Optimal Insertion Torque for Orthodontic Anchoring Screw Placement

Subjects: Dentistry, Oral Surgery & Medicine

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Eleven original articles with orthodontic anchoring screws (OASs) placement in humans including insertion torque (IT) and success rate were selected and were used to evaluate the relationships among IT, success rates, screw design, and placement methods at different sites. The ITs and success rates ranged from 6.0 ± 3.2 to 15.7 ± 2.3 Ncm and from 62.5 to 100.0% in the upper and lower buccal alveolar areas, respectively. For the mid-palatal area, the range was 14.5 ± 1.6 to 25.6 ± 5.5 Ncm and 83.0 to 100.0%, respectively. ITs of 5–12 and 6–14 Ncm were found to be optimal for the commonly used φ1.5–1.7 mm OASs in the upper and lower interproximal areas, respectively. In the mid-palatal suture area, ITs of 11–16 and 20–25 Ncm were considered suitable for tapered φ1.5 mm and φ2.0 mm OASs, respectively. Although identified optimal IT ranges deserve the recommendations, care must be taken to monitor the IT during placement constantly.

Keywords: orthodontic anchoring screw ; orthodontic mini-implant ; temporary anchorage device (TAD) ; placement torque ; insertion torque ; success rate

1. Introduction

Orthodontic anchoring screws (OASs) used for various movements are simple to use and reliable. OASs are frequently employed as absolute anchorage devices in the buccal interproximal areas of upper and lower jaws, and the mid-palatal area for en masse retraction of the anterior teeth and distalization of the dental arch. Therefore, information about OAS stability is exceedingly important for the success of orthodontic treatment.

Insertion torque (IT) has been considered one of the factors affecting OAS stability [1][2][3]. Screws used in orthodontics generally have a diameter of 1.0–2.3 mm and a length of 3–15 mm [4][5][6]. Motoyoshi et al. [7] investigated φ1.6 × 8 mm OASs and recommended that the optimal IT was 5–10 Ncm and this range has been adopted by many clinicians and researchers. However, there have been variations in the literature. A previous study used tapered, self-tapping, φ2.0 × 6 mm OASs, and reported ITs of 25.6 ± 5.5 Ncm [8], whereas another study used cylindrical, self-drilling, φ1.5 × 7 mm OASs in the maxillary buccal alveolar area and reported ITs of 6.0 ± 3.2 Ncm [9]. Thus, the IT values vary greatly with the placement method and OAS design (screw diameter, length, and tapered or cylindrical form) [1][5][6][7][8][9][10][11][12][13][14][15]. Therefore, clinicians may be hesitant to apply these values in practice.

For instance, the mid-palatal area contains cortical bone that is thicker than the bone in the interproximal area, and thus higher ITs may be more suitable. Moreover, ITs for OASs may be different according to OAS designs or insertion techniques.

2. Maternal Trait Mindfulness and Social Competence of Preschoolers

2.1. Placement Methods (Self-Drilling or Self-Tapping)

ITs and success rates of OASs placed in the buccal alveolar and mid-palatal areas are listed in **Figure 1**, **Figure 2** and **Figure 3**. However, data from one study [10] were not included because the data for φ1.3 mm and φ1.5 mm OASs in the buccal alveolar area were unified, and separate values were not available.

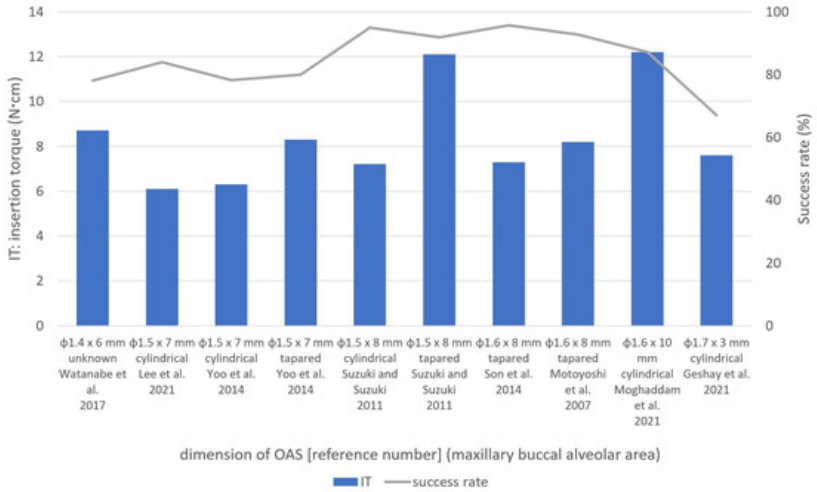

Figure 1. Insertion torques (ITs) and success rates according to OAS features in the maxillary buccal alveolar area. Explanations for each bar graph in the figure were listed in the following order: screw dimensions, screw form, authors, and published year [1][6][7][9][11][13][14][15].

