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Original Article

The effect of a new modified screwdriver in orthodontics

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Abstract: The traditional screwdriver cannot make precise height and direction of the mini-screw insertion as designed. The aim of this study was to investigate the effect of a new modified screwdriver. Methods: A manual screwdriver (Pute Biomedical Company, Hangzhou, China) was modified with an auxiliary positioning attachment. Fifteen orthodontic patients who needed mini-screws as absolute anchorage were chosen for this study, and CBCT radiographs were taken after implantation. 3D images were reconstructed by using Dolphin software for analysis and measurement. The distance from the tip of the screws to the distal end of the second premolar bracket slot and the mesial end of the first molar buccal tube (Variable TIP) were measured. The angle of the miniscrew's axis to the bone cortex (Variable AX-BC) was measured too. A pair t-test was used to evaluate the statistical difference between these two groups. Results: The average difference of the variable TIP in the MS group was 0.13±0.11 mm, while the TS group was 1.61±0.56 mm. The average angle of the miniscrew's axis to the bone cortex in the MS group was 29.8°±0.8°, while the TS group was 37.1°±5.6°. Results showed significant statistics difference between MS and TS groups (P<0.001). Conclusions: Compared to the traditional screwdriver, the height and angle of implant were more accurate by using the modified tool.

Keywords: Dental implants, mini-screws, location, screw-insertion, positioning

Introduction

For absolute anchorage, the mini-screw and mini-implant have been widely used in the orthodontic treatment for a long time [1, 2]. By using absolute anchorages, the movement of teeth intrusion or the whole dental arch distalization have been easier to implement. Compared with dental implants or microplates, mini-implants are smaller, painless and more economical, and it can be positioned in a variety of places in each jaw [3, 4]. The angle of mini-implant is usually 30° in the maxilla and 20° in the mandible [5]. However, how to put the mini-implant precisely is a difficult issue for orthodontists. The risks of invasion to the sinuses, periodontal ligament injury, or root injury could be reduced if mini-implant is positioned rightly.

According to previous research [6], small ellipsoid template which attached to the teeth with light-cured composite could be used to determine the site but not the angel. Kim [7] created a new surgical guidance system to position the mini-implant by using a replicate dental models and cone-beam computed tomography (CBCT) images. Compared with conventional radiographs, CBCT images provide more therapeutic information to diagnosis, nevertheless it costs more and requires more radiation [8-10]. Therefore, a simpler, more economical and reliable method is needed in the clinical practice.

In this study, a manual screwdriver was used to make the location and angle of mini-implant more accurate. Results showed that this new screwdriver is very efficient in clinical practice.

Materials and methods

Fifteen patients (5 males and 10 females) who needed mini-screws as absolute anchorage were chosen in this experiment. The age of the patients ranged from 20-35 years (the average age is 23.5 years). All were at the permanent teeth period without severe crowding in the posterior teeth of the maxilla. They agreed to

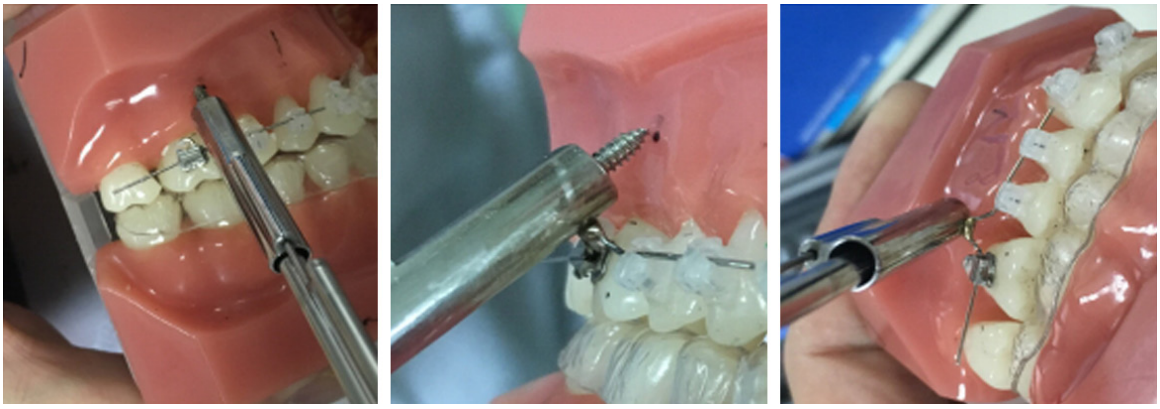

Figure 1. Diagram of the drilling using the modified screwdriver.

