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Accuracy in the Interface between Implant Components after a 5-year Functional Period; A Clinical Report

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ABSTRACT

The reduction in the assembly accuracy of the implant complex could result from fatigue and micromovement during the functional phases and from the manufacturing process. The long-term functional integrity of implant prostheses can be ensured by accurate fit of the interfaces between the assemblies from a biomechanical perspective. A single-implant restoration on the mandibular left first molar was removed after a 5-year functional period due to mobility, which was diagnosed as abutment screw loosening. The superstructure could not be retrieved, despite exceeding the torque value recommended by the manufacturer; therefore, the restoration was unscrewed and removed. The retrieved restoration, particularly the configuration of the abutment-gold cylinder and abutment-retaining screw interfaces, was analyzed with scanning electron microscopy. Moreover, the assembly accuracy of the old and new assemblies was compared. In the new specimen, a relatively an even linear gap was found between the threads of the abutment and screw and no vertical marginal gaps were found at the abutment-cylinder interface, wherein the horizontal and vertical contacts were incomplete. In the old specimen, an irregular pattern of screw-thread engagement, an irregular linear space at the abutment-cylinder interface, a partially worn-out screw configuration and remnants of the screw in the interface were observed.

Key words : Functional integrity, Internal fit, Machining tolerance

INTRODUCTION

Implant-supported prostheses are a treatment modality with long-term effectiveness and some reported postoperative complications, including both biological and mechanical complications.

Biological complications result from periodontal disease around the implant which is related to the endosteal component of the implant system. This complication can be controlled or prevented by regular periodontal treatment to reduce the colonization of oral microorganisms causing peri-implantitis.

Mechanical complications, which are related to prosthetic components, including the abutment and its connecting parts, manifest as screw, fixture and abutment fractures and component deformation, such as bending. These complications are considered as consequences of material fatigue or overload on the prostheses and are affected by the prosthetic design, the material itself and patient-related factors, such as bruxism, clenching, and a large crown-to-implant ratio[1].

A number of previous studies on mechanical failures have focused on material defects during production, inadequate implant designs and dimensions, implant locations and posi-

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tions, and the fit of the superstructure[2-8]. Among these factors, the accuracy of the interfacial fit between the components, such as fixture-abutment, abutment-screw, fixture-screw and abutment-cylinder interfaces, has rarely been investigated. In practice, customized abutments and screws have been widely used without any verification of the accuracy of intercomponent fit. In addition, clinical complications such as wear and fatigue fracture could be regarded as a common type of failure for titanium fixture-titanium abutment interfaces and titanium fixture-zirconia abutment interfaces owing to material flexure and crack propagation under cyclic loading[3].

Clinicians should be able to confidently provide implant treatment to patients seeking dental rehabilitation and achieve long-term success. However, most studies investigating the factors associated with mechanical complications of implants were performed in vitro in accordance with International Standard Organization (ISO) 14801[8] and most of these studies were limited from a lack of clinical validation. Therefore, clinical cases related to potential risk factors need to be reported and shared to develop subsequent in vitro studies to collect relevant data.

This clinical report presents a clinical situation related to mechanical implant failure and provides clues to investigate whether this complication resulted from ill-fitting components or developed due to micromovement during the functional period.

CASE REPORT

A 68-year-old patient returned with a complaint of mobility of the old implant restoration on the mandibular left first molar after 5 years of function. An implant was placed distally in the missing region, and the superstructure was composed of two premolar crowns (Fig 1). Both clinical and radiographic examinations revealed that there was neither symptom of peri-implantitis nor pathologic bone resorption around the implant and that the mobility originated from the deterioration of the integrity of the prosthetic components.

This single screw-retained fixed implant prosthesis was composed of a conical screw abutment with an internal hex connection and a screw-retained crown on a gold cylinder (Implantium, Dentium, Seoul, Korea). To retrieve the superstructure unit, an attempt was made to loosen the retaining screw with a screwdriver and wrench; however, this attempt failed. The superstructure could be unscrewed and removed after preparing the external surface of a single crown (Fig 1).