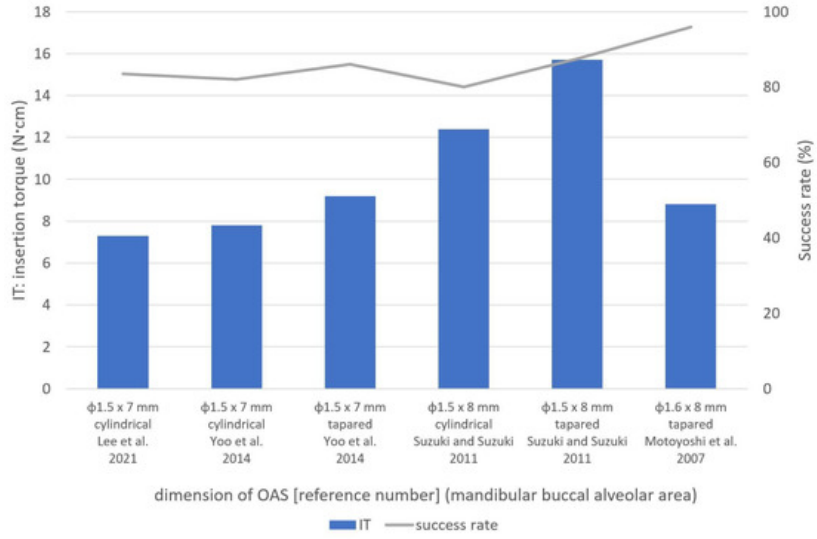

Figure 2. Insertion torques (ITs) and success rates according to OAS features in the mandibular buccal alveolar area. Explanations for each bar graph in the figure were listed in the following order: screw dimensions, screw form, authors, and published year [7][9][13][15].

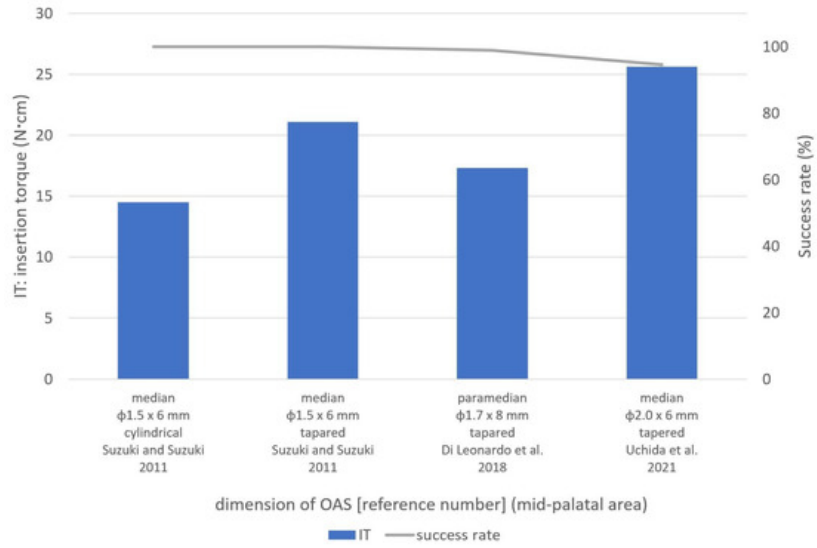

Figure 3. Insertion torques (ITs) and success rates according to OAS features in the mid-palatal area. Explanations for each bar graph in the figure were listed in the following order: screw dimensions, screw form, authors, and published year [8][12][15].

In self-drilling OASs, the ITs ranged from 6.0 ± 3.2 Ncm [9] to 21.1 ± 2.2 Ncm [15], while the success rates ranged from 64.3% [6] to 100.0% [10][15]. Thinner, cylindrical, φ1.5 mm OASs had the lowest ITs [9], whereas the highest ITs were in the mid-palatal area [15]. Thus, IT in self-drilling OASs was affected not only by OAS diameter but also by the placement site. Short 3.0 mm OASs had the lowest success rates [6]. Therefore, short, self-drilling OASs were found to increase the risk of failure.

