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ORIGINAL ARTICLE

Influence of different implant materials on the primary stability of orthodontic mini-implants

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Titanium alloy

Abstract This study evaluates the influence of different implant materials on the primary stability of orthodontic mini-implants by measuring the resonance frequency. Twenty-five orthodontic mini-implants with a diameter of 2 mm were used. The first group contained stainless steel mini-implants with two different lengths (10 and 12 mm). The second group included titanium alloy mini-implants with two different lengths (10 and 12 mm) and stainless steel mini-implants 10 mm in length. The mini-implants were inserted into artificial bones with a 2-mm-thick cortical layer and 40 or 20 lb/ft^3 trabecular bone density at insertion depths of 2, 4, and 6 mm. The resonance frequency of the mini-implants in the artificial bone was detected with the Implomates® device. Data were analyzed by two-way analysis of variance followed by the Tukey honestly significant difference test ($\alpha = 0.05$). Greater insertion depth resulted in higher resonance frequency, whereas longer mini-implants showed lower resonance frequency values. However, resonance frequency was not influenced by the implant materials titanium alloy or stainless steel. Therefore, the primary stability of a mini-implant is influenced by insertion depth and not by implant material. Insertion depth is extremely important for primary implant stability and is critical for treatment success.

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Introduction

Titanium alloy is currently widely used in orthodontic mini-implants. The demand for titanium has increased because of its use in various industrial fields, and it is becoming more expensive [1]. Thus, in some countries, stainless steel mini-implants — rather than titanium alloy mini-implants — are more commonly used.

The requirement for orthodontic treatment modalities that provide maximal anchorage control and minimal patient compliance has led to the application of implant-assisted orthodontics [2]. Mini-implants allow orthodontists to achieve treatment goals that were previously considered extremely difficult, if not impossible. The clinical success rate of mini-implants in implant orthodontics exceeds 80% [3], a figure that has improved considerably from the past, but which remains imperfect.

Mini-implant stability has traditionally been difficult to evaluate and is often reduced to a simple assessment of mobility. Dental implant stability can be measured using a resonance frequency analyzer [4]. In 2000, the Osstell® device (Integration Diagnostics AB, Göteborg, Sweden) was introduced to determine the status of dental implants. Another type of resonance frequency analysis has proven useful for detecting dental implant stability in a series of *in vivo* and *in vitro* experiments [5—7]. This study used a novel resonance frequency detection device (Implomates®; BioTech One Inc., Taipei, Taiwan) to monitor the stability of orthodontic mini-implants.

The present study evaluates the influence of different implant materials on the primary stability of orthodontic mini-implants by measuring the resonance frequency.

Materials and methods

Orthodontic mini-implants

Twenty-five orthodontic mini-implants (2.0 mm in diameter; Bio-Ray, Syntec Scientific Corp., Taipei, Taiwan) were used (Fig. 1 and Table 1). The first group contained stainless steel mini-implants with two different lengths (10 and 12 mm). The second group included titanium alloy mini-implants with two different lengths (10 and 12 mm) and stainless steel mini-implants of 10 mm length. This study used five of each type.

Bone specimens

Mechanical test blocks of artificial bone (Sawbones®; Pacific Research Laboratories Inc., Vashon Island, WA, USA) were selected (Table 2) as a jaw bone equivalent. The mean bone mineral density is 0.55 g/cm^3 for the anterior maxilla and 0.31 g/cm^3 for the posterior maxilla [8]. Polyurethane foam blocks with a bone density of 40 lb/ft^3 (0.64 g/cm^3) and 20 lb/ft^3 (0.32 g/cm^3) were chosen for the experimental groups. The average cortical bone thickness ranges from 1.09 to 2.12 mm in the maxilla and from 1.59 to 3.03 mm in the mandible [9]. Sheets with a cortical layer thickness of 2 mm were selected.

Pilot hole preparation and mini-implant insertion

Two pilot holes were prepared, one without a pilot hole and one with a 1-mm pilot hole diameter. The 1-mm-diameter

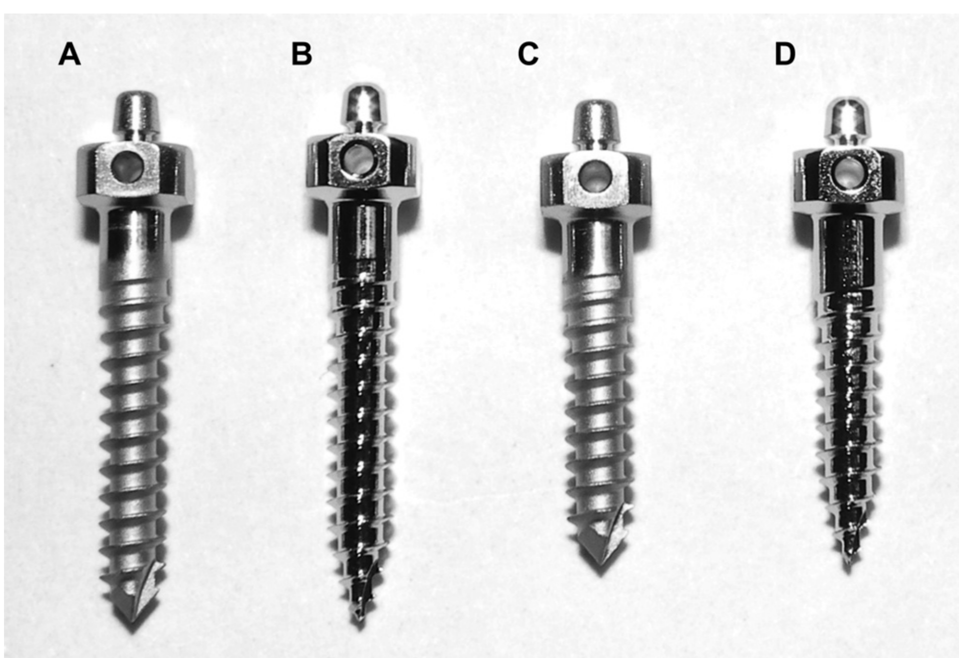

Figure 1. (A) Titanium alloy mini-implant (diameter, 2 mm; length, 12 mm). (B) Stainless steel mini-implant (diameter, 2 mm; length, 12 mm). (C) Titanium alloy mini-implant (diameter, 2 mm; length, 10 mm). (D) Stainless steel mini-implant (diameter, 2 mm; length, 10 mm).