To investigate the causative factors associated with the

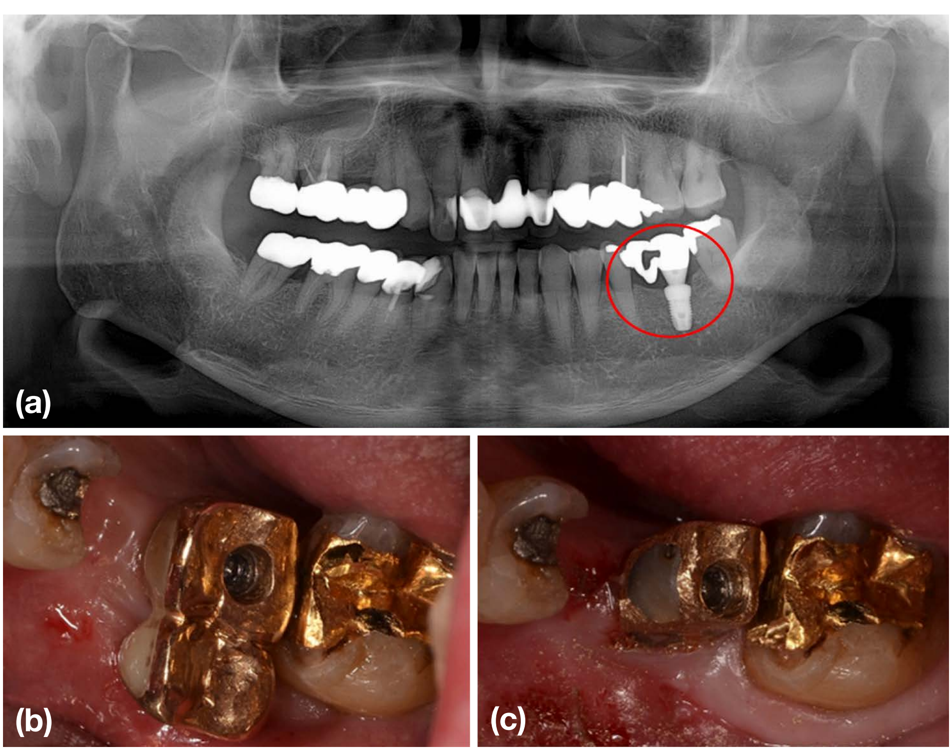

Figure 1. *A panoramic radiograph (a) and clinical photographs of the retrieved implant superstructure at revisit (b, c).*

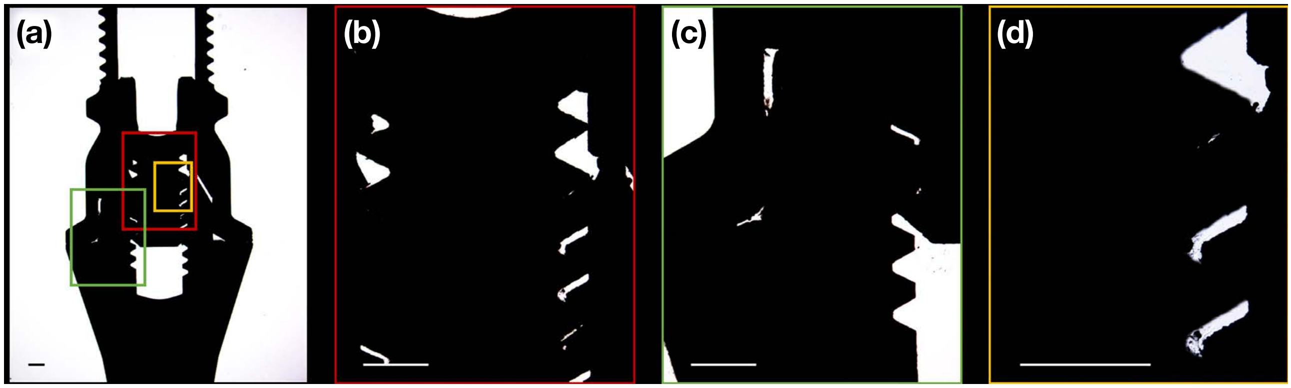

Figure 2. Example of cross section view of new specimen under SEM magnification of ×1.25 (a), ×5 (b, c), and ×10 (d).

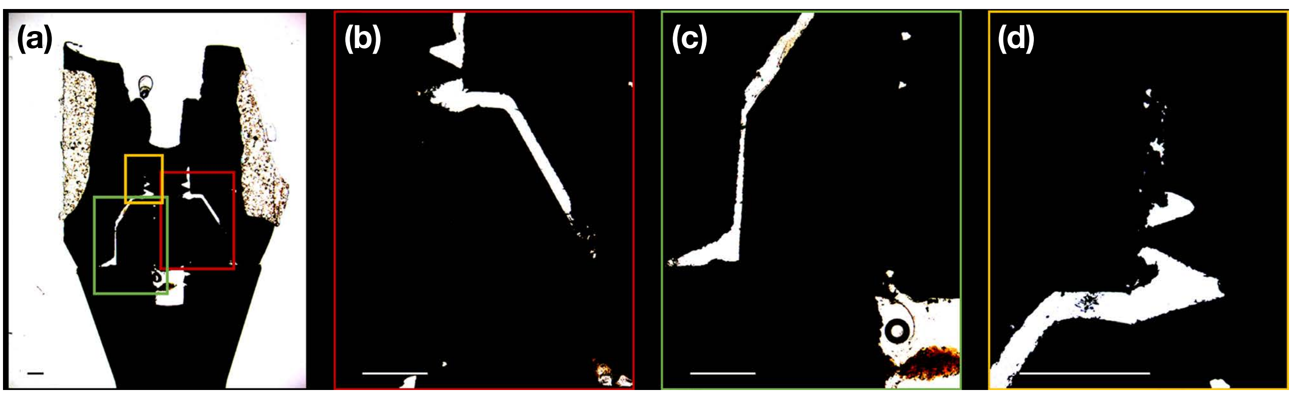

Figure 3. Example of cross section view of old specimen of 5-year loading under SEM magnification of ×1.25 (a), x5 (b, c), and ×10 (d).