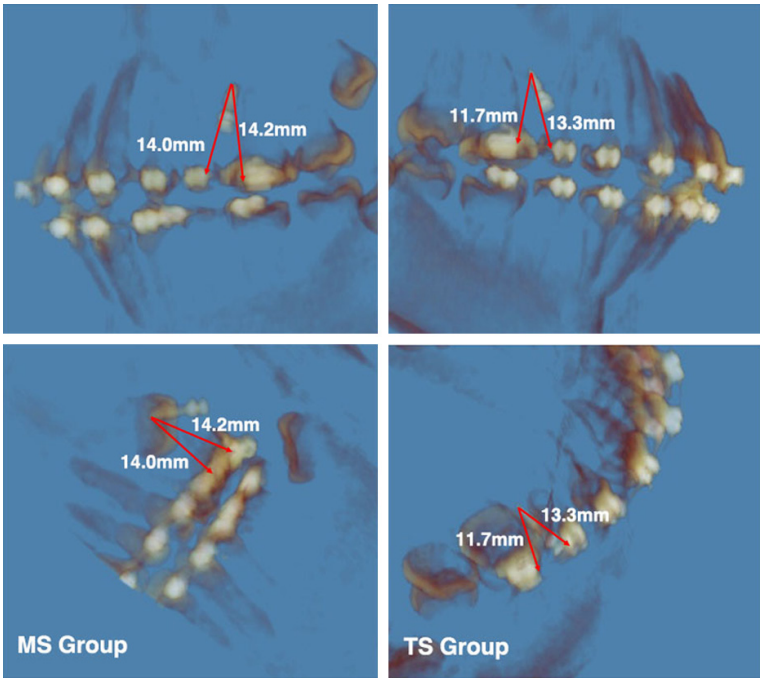

Figure 2. Measurement of the variable TIP of the two groups.

take CBCT radiographs after implantation to find out the relationship between mini-screws and teeth roots. The left side of maxilla alveolar was set as the experimental group (Modified screwdriver group, MS, Pute Biomedical Company, Hangzhou, China), while the right side was the control group (Traditional screwdriver group, TS, Pute Biomedical Company, Hangzhou, China).

After 3-5 months teeth alignment, mini-screws (8 mm length, 1.5 mm diameter, Pute Biomedical Company, Hangzhou, China) were implanted in both side of maxilla alveolar by using TS or MS. The mini-screws were drilled at the angle of 30° between the second premolar and first molar in the maxilla. The height was 6 mm distance from the gingival margin of the premolars (**Figure 1**). CBCT were taken for each patient after implantation. CBCT data was transduced into the Dolphin software (GAC International Inc, Bohemia, New York, USA) to reconstruct the 3D images. The distance from the tip of screw to the distal end of the second premolar bracket slot and the mesial end of the first molar buccal tube (variable TIP) was measured respectively (**Figure 2**). If the difference of the variable TIP was zero, the axis of the mini-screw was parallel to the buccal-palatal axis of the teeth. The angle of the mini-screw's axis to the bone cortex was also measured (**Figure 3**) with the NNT software (QR s.r. l corp, Verona, Italy). The measurements were made twice by the same doctor irrelevant of this study, and the mean value was taken into the statistical analysis. A paired t-test was done to evaluate the statistical difference between the two groups.

The middle point of the orthodontic wire between the distal end of the second premolar bracket slot and the mesial end of the first molar's buccal tube was decided, then a verti-

