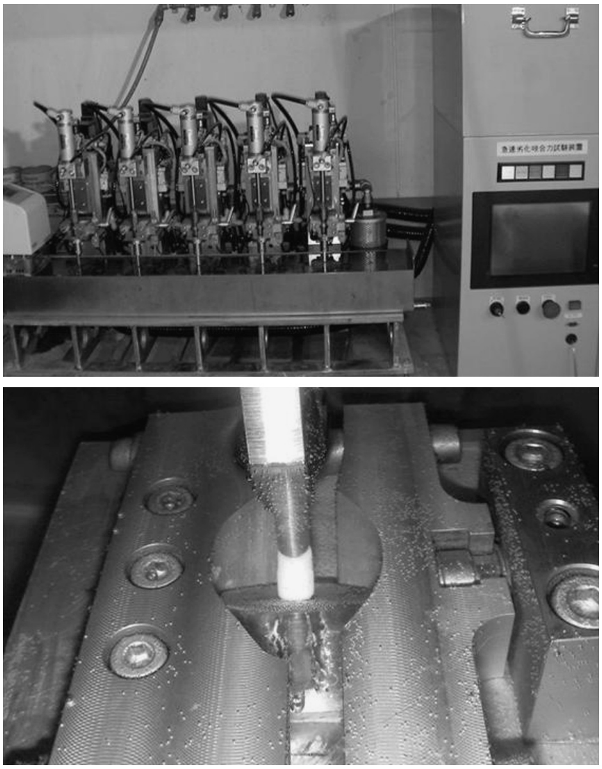

Fig. 2. Air cylindrical cyclic loading device to simulate mastication (Upper). Specimen holder mounted in position under loading stylus (Lower).

zirconia abutments of different heights. The reverse torque of the abutment screw was measured before and after loading. The reverse torque values were also compared at various loading points. Titanium abutments were used as controls for comparison.

2. Materials and methods

Thirty titanium implants (GC implant Re, GC) with an external hexagon shape (length, 12 mm; diameter, 3.8 mm) were positioned in an acrylic block with a center hole 5 mm in diameter and 13 mm in depth. The implants were embedded in the center hole with autopolymerizing resin (Pattern resin, GC) using a surveyor so that the platform of the implant was 1 mm above the edge of the acrylic block, which was perpendicular to the surveyor arm. The implants were divided into two groups. The master abutments, the heights of which were 5, 8, and 11 mm, were waxed up using a temporary plastic cylinder (GC). Then, custom-made titanium abutments were fabricated using a CAD/CAM system (Dental CAD/CAM GN-I, GC). Zirconia abutments were milled from presintered zirconia block and then were completely sintered. Fifteen titanium and 15 zirconia abutments of 3 different heights were made from each type of block (Fig. 1). Each group was divided into three subgroups of five specimens each. Each abutment and implant was connected with titanium screws (UCLA abutment screw, GC) at 35 N cm using a torque wrench (Ratchet wrench, GC). A torque gauge (Tohnichi Mfg, Tokyo, Japan) was used to measure the reverse torque value of each abutment, which showed the load value to screw loosening. Each abutment was measured, and the average value was obtained as before loading. Then, each specimen was retightened using the same torque wrench. An air cylindrical cyclic loading device was used to simulate mastication (Fig. 2). According to the method reported by Nishimura [9], each specimen was firmly mounted in a stainless holder, which was loaded at a 45-degree angle to the longitudinal axis of the implant abutment, and dynamic vertical loading was applied on the top of each abutment with 250 N (from 0 to 250 N). Then, up to 100,000 loads were conducted with a contact time of 0.2 seconds at a frequency of 1 Hz, as reported by Lee et al. [10]. The temperature of each specimen was maintained at 37 °C by means of a thermostatically controlled water-circulating device. After the repeating loads were finished, the reverse torque value of each abutment was measured, and the average value was calculated.

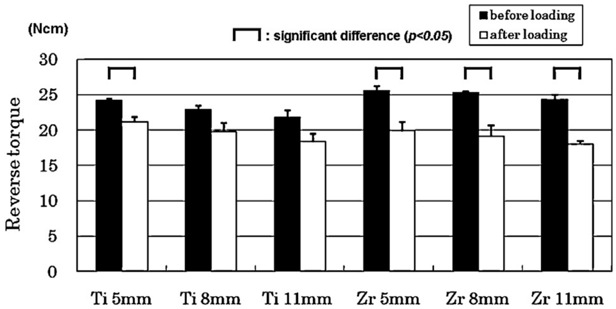

Fig. 3. Mean reverse torque values before and after loading.