Int. J. Oral Maxillofac. Surg. 2007; 36: 695–699
doi:10.1016/j.ijom.2007.03.009, available online at http://www.sciencedirect.com

International Journal of
Oral & Maxillofacial Surgery

Clinical Paper
Surgical Orthodontics

Application of orthodontic mini-implants in adolescents

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M. Motoyoshi, M. Matsuoka, N. Shimizu: Application of orthodontic mini-implants in adolescents. Int. J. Oral Maxillofac. Surg. 2007; 36: 695–699.

Abstract. The aim of this study was to determine the success rate of mini-implants in adolescents, and also whether a latent period is necessary and the optimum placement torque in an attempt to improve the success rate in adolescent patients. There were 57 orthodontic patients involved in the study, with ages ranging from 11.7 to 36.1 years, who underwent surgery to insert mini-implants (169 implants). When a mini-implant endured an orthodontic force applied for 6 months or more without any mobility, it was considered a success. The success rate was 63.8% in the early-load group (less than 1-month latent period) of adolescents, 97.2% in the late-load group (3-month latent period) of adolescents and 91.9% in the adult group. The success rate of the early-load group of adolescents was significantly inferior to those of the other groups ($P < 0.01$). In measurements of the placement torque in adolescents, the success rate of the 5–10 N cm group was significantly higher than the other groups only in the maxilla of the early-load group. Although the optimum torque could not be defined, a latent period of 3 months before loading is recommended to improve the success rate of the mini-implant when placed in the alveolar bone in adolescent patients.

Key words: anchorage; orthodontics; screw; cutting torque; survival rate.

Accepted for publication 19 March 2007
Available online 22 May 2007

Areas of tooth movement and areas that resist orthodontic forces commonly occur with orthodontic appliances. An orthodontic anchorage ensures that teeth move predictably and avoid insufficient reciprocal movement.

Titanium mini-implants have been developed and utilized as an anchor during orthodontic treatment[1,4,5,8,11,13,15]. The mini-implants designed for orthodontic anchorage can be placed at various locations in the alveolar bone, and the surgical procedure avoids infection because of the small screw size[5]. The success rate of the mini-implant has recently risen to nearly 90%[2] due to consideration of risk factors, devices for placement technique and improvement of the screw shape. The mini-implant has been proved to be successful and is now useful in clinical applications.

In the orthodontic field, young patients are frequently treated. The mini-implants placed in alveolar bones in adolescent patients act effectively, and remarkable improvement is often observed, even in cases with skeletal problems. But, in the clinic, mini-implants often loosen during orthodontic treatment, and this is often observed in teenagers[12]. The success rate of the mini-implant in adolescent patients was about 60% in a primary investigation (unpublished data). This is likely to be related to active bone metabolism in growing children and to low maturation of the bone, including the maxillo-mandibular bone. It would be clinically useful if the mini-implant could be applied regardless of age.

Immediate or early loading of the mini-implant as well as the dental implant has been preferred to reduce treatment duration and to respond to the requirements of patients[7]. The goal of this study was to investigate the relationship between success rate of mini-implants and having a latent period before loading to verify the possibility of early loading for adolescents.

0901-5027/080695 + 05 $30.00/0

Fig. 1. Mini-implant used in this study and anterior teeth retraction using nickel titanium coil spring to the mini-implant.

Placement torque when tightening the mini-implant was also measured to find the best torque to improve the success rate in adolescents.

Materials and methods

A total of 57 patients had surgery to place titanium mini-implants (1.6 mm in diameter and 8 mm in length; produced by Biodent Co., Ltd., Tokyo, Japan) (Fig. 1) in the posterior alveolar bone as anchors for orthodontic treatment at Nihon University Dental Hospital. In accordance with the ethics committee rules, the use of the mini-implants as anchors and the possibility of inflammation and loosening were explained to each patient. The data presented here are from patients who gave their consent to be part of the study before placement of the mini-implant.

