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ORIGINAL ARTICLE

Insertion torque, resonance frequency, and removal torque analysis of microimplants

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Abstract This study aimed to compare the insertion torque (IT), resonance frequency (RF), and removal torque (RT) among three microimplant brands. Thirty microimplants of the three brands were used as follows: Type A (titanium alloy, 1.5-mm × 8-mm), Type B (stainless steel, 1.5-mm × 8-mm), and Type C (titanium alloy, 1.5-mm × 9-mm). A synthetic bone with a 2-mm cortical bone and bone marrow was used. Each microimplant was inserted into the synthetic bone, without predrilling, to a 7 mm depth. The IT, RF, and RT were measured in both vertical and horizontal directions. One-way analysis of variance and Spearman's rank correlation coefficient tests were used for intergroup and intragroup comparisons, respectively. In the vertical test, the ITs of Type C (7.8 Ncm) and Type B (7.5 Ncm) were significantly higher than that of Type A (4.4 Ncm). The RFs of Type C (11.5 kHz) and Type A (10.2 kHz) were significantly higher than that of Type B (7.5 kHz). Type C (7.4 Ncm) and Type B (7.3 Ncm) had significantly higher RTs than did Type A (4.1 Ncm). In the horizontal test, both the ITs and RTs were significantly higher for Type C, compared with Type A. No significant differences were found among the

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groups, and the study hypothesis was accepted. Type A had the lowest inner/outer diameter ratio and widest apical facing angle, engendering the lowest IT and highest RF values. However, no significant correlations in the IT, RF, and RT were observed among the three groups.

Introduction

Favorable anchorage design is a critical factor for successful orthodontic treatment. Orthodontic microimplants have been verified as highly stable anchorage devices exhibiting diverse applications for effectively overcoming the difficulties encountered in orthodontic treatment. The stability and reliability of microimplants enable the successfully controlling orthodontic forces, limiting undesired tooth movements and correcting severe malocclusion. Orthodontic microimplants have a success rate of 60–90% [1–3]; therefore, they can be used as an effective tool for orthodontic treatment.

The stability of orthodontic microimplants that are inserted into bones can be categorized into two types; primary and secondary. Primary stability is the initial strength of the mechanical interlock between a microimplant and bone, whereas secondary stability is a biological osseointegration between an orthodontic microimplant and bone during healing. However, orthodontic microimplants are typically loaded with the orthodontic force immediately or after a period of 2–3 weeks, unlike dental implants that require at least 4 months for bone integration (secondary stability). Therefore, primary stability is the most critical concern in the application of orthodontic implants.

Different technologies have been employed to evaluate the stability of orthodontic microimplants, and such technologies include insertion torque (IT) [4,5], removal torque (RT) [6,7], and resonance frequency (RF) analysis [8–10]. RF analysis is a noninvasive, harmless, repeatable, and reliable method that has been successfully and widely used to measure the stability of dental implants. However, this method has seldom been used to study the stability of orthodontic implants. Therefore, the objective of the current study was to use the IT, RF, and RT analyses to investigate and compare the mechanical forces among three different brands of orthodontic microimplants.

Methods

As illustrated in Figure 1, 30 commercial orthodontic microimplants exhibiting three distinct features and belonging to three different brands were used in this study, and they can be categorized as follows: Type A (titanium alloy, 1.5-mm × 8-mm), Type B (stainless steel, 1.5-mm × 8-mm), and Type C (titanium alloy, 1.5-mm × 9-mm). From each of the three brands, five microimplants were used for vertical tests (90°) and five for horizontal tests (0°). Both the vertical and horizontal tests could include and interpret the degree of insertion of the clinical condition. Each test included IT, RF, and RT analyses.

Scanning electron microscope analysis (Hitachi SU8010, Tokyo, Japan) was applied to evaluate the surface feature of a thread (Figure 2). Under a clinical condition, a microimplant is placed in the interdental alveolar bone, which possesses a 2-mm thick cortical plate. A synthetic bone (Sawbone, Pacific Research Laboratories Inc., Vashon Island, WA, USA) with a 2-mm thick cortical plate (40 pcf) was developed from rigid polyurethane foam. The density of the cortical plate represented the relative densities of the maxillary and mandibular cortices, whereas the density of the cancellous bone (20 pcf) represented that of the bone marrow.

Each microimplant was inserted into the synthetic bone, without predrilling, to a depth of 7 mm, leaving at least 1-mm gingival thickness for IT and RT measurements using a digital torque meter (Lutron, Taipei, Taiwan). The analyzer (Implomates, BioTech One, Inc., Taipei, Taiwan) was based on the impulse force method and was used to measure resonance frequencies (Figure 3).

Figure 1. The microimplants manufactured with three designed types, from left to right: Type A (1.5-mm × 8-mm), Type B (1.5-mm × 8-mm), and Type C (1.5-mm × 9-mm).