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# Comparative evaluation of micro-implant and headgear anchorage used with a pre-adjusted appliance system

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SUMMARY The aim of this study was to compare and evaluate the anchorage effectiveness of using either micro-implants or extraoral headgear with the McLaughlin–Bennett–Trevisi (MBT) system.

Thirty young Chinese adults (14 males and 16 females) aged 18–22 years with anterior bimaxillary protrusion were divided randomly into two equal groups, treated with the MBT system anchored by either micro-implants or headgear. Nine measurements obtained before and after treatment from lateral cephalometric radiographs were assessed for the two groups, using the Mann–Whitney *U* test with $\alpha$ = 0.05 for statistical significance.

The maxillary incisors in the micro-implant group were significantly more retracted and intruded, while the lower incisors were more lingually inclined, than in the headgear group. The occlusal and mandibular planes were rotated more counterclockwise in the micro-implant group than in the headgear group ($P < 0.05$).

Compared with headgear anchorage, micro-implant anchorage may counteract clockwise rotation of the occlusal and mandibular planes and result in different final positions for the maxillary and mandibular incisors.

## Introduction

The introduction of the pre-adjusted straightwire appliance was a significant advance in orthodontic treatment (Andrews, 1976). McLaughlin and Bennett (1989) and McLaughlin *et al.* (2001) suggested a modification to pre-adjusted straightwire appliances with their McLaughlin–Bennett–Trevisi (MBT) system, which aimed to achieve improved three-dimensional control of the teeth, permitting sliding biomechanics during orthodontic treatment by altering torque specifications.

Orthodontic tooth movement always requires anchorage, either intra- or extraoral for the delivery of force. Gainsforth and Higley (1945) reported a versatile option for implant anchorage, although their research was unsuccessful. During the 1980s, osseointegrated implant anchorage, using regular prosthodontic implants, was introduced in limited sites (Roberts *et al.*, 1984, 1989). However, problems with their use resulted in the production of specialized small implants for orthodontic anchorage (Kanomi, 1997; Costa *et al.*, 1998; Park, 1999; Maino *et al.*, 2003). Small screw-shape implants, microscrews, or micro-implants have become popular (Park *et al.*, 2005). Micro-implants are inexpensive, simple to place and remove, immediately loadable, relatively comfortable, and readily accepted by patients. In addition, they are small enough to be placed into most areas of alveolar bone and can offer excellent anchorage control.

For historical and clinical reasons, traditional headgear is still popular and relatively effective for maximum anchorage control. However, ocular injuries are a recognized safety risk with headgear (Samuels, 1996), and its use relies on satisfactory patient compliance (Clemmer and Hayes, 1979). Lack of patient co-operation often results in anchorage loss with inadequate treatment outcomes. Adult patients in particular may reject the prescribed use of headgear because of aesthetic and social concerns.

The objective of the present study was to assess, in young adults, the effectiveness of orthodontic anchorage when using either micro-implants or extraoral headgear with the MBT system. The null hypothesis tested was that, when the MBT system is used to treat young adults with bimaxillary anterior protrusion, there are no significant differences in selected lateral cephalometric measurements when using either micro-implant or headgear anchorage.

## Subjects and methods

### *Subjects*

Thirty healthy male and female subjects (14 males and 16 females) aged 18–22 years attending the Orthodontic Department at the School of Stomatology, Nanjing Medical University, were recruited for the study. The patients were diagnosed with bimaxillary anterior protrusion, which required maximum anchorage and the extraction of all first premolars to obtain a satisfactory treatment result using the MBT system. The subjects were randomly divided

(RandA1.0 Software, Planta Medical Technology and Development Co. Ltd, Beijing, China) into two equal groups, one anchored by intraoral micro-implants and one by extraoral headgear. The study was approved by the Ethics Committee of Nanjing Medical University and each subject signed a consent form.

*Treatment mechanics*

After first premolar extractions, MBT pre-adjusted appliances (Unitek Gemini, 3M Unitek, Monrovia, California, USA) were bonded and banded according to the technique developed by McLaughlin and Bennett (1989) and McLaughlin *et al.* (2001). One-step retraction of the anterior arch segment was carried out with the second molars included in the mechanics.