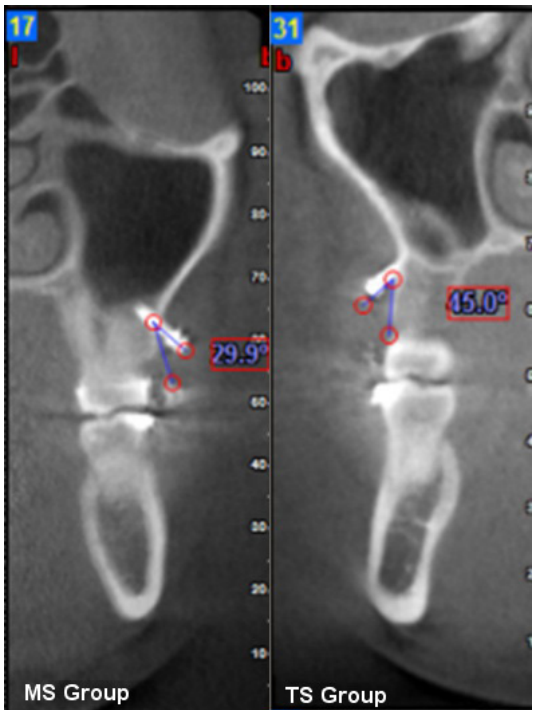

Figure 3. Measurement of the variable AX-BC of the two groups.

cal line to the wire was drawn, so the insertion point was the cross of the blue line (6 mm distance from the gingival margin of the second premolar) and the red line (vertical to the wire across the middle point of the orthodontic wire between the distal end of the second premolar bracket slot and the mesial end of the first molar buccal tube (**Figure 4**).

The parts of the modified screwdriver are shown in **Figure 5**. **Figure 5A**, along with the traditional screwdriver. **Figure 5B** is the auxiliary positioning attachment. **Figure 5C** is the modified screwdriver tip. The assembly parts of the modified screwdriver were as follows (**Figure 5D**): part 1 is the hand shank, part 2 is the roll booster, part 3 is the fixed link, part 4 is the drive pipe, part 5 is connecting rod, part 6 is locating rod and part 7 is the screw. Compared to the TS, the most different part of the MS is the auxiliary positioning attachment which can be divided into four parts (part 3\4\5\6). The part 4 is comprised of two welded tubes which are casings around by part 3 and part 5 respectively. The body of the screwdriver may roll into part 4. The part 6 is placed in the slot of the bracket and the pipe of the buccal tube or the band. The rod was bent by a 0.5 mm stainless steel wire to ensure the insertion of screwdriver

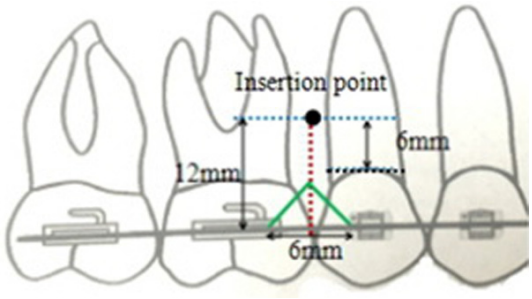

Figure 4. Diagram of the insertion point. Blue line: 6 mm distance from the gingival margin of the second premolar parallel to the wire. Red line: imitated vertical line to the wire across the middle point of the orthodontic wire between the distal end of the bracket slot and the mesial end of the first molar's buccal tube. Green line: vertical arm of the locating rod.

was at a consistent angle (part 6-1, vertical arm) and the stability of the screwdriver (part 6-2, horizontal arm). The part 5 is ligated to the hand shank by part 7. The function of the part 5 is to enhance the stability of the screwdriver.

The key point of MS is that the horizontal arm is perpendicular to the tooth axis, so as the relationship of the horizontal arm and the axis of the screwdriver. Therefore, the axis of the screwdriver is perpendicular to the axis of the teeth. In other words, the axis of the screwdriver is parallel to the buccal-palatal axis of the teeth. Therefore, the screw will not contact the roots of the premolar and the molar at all (**Figure 6**).

Results

The average distance difference of the variable TIP in the MS group was 0.13±0.11 mm, while the TS group was 1.61±0.56 mm (**Figure 7**). There was statistically significant difference between the two groups ($P<0.001$). The average angle of the miniscrew's axis to the bone cortex in the MS group was 29.8°±0.8°, and the TS group was 37.1°±5.6° (**Figure 8**). There was statistically significant difference ($P<0.001$).

From what has been showed above, the MS group was more precise to the planned angle, and more parallel to the roots of the adjacent teeth.