unscrewing prosthetic screw and abutment loosening, the retrieved part of the restoration, particularly the configuration of the abutment-crown interface and the abutment-screw interface, was analyzed with scanning electron microscopy (SEM). A new abutment and cylinder were connected using titanium retaining screw with a torque of 30 N cm and then subjected to SEM analysis to compare the assembly accuracy to the old specimen from the patient. Each specimen was embedded in acrylic resin (Technovit 7200 VLC, Kulzer, Wehrheim, Germany), sectioned with a high-precision diamond disk along the longitudinal axis and observed under a scanning electron microscope (EXAKT 300CP, 5× and 10× magnification)[5].

1. Characteristics of the interfaces

In the new specimen, the prosthetic screw was well adapted and engaged in the thread spaces (Fig 2a). Relatively an even linear space appeared between the internal threads of the abutment and the retaining screw (Fig 2b and d). Although no vertical marginal gaps appeared between the abutment and the cylinder, these were incomplete horizontal and vertical contacts (Fig 2a and c). Previous studies could not ascertain whether this contact ratio could be regarded as machining tolerance, i.e., whether an incomplete contact was insubstantial or had no influence on structural integrity. Moreover, in the old specimen subjected to 5 years of loading, an irregular pattern of screw-thread engagement, a fused screw-thread shape, and irregular linear spaces at the abutment-cylinder interface were found in the SEM images (Fig 3b and c). More highly magnified views showed the configuration of the partially worn-out screw and its remnants in the interface, which could indicate that this geometry was produced by wear during mastication (Fig 3d). For the vertical and horizontal contacts, no uniform interfacial contact between the abutment and coping cylinder was found, which was also considered to be caused by the wear due to fatigue loading (Fig 3a).

DISCUSSION

From a mechanical point of view, the abutment screw loosening in this report could be considered as one of the most common types of mechanical complications; previous studies reported that 57% of abutment screws loosened during the first year of function, only 37% remained stable throughout a 3-year follow-up, and the incidence rate decreased to 12.7% at a 5-year follow-up due to advancements in materials technology[9,10]. However, the old prosthetic screw could not be retrieved with a wrench even with higher torque than the value recommended by the manufacturer; this phenomenon could be regarded as cold welding between the retaining screw and the gold cylinder.

Implant-abutment connection is a major factor in screw stability. These include implant-abutment connection type, geometrical morphology such as height or angle of abutment, abutment screw design and material, restoration type, human factor, and manufacturing-related factors such as manufacturing errors and originality of components[7,11]. One study stated that an implant with a uniform collar thickness and no sharp corners exhibited higher fracture toughness regardless of the diameter of the implant[7]. Hence, the functional integrity is ensured by accurate application of biomechanical principles in the implant design, interfacial fit and so on. The grossly irregular spaces at the abutment-gold cylinder interface and the round pattern of the cylinder margin were shown in the specimens subjected to a 5-year functional period. It was inferred that this worn-out feature resulted from the fatigue stress and micromovement of the superstructure during the functional period. However, the inherent misfit or the exaggerated machining tolerance could also be the main cause of the reduction in assembly accuracy. Therefore, even mechanical complications could be caused by multiple factors, but stable structural integrity should be an essential prerequisite prior to applying the functional load.

A loose fit of the prefabricated components could be caused by manufacturing tolerances, but the range of dimensional tolerances has not been verified by scientific evidence. Previous studies demonstrated that structural instability, such as loose fit between components, could induce micromovement that results in progressive screw loosening of the abutment and the prosthetic coping screw and showed correlations between abutment rotation and prosthetic screw loosening[12-14]. The increase in interfacial surface area could provide prostheses with resistance against external stresses under dynamic functional loading and better load distribution leading to longer fatigue life, which determines the mechanical success of implant-supported prostheses[1,6]. Although most contacts between the coupling surfaces of the implant components have no intimate full-surface fit, the amount of the intimate contact and the contact ratio in every interface inside the implant complex have not been investigated, and further study is needed to determine how much these factors influence the mechanical integrity and longevity of the implant. Moreover, to guarantee the longevity of implant prostheses, it should be determined whether the irregular gaps at the interfaces, the worn-out shape, and the fused features in the old assembly in this report were the consequences of 5-year functional period or a result of manufacturer imperfections.

CONCLUSION

The stable structural integrity such as intercomponent fit should be an essential prerequisite prior to applying the functional load to prevent mechanical complications. The inherent misfit or the exaggerated machining tolerance could be the main cause of the reduction in assembly accuracy.

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CONFLICTS OF INTEREST

The author declares that there is no conflict of interest regarding the publication of this study.

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