For the micro-implant group, after arch alignment and levelling, four orthodontic micro-implants (AbsoAnchor, Dentos Inc., Daugu, Korea), one in each quadrant of the jaw, were implanted in each patient. After administration of local anaesthesia, 1.2 mm diameter micro-implants (maxilla 6 mm length, mandible 5 mm length) were screwed into the buccal alveolar bone between the maxillary second premolars and first molars, and between the mandibular first molars and second molars, at the apical level (Park, 2002). Rectangular arch wires (0.019 × 0.025 inch) with hooks were inserted, and the micro-implants loaded immediately with 100 g of force using activated nickel titanium coil springs (Grikin Co., Beijing, China) to retract the anterior teeth.

For the headgear group, after arch alignment and levelling, occipital headgear (Shinye Odontological Materials Co. Ltd, Hangzhou, China) was applied during the same period as for the micro-implant group. The outer face bows were bent upwards at an angle of 20 degrees, and a force of 350 g applied until all premolar spaces were closed. Class III elastic traction of 100 g was used during retraction of the mandibular anterior teeth to augment the mandibular anchorage.

*Data collection*

Lateral cephalometric radiographs were taken immediately before and after treatment for all subjects. Tracing, superimposition, and measurement were undertaken manually by two examiners who did not participate in the study design (Figure 1).

Selected measurements included in the study were (1) SNA, the anteroposterior position of the maxillary apical base; (2) SNB, the anteroposterior position of the mandibular apical base; (3) FMA, the mandibular plane–Frankfort horizontal plane angle; (4) FOA, the occlusal plane–Frankfort horizontal plane angle; (5) $\underline{1} - \text{SN}$, the axial inclination of the maxillary central incisor to the SN plane; (6) IMPA, the axial inclination of the mandibular central incisor to the mandibular plane; (7) $\underline{1} - \overline{1}$, the angle between the axes of the maxillary and mandibular central incisors; (8) Is–FH, the distance of the incisal edge of the maxillary central incisor perpendicular to the Frankfort horizontal plane; (9) Is–VFH, VFH is the vertical line from sella to the Frankfort horizontal plane, and Is–VFH is the distance of the incisal edge of the maxillary central incisor perpendicular to VFH.

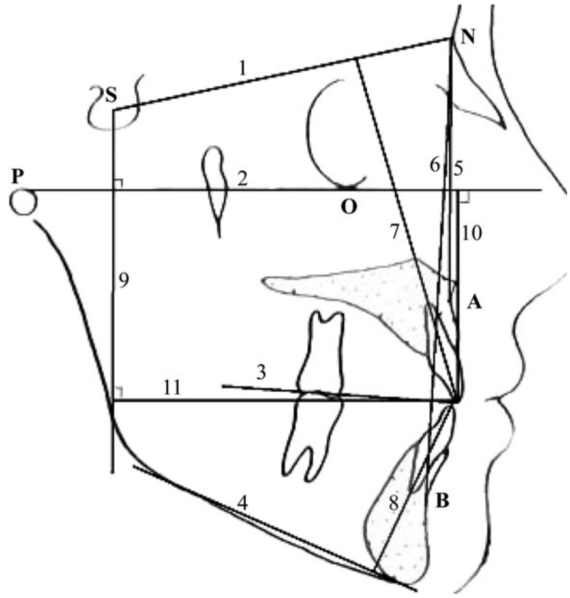


**Figure 1** Cephalometric radiographic tracing. S, sella point; N, nasion point; P, porion point; O, orbitale point; A, A point; B, B point; 1, SN plane; 2, FH plane; 3, occlusal plane; 4, mandibular plane; 5, NA line; 6, NB line; 7, long axis of the maxillary central incisor; 8, long axis of the mandibular central incisor; 9, VFH (vertical line from point sella to Frankfort horizontal plane); 10, Is–FH line; 11, Is–VFH line.

*Statistical analysis*

Statistical analysis was undertaken using the Statistical Package for Social Sciences (Version 13.0, SPSS Inc., Chicago, Illinois, USA). Data distributions were reported using medians, ranges, and percentiles. Because of the limited sample size, Mann–Whitney *U*-tests were used to compare cephalometric measurements between the two groups. The level of probability for statistical significance was set at $\alpha = 0.05$.

To assess intra- and interexaminer reliability, the cephalometric radiographs were re-traced and re-measured by the same two examiners after a period of 3 months. Differences between the original and the repeated cephalometric measurements were analysed using paired and unpaired Student's *t*-tests.