Regarding self-tapping OASs, Motoyoshi et al. [7] used tapered φ1.6 × 8.0 mm OASs in the upper and lower buccal alveolar areas. In their study, OASs with a 1.0 mm pilot hole in maxilla (diameter ratio: bone drilling diameter/screw diameter × 100 [%] = 62.5%) and a 1.3 or 1.4 mm pilot hole in the mandible (diameter ratio = 81.3–87.5%) showed ITs and success rates of 7.6–8.9 Ncm and 91.8–95.0% in the maxilla and 8.5–8.8 Ncm and 91.9–100.0% in the mandible, respectively (except for the early-loading adolescent group) [7]. They also stated that the pilot-hole diameter in the mandible was extended from 1.3 mm to 1.4 mm when IT exceeded 10 Ncm depending on bone stiffness or cortical bone thickness. ITs and pilot-hole diameters are likely to affect the success rates in self-tapping OASs [7].

In the mid-palatal area, tapered φ2.0 × 6 mm OASs placed into 1.2 mm (diameter ratio = 60.0%) and 1.5 mm pilot holes (diameter ratio = 75.0%) had success rates of 94.5% (IT = 25.6 ± 5.5 Ncm) and 83.0% (IT not available), respectively, with a significant difference [8]. Therefore, it is suggested that the IT should be controlled, using different pilot-hole diameters in different placement sites with varying cortical bone thickness, to prevent bone and OAS fracture.

This contradiction between the results of two studies [14][15] may be explained by the differences in OAS characteristics. One important difference was the diameter ratio for self-tapping OASs (62.5% in the Son et al. [14] study). The tightness for tapered OASs could increase the IT and may be considered equivalent to the ITs observed in self-drilling OASs. Another study by Suzuki and Suzuki [15] used a diameter ratio of 75.0% in self-tapping OASs [15]. Under such conditions, the diameter ratio may cause lower ITs that are not equivalent to the ITs of self-drilling OASs. Another difference was the shape of the OASs. Suzuki and Suzuki [15] used cylindrical self-tapping OASs in contrast to the tapered screws in the Son et al. study [14].

As a result, no significant differences in ITs and success rates were recognized between the self-drilling and self-tapping OASs if the same OAS shape was used. However, an in vitro study using the synthetic bone blocks by Tepedino et al. evaluated the relationship between insertion torque and stability of the self-tapping and the self-drilling OASs and concluded that the self-drilling OASs showed a higher maximum IT than the self-tapping OASs under the same conditions of bone-like support and same inner diameter [2].

2.2. Shapes and Dimensions of OASs

2.2.1. Tapered and Cylindrical OASs

Yoo et al. [13] compared tapered and cylindrical self-drilling φ1.5 × 7 mm OASs and reported significantly higher ITs in tapered OASs (8.3 ± 3.7 Ncm) than in cylindrical OASs (6.3 ± 2.8 Ncm) in the maxillary buccal alveolar area. They reported no significant differences in success rates [13].

Suzuki and Suzuki [15] used tapered (self-drilling) and cylindrical (self-tapping) OASs of the same dimension (φ1.5 × 8 mm in the buccal alveolar area, and φ1.5 × 6 mm in the mid-palatal suture area), and found that tapered OASs had higher ITs (12.1 ± 3.1 Ncm, 15.7 ± 2.3 Ncm, and 21.1 ± 2.2 Ncm, respectively) than cylindrical OASs (7.2 ± 1.4 Ncm, 12.4 ± 1.2 Ncm, and 14.5 ± 1.6 Ncm) in all sites [15].

In an in vitro study, Assad-Loss et al. [16] evaluated the fracture torques for several OAS designs (φ1.5–1.6 × 6–7 mm) and reported that the characteristic that most influenced the results was the ratio between the internal and external diameters. Cunha et al. [17] compared ITs in tapered and cylindrical φ1.6 × 8 mm OASs using low- and high-density bovine bone and reported that tapered OASs had higher ITs than cylindrical OASs in the high-density bone, but there were no significant differences in the low-density bone [17].

2.2.2. OAS Dimensions

An in vitro study by Chen et al. [18] examined the mechanical properties of φ1.3 × 7 mm OASs (self-drilling) using artificial bone with densities of 20, 30, and 40 pcf, and reported ITs of 3.9, 5.2, and 10.0 Ncm, respectively.