Discussion

The skeletal anchorage system has been developed into two categories. One is originated from osseointegrated dental implants, and the

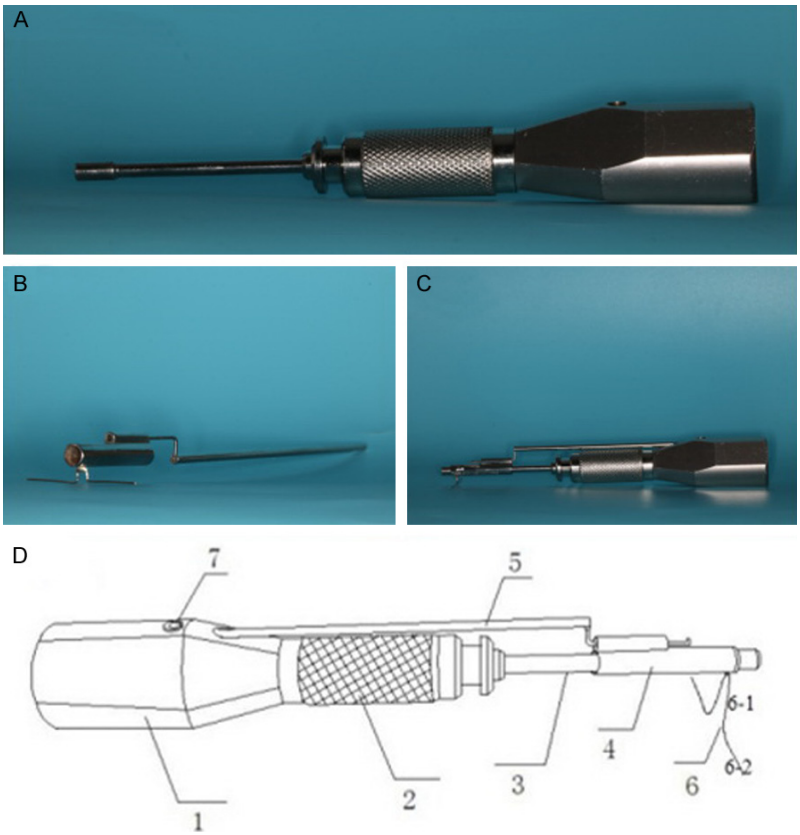

Figure 5. Diagram of the traditional screwdriver and modified screwdriver. A. Traditional screwdriver. B. Auxiliary positioning attachment. C. Modified screwdriver tip. D. The assembly of the modified screwdriver. (1 Hand shank. 2 Roll booster, 3 Fixed link, 4 Drive pipe, 5 Connecting rod, 6 Locating rod, 6-1 Vertical arm, 6-2 Horizontal arm, 7 Screw).

Figure 6. Display of the key point of MS.

other is from surgical mini-implants which is used in the orthodontic clinic more frequently. Studies [11-13] found that implantation could be successful either immediate loading or delay loading. In this study, loading was added to the mini-screw two weeks later after insertion.

Though many techniques had been invented to improve the accuracy of the screw placement, the blind-placement was the most common-used. However, blind-placement could lead to the mini-screw being too close to the root, and that led to the implant being loose and injuring the root [14]. Despite quick recovery ability of injury periodontal tissues [15], selecting insertion sites and angles carefully are still very important. In this experiment, the TS group used the blind-placement method, while the MS group used the auxiliary positioning method.

According to Poggio's research [16], in the interradicular spaces, safe distance between the first molar and second premolar of the buccal side was 5 to 8 mm from the alveolar crest. In this research, the height of the insertion was chosen at the site of 6 mm distance from the gingival margin of the second premolar. Moreover, if the insertion site needed to be distalized or mesialized, the length of the vertical arms was adjusted asymmetrically to adapt the situation. If only the horizontal arms of the locating rod were perpendicular to the axis of the screwdriver, the miniscrew was parallel to the roots of the adjacent teeth.

The distance from the insertion site to the the arch wire was about 12 mm, and the length of the wire between the brackets of second premolar and first molar was about 6 mm. The set insertion angle was 30°, the radius of part 4 was 3 mm, so the vertical distance of the locating rod's melted point to the wire is 3 mm (12 mm*sin 30°-3 mm). The length of the base-side and the height of the triangle were 6 mm and 3 mm respectively, while the length of the two hypotenuses (green line, the vertical arms of the locating rod, **Figure 9**) was 4.2 mm. Moreover, the length of the vertical arms was adjustable to adapt variable insertion angles or different heights. Without any auxiliary device, TS could not drill the mini-screw at a consistent