## Results

The two groups of subjects were comparable regarding their ages and initial cephalometric measurements (Table 1). The median treatment time for the micro-implant group of 22.0

**Table 1** Mann—Whitney *U*-tests comparing the pre-treatment ages and cephalometric measurements between the groups.

| Measurement | Headgear group | | | | Micro-implant group | | | | Mann–Whitney *U* | *P* |
|---|---|---|---|---|---|---|---|---|---|---|
| | Median | Range | $P_{25}$ | $P_{75}$ | Median | Range | $P_{25}$ | $P_{75}$ | | |
| Age (years) | 20.33 | 3.67 | 19.42 | 20.67 | 20.50 | 3.14 | 19.92 | 20.67 | 96.50 | 0.51 |
| SNA (°) | 84.28 | 2.48 | 83.70 | 84.61 | 83.80 | 2.48 | 82.25 | 84.93 | 93.00 | 0.44 |
| SNB (°) | 82.44 | 2.21 | 82.21 | 82.93 | 82.60 | 2.46 | 82.25 | 82.93 | 98.00 | 0.57 |
| FMA (°) | 27.55 | 3.40 | 26.92 | 28.04 | 26.89 | 3.63 | 26.28 | 27.62 | 67.00 | 0.06 |
| FOA (°) | 11.99 | 2.91 | 11.85 | 12.55 | 12.42 | 3.01 | 11.55 | 12.68 | 108.50 | 0.87 |
| $\underline{1} - \mathrm{SN}$ (°) | 114.73 | 10.76 | 112.10 | 116.32 | 113.73 | 8.05 | 112.26 | 115.21 | 104.00 | 0.74 |
| IMPA (°) | 98.44 | 6.43 | 97.83 | 101.00 | 98.55 | 7.82 | 97.11 | 100.66 | 101.50 | 0.65 |
| $\underline{1} - 1$ (°) | 110.33 | 11.24 | 107.93 | 112.00 | 113.98 | 9.60 | 107.67 | 115.30 | 84.00 | 0.25 |
| Is–FH (mm) | 56.66 | 10.78 | 55.82 | 68.68 | 56.93 | 8.68 | 55.82 | 58.81 | 110.50 | 0.94 |
| Is–VFH (mm) | 80.88 | 14.53 | 79.03 | 84.44 | 79.44 | 13.01 | 78.11 | 81.08 | 73.00 | 0.11 |

**Table 2** Mann—Whitney *U*-tests comparing the post-treatment cephalometric measurements between groups.

| Measurement | Headgear group | | | | Micro-implant group | | | | Mann–Whitney *U* | *P* |
|---|---|---|---|---|---|---|---|---|---|---|
| | Median | Range | $P_{25}$ | $P_{75}$ | Median | Range | $P_{25}$ | $P_{75}$ | | |
| SNA (°) | 82.83 | 2.62 | 82.51 | 83.27 | 82.73 | 2.47 | 82.35 | 83.17 | 107.00 | 0.84 |
| SNB (°) | 81.37 | 2.06 | 81.00 | 81.74 | 81.56 | 1.82 | 81.13 | 81.71 | 101.50 | 0.65 |
| FMA (°) | 28.58 | 4.23 | 27.92 | 28.01 | 27.02 | 3.30 | 26.55 | 28.28 | 39.00 | 0.00* |
| FOA (°) | 13.56 | 2.83 | 13.21 | 14.15 | 11.45 | 3.50 | 11.16 | 12.16 | 14.00 | 0.00* |
| $\underline{1} - \mathrm{SN}$ (°) | 107.61 | 8.27 | 105.04 | 108.83 | 107.07 | 8.14 | 105.09 | 108.95 | 111.00 | 0.97 |
| IMPA (°) | 95.78 | 5.00 | 94.30 | 97.46 | 94.04 | 6.74 | 93.06 | 96.59 | 62.00 | 0.04* |
| $\underline{1} - 1$ (°) | 125.65 | 7.86 | 123.87 | 126.41 | 129.20 | 9.55 | 127.82 | 132.10 | 30.00 | 0.00* |
| Is–FH (mm) | 58.69 | 11.58 | 54.81 | 59.88 | 54.78 | 8.99 | 54.21 | 57.69 | 63.50 | 0.04* |
| Is–VFH (mm) | 75.29 | 14.29 | 73.01 | 78.07 | 72.79 | 10.31 | 72.12 | 74.71 | 62.00 | 0.04* |

$P_{25}$, the 25th percentile; $P_{75}$, the 75th percentile.
*$P < 0.05$.

(range = 8.0) months and for the headgear group of 23.0 (7.0) months, were not significant ($P = 0.16$).