There were 30 adolescent orthodontic patients (83 implants, 6 males and 24 females) with ages ranging from 11.7 to 18.9 years (mean 15.9, SD 1.9), and 27 adult orthodontic patients (86 implants, 3 males and 24 females) with ages ranging from 20.4 to 36.1 years (mean 26.2, SD 5.6). Of the 30 adolescent patients, 47 implants were inserted into the alveolar bone in 15 patients (mean age 15.9 years, SD 1.2), with orthodontic forces loaded from 2 to 4 weeks after implant placement (early-load group). The other 36 implants, which were placed in the other 15 patients (mean age 16.0 years, SD 2.4), had orthodontic forces loaded from 3 months or more after placement (late-load group). In the 27 adult patients, 86 implants were placed and orthodontic forces were loaded from 2 to 4 weeks after placement.

Surgical technique

After local anaesthesia was performed, a pilot hole was prepared in the buccal alveolar bone in the attached gingival region of the second premolar to the second molar of the maxilla and/or the mandible without flap operation in each patient. The direction of drilling the pilot hole was fixed obliquely, approximately 30 degrees from the long axis of the neighbouring tooth, to obtain sufficient thickness of cortical bone. In the preparation of the pilot hole, the following method was performed in this study, because it was expected to increase the success rate of controlling placement torque within the recommended range (5–10 N cm) according to the results of a previous study[10]. Considering diversified bone stiffness, the pilot hole was prepared using bone drills of 1 mm and 1.3 or 1.4 mm diameter and 8 mm length in the maxilla and the mandible, with saline irrigation. In the mandible, one of the bone drills of 1.3 or 1.4 mm diameter was chosen in proportion to the bone stiffness: when the placement torque exceeded 10 N cm during insertion of a mini-implant in the pilot hole of 1.3 mm in diameter, the pilot hole was extended using the bone drill of 1.4 mm in diameter. The placement torque was measured using a torque screwdriver with a round dial gauge and a pointer to read the peak value (N2DPSK, Nakamura MFG Co., Ltd., Tokyo, Japan). The peak placement torque value was recorded at the terminal turning when the mini-implant was tightened into the pilot hole. To control infection, a cephem antibiotic was prescribed for each patient for 3 days after placement.

Orthodontic force application

All mini-implants were utilized as anchorage for retraction of anterior teeth in the premolar extraction cases. Approximately 2 N orthodontic force was applied to each implant using a nickel titanium coil spring (Tomy International, Inc., Tokyo, Japan) during anterior teeth retraction. Success or failure of the mini-implant was decided 6 months or more after application of orthodontic forces. When the mini-implant loosened before 6 months, it was considered a failure. When the mini-implant endured an orthodontic force applied for 6 months or more without any mobility, it was considered a success.

Statistical analysis

The Chi-squire test or Fisher exact probability test was performed to compare the success rate of the mini-implant with respect to age, latent period and placement torque. The analyses were carried out using an SPSS statistical analysis program (SPSS Japan, Inc., Tokyo, Japan).

Results

Average latent period for each group was 2.6 weeks in the early-load group of adolescents, 13.2 weeks in the late-load group of adolescents and 2.2 weeks in the adult group.

Success rates for the mini-implants ranged from 88.9% to 100.0% in the adult patients, 55.6% to 71.4% in the early-load group of adolescents and 90.9% to 100.0% in the late-load group of adolescents. There was no significant difference among the placement locations (Table 1). Significant differences were observed in the early-load group of adolescents as compared to the other groups.

Placement torques in this study were distributed in a range of 7.6–9.2 N cm. There was no significant difference according to placement location and age (Table 2). The relationship between the success rate of the mini-implant and the placement torque is shown as a bar graph for each group (Figs 2–4). In the adult group, the success rate of the 5–10-N cm group was significantly better than that of the 10-N cm group in the maxilla and the sum total (Fig. 2). In the early-load group of adolescents, the success rate in the 5–10-N cm group was the highest compared to the other groups in the maxilla (Fig. 3). The success rate of the late-load group of adolescents was nearly 100%, and there was no significant difference according to the placement torque (Fig. 4).

Discussion

Tseng et al.[14] reported a 100% success rate for a mini-implant of more than 12 mm in length, and considered that the length of the mini-implant was related to the success