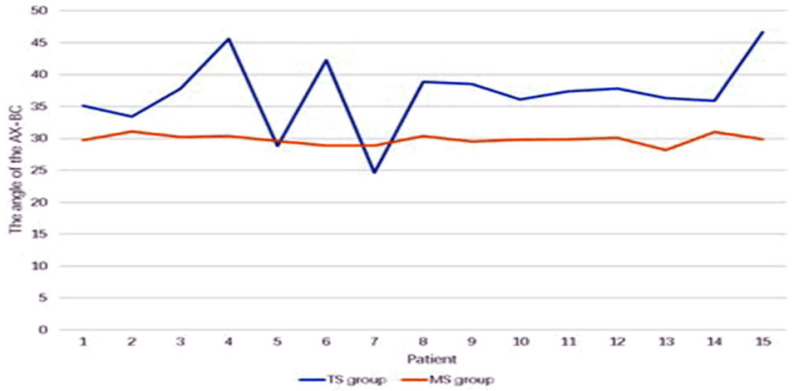

Figure 7. Display of the angle of the the miniscrew's axis to the bone cortex.

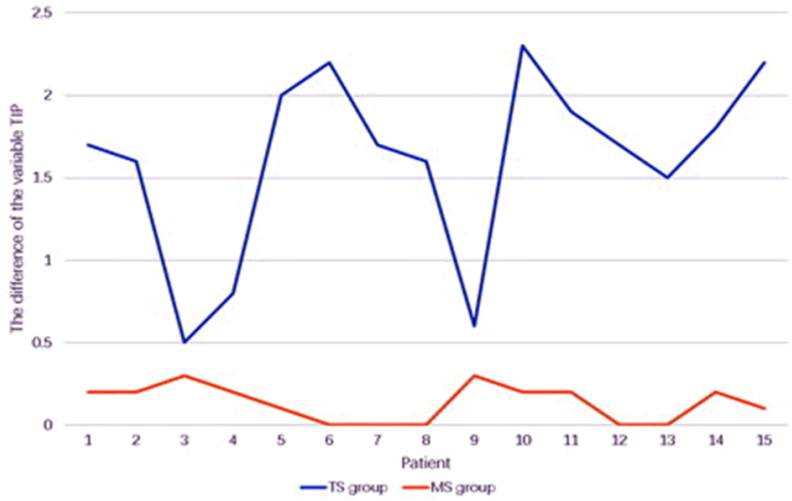

Figure 8. Display of the difference of the variable TIP.

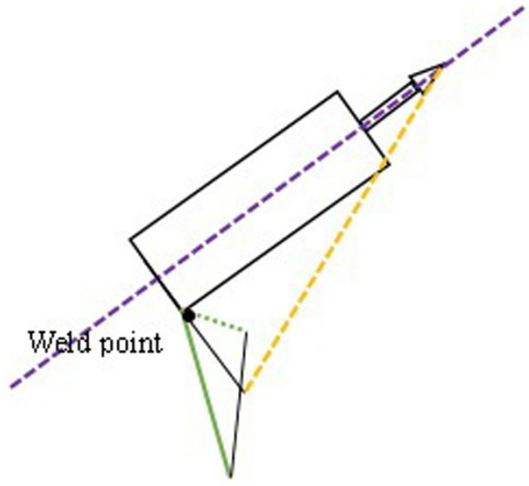

Figure 9. Diagram of the calculation of the vertical arm. Yellow line: cortical bone. Purple line: axis of the screwdriver. Green line: vertical arm of the locating rod.

angle, and there was significant difference among the individuals, while the MS groups showed the consistency.

In the process of the insertion, wobbling of the screwdriver was unavoidable. Wobbling may damage the cortical bone and decrease the stability of the miniscrews [17, 18]. The modified screwdriver had the locating rod. The horizontal arms of the rod were placed in the bracket slot of the second premolar and the buccal tube of the first molar. Two bends were made in the distal end of bracket slot and in the mesial end of the buccal tube, which may resist the wobbling of the screwdriver in the media-distal and vertical direction. The drive pipe also played a role in the stability of the insertion which decrease the failure rate of the miniscrews.

Compared to the TS, with the help of radiography, the insertion height and intentional angle of mini-screws are more accurate by using MS. Moreover, it can be used in the lingual orthodontic systems, as well as buccal ones. There are still some deficiencies in the modified screwdriver, and further improvements can be made more easily, precisely, and conveniently.

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Disclosure of conflict of interest

None.

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