At the end of treatment (Table 2), final measurement between the two groups showed that IMPA was significantly smaller, and $\underline{1} - \overline{1}$ angle significantly larger, in the micro-implant group than in the headgear group. However, the axial inclinations of the maxillary incisors $(\underline{1} - \mathrm{SN})$ in both groups were not significantly different, indicating that the mandibular incisors were significantly more upright in the micro-implant group than in the headgear group. Changes in other measurements showed that the mandibular (FMA) and occlusal (FOA) planes were rotated significantly less clockwise in the micro-implant group than in the headgear group. The incisal edges of the maxillary central incisors also had significantly greater palatal retraction and intrusion in the micro-implant group than in the headgear group as shown by the measurements for Is–VFH and Is–FH, respectively. There were no significant differences between the two groups for SNA and SNB (Table 2).

## Discussion

### *Labiolingual inclinations of incisors*

Normal values for $\underline{1} - \mathrm{SN}$, $\underline{1} - \overline{1}$, and IMPA in Chinese subjects are reported as 105.7 (standard deviation = 6.3), 125.4 (7.9), and 96.5 (7.1) degrees, respectively (Fu, 2003).

The torque of the MBT bracket for the maxillary central incisor is 17 degrees, which is larger than the original inclination of the maxillary central incisor, in order to achieve a more ideal position after retraction. The results for $\underline{1} - \mathrm{SN}$ in the present study showed that the maxillary incisors were slightly more upright in the micro-implant group than in the headgear group after treatment, but the difference was not significant ($P = 0.97$).

For the mandibular incisors, MBT brackets have a much higher negative torque than that present in the original straightwire appliance. For the IPMA results, the mandibular incisors were significantly more lingually inclined in the micro-implant group than in the headgear group ($P = 0.04$). In the micro-implant group, the intermeisal angle or $\underline{1}-\overline{1}$, was greater than normal, which also indicated that the mandibular incisors in this group were lingually inclined, as the maxillary incisor values were approximately normal (Fu, 2003).

Park and Kwon (2003) showed three cases treated with microscrew implants and sliding mechanics with pre-adjusted appliances, where the inclinations of the maxillary incisors were normal, but the mandibular incisors were too upright. The present study involved young Chinese adults, and the results for the inclinations of the maxillary and mandibular incisors were similar to the findings of Park and Kwon (2003). Spaces present between the 0.019 × 0.025 inch rectangular wire and the bracket slot lead to a small loss of torque. Therefore, adding extra positive torque to the lower archwire should be considered when the MBT pre-adjusted appliance is used with micro-implants.

When considering Is–VFH, the incisal edges of the maxillary incisors moved more palatally in the micro-implant group than in the headgear group. The mandibular incisors also moved more lingually in the micro-implant group than in the headgear group, which may be the most important reason for the different inclinations of the mandibular incisors found between the two groups.

The mandibular micro-implants were placed more distally than the maxillary micro-implants. Therefore, the vertical component of retraction force was smaller in the mandible than in the maxilla, and the horizontal component of retraction force was greater in the mandible than in the maxilla, with the mandibular incisors more apt to be lingually inclined. Class III elastic traction with interarch traction was employed to enhance mandibular anchorage in the headgear group when mandibular spaces were being closed. Differences in force direction may be another reason why in the headgear group the axial inclinations of the mandibular incisors were relatively normal (Fu, 2003).

### *Changes of maxillary incisal edges*

The incisal edges of the maxillary incisors in both groups moved palatally without significant anchorage loss, but in the micro-implant group they moved relatively more ($P = 0.04$).

Following placement of a micro-implant, after approximately 3 months for most conditions, new bone forms and osseointegration gradually occurs. The implant then behaves in the same manner as an 'ankylosed tooth' (Akin-Nergiz *et al.*, 1998), to provide 'absolute anchorage', which may prevent or minimize any anchorage loss. By comparison, headgear enhances molar tooth anchorage in an indirect and variable manner. The anchorage molars will usually move forward somewhat, and the anterior teeth will often retract less when anchored by headgear than when anchored by micro-implants.

Intrusion of the anterior teeth was present when anchorage involved micro-implants, while a small amount of extrusion was found when anchorage headgear was used for. The incisors will be extruded to some extent because of the 'pendulum effect' during their retraction, but that effect will be alleviated in the MBT system due to the practice of lace back and archwire bend back. For the micro-implant group, the intrusion of the incisal edges of the maxillary incisors was beneficial to counterclockwise rotation of the occlusal and mandibular planes.