Large φ2.0 × 6 mm OASs used in one study in the mid-palatal suture area had a success rate of 94.5% and the highest ITs (25.6 ± 5.5 Ncm) [8]. An in vitro study by Nienkemper et al. [19] evaluated φ2.0 × 9 mm OASs using pig pelvic bone and reported that the ITs for insertion depths of 4 mm, 5 mm, and 6 mm were 15.4 ± 7.0 Ncm, 26.2 ± 10.4 Ncm, and 27.2 ±

14.1 Ncm, respectively. Considering these results [19], the high ITs of φ2.0 × 6 mm OASs [8] may be appropriate for regions with high-density bone, such as the mid-palatal suture area.

2.3. Placement Location

2.3.1. Buccal Alveolar Area

The buccal alveolar area is a frequent site for OAS placement in orthodontic practice because of the simplicity of the procedure and advantageous anchorage. Motoyoshi et al. [7] recommended ITs of 5–10 Ncm to improve the success rate of φ1.6 mm OASs. As diameters of 1.3–1.7 mm were used in this area [1][6][7][8][9][10][11][12][13][14][15], a reference IT range for various conditions would be desirable.

Based on these studies, φ1.5–1.7 mm OASs were commonly used in this area, and ITs of 5–8 Ncm and 6–12 Ncm were optimal for cylindrical OASs in the upper and lower buccal alveolar areas, respectively. For tapered OASs, ITs of 6–12 Ncm and 8–15 Ncm were most suitable

2.3.2. Mid-Palatal Area

OAS placement in the mid-palatal area is used for various purposes, such as the retraction of anterior teeth and intrusion, distalization, and protraction of molars in the maxillary arch [20]. OAS placement in this area is also considered anatomically more favorable than the interproximal area [21]. However, as reported by Naya-Imai et al. [22], the sutured depth of mid-palatal suture should be considered using adequate imaging, such as cone-beam computed tomography, before OAS placement because there could be incomplete suture closure even in adults. Concerning this matter, they concluded that the OAS placement in mid-palatal sutures should be avoided regardless of age to prevent the insertion into unsutured areas.

The mid-palatal area has a thicker cortex, especially close to the median suture, which often requires pre-drilling before OAS placement for IT control [8][15]. Suzuki and Suzuki [15] used both cylindrical and tapered OASs (φ1.5 mm) in this area and reported lower ITs for the former. Cylindrical OASs had ITs and success rates of 14.5 ± 1.6 Ncm and 100.0%, respectively.

In an in vitro study, Wilmes et al. [23] reported that the maximum torques at the time of fracture for φ1.5 mm and φ2.0 mm OASs were 20.1 ± 3.8 Ncm and 49.2 ± 7.5 Ncm, respectively. In an in vitro study by Dalla Rosa et al. [24], the yield torque to fracture for φ1.5 mm OASs was 16.3 ± 1.6 Ncm. Based on these studies, the ITs of 21.1 ± 2.2 Ncm for φ1.5 mm OASs reported by Suzuki and Suzuki [15] exceeded the yield torque. Therefore, the use of φ2.0 mm tapered OASs with ITs of 20–25 Ncm is thought to be suitable in the mid-palatal suture area.

2.3.3. Infrazygomatic Crest and the Buccal Shelf Areas

The infrazygomatic crest and the buccal shelf area have some clinical advantages over alveolar interproximal areas [25] [26], but few studies have investigated OASs in these sites. Sreenivasagan et al. [3] investigated the ITs of OASs (φ2.0 × 12 mm) in these areas and found that the ITs and success rates at the infrazygomatic crest (12 screws) and buccal shelf (four screws) areas were 10.1 Ncm and 83.3%, and 10.3 Ncm and 100.0%, respectively. Approximately 10 Ncm IT is considered optimal in these areas, but further studies are required to investigate these placement sites.

3. Conclusions

The studies included in this are indicated as follows. The ITs and success rates ranged from 6.0 ± 3.2 Ncm to 15.7 ± 2.3 Ncm and from 62.5% to 100.0% in the upper and lower buccal alveolar areas, respectively. For the mid-palatal area, the range was 14.5 ± 1.6 Ncm to 25.6 ± 5.5 Ncm and 83.0% to 100.0%, respectively. ITs of 5–12 Ncm and 6–14 Ncm were found to be optimal for the commonly used φ1.5–1.7 mm OASs in the upper and lower interproximal areas, respectively. In the mid-palatal suture area, ITs of 11–16 Ncm and 20–25 Ncm were considered suitable for tapered φ1.5 mm and φ2.0 mm OASs, respectively.

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