### *Changes of maxillary and mandibular basal bone*

For angles SNA and SNB, there were no statistically significant differences between the groups ($P > 0.05$). Both anchorage methods produced significant basal bone changes, which is important when treating patients with bimaxillary protrusion.

### *Changes in the mandibular and occlusal planes*

Usually, orthodontic treatment will rotate the mandible clockwise to increase lower face height, which can impair aesthetics and final occlusal stability, because of an imbalance between the dentition and muscles (Vaden, 1996).

In the present study, FMA and FOA both increased slightly in the headgear group during treatment, with the mandibular and occlusal planes both rotating clockwise. However, in the micro-implant group, because of the implant site positions, retraction forces also produced intrusion forces to the dentition. Therefore, the mandibular and occlusal planes rotated either counterclockwise or significantly less clockwise than in the headgear group ($P < 0.05$).

The use of a J-hook can also lead to a counterclockwise rotation of the mandible, but requires good patient compliance (Chae, 2006). Adults have aesthetic and social concerns, and may also not appreciate that vertical profile problems are as important as anteroposterior profile problems, making compliance more difficult to obtain when a J-hook is introduced.

## Conclusions

When compared with headgear anchorage, micro-implants may result in more retraction and intrusion of the maxillary incisors and more lingual inclination of the mandibular incisors, and may also counteract clockwise rotation of the mandibular and occlusal planes, during MBT treatment for bimaxillary protrusion in young adults. Except for the SNA, SNB, and $\underline{1}-SN$ cephalometric measurements, the null hypothesis was not accepted for the nine selected measurements.

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## References

Akin-Nergiz N, Nergiz I, Schulz A, Arpak N, Niedermeier W 1998 Reactions of peri-implant tissues to continuous loading of osseointegrated implants. American Journal of Orthodontics and Dentofacial Orthopedics 114: 292–298

Andrews L F 1976 The straight-wire appliance, origin, controversy, commentary. Journal of Clinical Orthodontics 10: 99–114

Chae J M 2006 A new protocol of Tweed-Merrified directional force technology with micro implant ancharage. American Journal of Orthodontics and Dentofacial Orthopedics 130: 100–109

Clemmer E J, Hayes E W 1979 Patient cooperation in wearing orthodontic headgear. American Journal of Orthodontics 75: 517–524

Costa A, Raffaini M, Melsen B 1998 Miniscrew as orthodontic anchorage: a preliminary report. International Journal of Adult Orthodontics and Orthognathic Surgery 13: 201–209

Fu M K 2003 Orthodontics. People's Medical Publishing House, Beijing, pp. 75–77

Gainsforth B L, Higley L B 1945 A study of orthodontic anchorage possibilities in basal bone. American Journal of Orthodontics 31: 406–417

Kanomi R 1997 Mini-implant for orthodontic anchorage. Journal of Clinical Orthodontics 31: 763–767

Maino B G, Bednar J, Pagin P, Mura P 2003 The spider screw for skeletal anchorage. Journal of Clinical Orthodontics 37: 90–97

McLaughlin R P, Bennett J C 1989 The transition from standard edgewise to preadjusted appliance systems. Journal of Clinical Orthodontics 23: 142–153

McLaughlin R P, Bennett J C, Trevisi H 2001 Systemized orthodontic treatment mechanics. Mosby, St Louis

Park H S 1999 The skeletal cortical anchorage using titanium microscrew implants. Korean Journal of Orthodontics 29: 699–706

Park H S 2002 An anatomical study using CT images for implantation of micro-implants. Korean Journal of Orthodontics 32: 435–441

Park H S, Jang B K, Kyung H M 2005 Maxillary molar intrusion with micro-implant anchorage (MIA). Australian Orthodontic Journal 21: 129–135

Park H S, Kwon T-G 2003 Sliding mechanics with microscrew implant anchorage. Angle Orthodontist 74: 703–710

Roberts W E, Helm F R, Marshall K J, Gongloff R K 1989 Rigid endosseous implants for orthodontic and orthopedic anchorage. Angle Orthodontist 59: 247–256

Roberts W E, Smith R K, Zilberman Y, Mozsary P G, Smith R S 1984 Osseous adaptation to continuous loading of rigid endosseous implants. American Journal of Orthodontics 86: 95–111

Samuels R H 1996 A review of orthodontic face-bow injuries and safety equipment. American Journal of Orthodontics and Dentofacial Orthopedics 110: 269–272

Vaden J L 1996 The Tweed-Merrifield philosophy. Seminars in Orthodontics 2: 237–240