Review Article

Effectiveness of TAD-anchored maxillary protraction in late mixed dentition
A systematic review

Xiaoxia Feng[a]; Jianhua Li[a]; Yu Li[b]; Zhihe Zhao[c]; Sen Zhao[a]; Jue Wang[a]

ABSTRACT

Objective: To evaluate the effectiveness of temporary anchorage device (TAD)-anchored maxillary protraction (MP) in terms of the skeletal and dentoalveolar changes and to compare it with traditional tooth-anchored MP.

Materials and Methods: A computerized literature search for relative randomized controlled trials and prospective controlled trials was performed in PubMed, MEDLINE, Cochrane Central Register of Controlled Trials, Embase, CNKI, and Google Scholar, complemented with manual search. Data extraction and quality assessment were carried out by two reviewers independently. Meta-analysis was followed when possible; otherwise, description was done.

Results: Forty articles were found, among which four trials were qualified for meta-analysis. The results showed that there was significant difference between TAD-anchored MP and untreated control in terms of maxillary advancement (weighted mean differences (WMD) 3.08 mm; 95% CI: 1.61 to approximately 4.56; $P < .0001$), but there were no consistent points in terms of mandibular rotation. Also, there were significant differences between both treatment patterns regarding maxillary advancement (WMD 1.41 mm; 95% CI: 0.47 to approximately 2.35; $P = .003$), mandibular rotation (WMD -1.39°, 95% CI: -2.47 to approximately -0.31; $P = .01$), proclination of maxillary incisors (WMD -2.29°; 95% CI: -4.41 to approximately -0.17; $P = .03$), and extrusion of maxillary molars (WMD -1.68 mm; 95% CI: -2.51 to approximately -0.85; $P < .0001$).

Conclusions: According to the present results, TAD-anchored MP might have a greater maxillary advancement effect and might reduce skeletal and dental side effects, compared with tooth-anchored MP. (*Angle Orthod.* 2012;82:1107–1114.)

KEY WORDS: Systematic review; Maxillary deficiency; Maxillary protraction; Temporary anchorage device

INTRODUCTION

Tooth-anchored maxillary protraction (MP) is known as the regular orthopedic therapy to treat children with maxillary deficiency. However, the therapy itself has three main shortcomings. Firstly, it has a relatively strict age limit and its optimal age is younger than 10 years old.[1] Secondly, maxillary deficiency combined with long face type is a great challenge for it.[2] Thirdly, so far, its effectiveness is still doubtful since the success rate is only about 70%, and the treatment does not seem to bring a clinically significant psychosocial benefit.[3] Recently, a long-term study has proved that no maxillary differences are still maintained after 8.5 years of follow-up.[4]

The shortcomings of tooth-anchored MP may be relevant to its combinative effects, including skeletal and undesirable dentoalveolar changes.[5–7] Maxillary advancement is mostly expected, while other effects,

[a] PhD student, State Key Laboratory of Oral Diseases, Department of Orthodontics, West China Stomatological Hospital, Sichuan University, Sichuan, PR China.

[b] Instructor, State Key Laboratory of Oral Diseases, Department of Orthodontics, West China Stomatological Hospital, Sichuan University, Sichuan, PR China.

[c] Professor and Chair, State Key Laboratory of Oral Diseases, Department of Orthodontics, West China Stomatological Hospital, Sichuan University, Sichuan, PR China.

Corresponding author: Dr Zhihe Zhao, Professor and Chair, State Key Laboratory of Oral Diseases, Department of Orthodontics, West China Stomatological Hospital, Sichuan University, #14, 3rd section of Renmin South Road, Chengdu 610041, PR China
(e-mail: zhzhao@scu.edu.cn).

Accepted: February 2012. Submitted: November 2011.
Published Online: March 29, 2012

especially the unwanted tooth movement, such as extrusion and mesialization of the maxillary molars and proclination of the maxillary incisors, may have adverse impacts on the treatment results. Of course, its side effects may be at least partly due to the tooth-anchored system. The mechanism of maxillary protraction is to apply force directly on the circum-maxillary sutures, stimulating bone apposition in the suture areas.[8] However, in tooth-anchored MP, part of the traction force was consumed by the tooth movement in the alveolar bone. In other words, the orthopedic effect is partly compromised by the orthodontic effect, which is against the goal of achieving the utmost skeletal alteration rather than dental compensation.

Up to now, in order to increase the skeletal effects of maxillary protraction and avoid the undesirable dental effects, orthodontists have attempted to transfer the orthopedic force directly to bone by way of a temporary anchorage device (TAD), such as osseointegrated titanium implants,[9] onplants,[10] titanium screws,[11] and miniplates.[12–25] TAD-anchored MP with miniplates is most frequently used; this procedure uses extraoral elastics[12–20] and intermaxillary elastics.[21–25] In the former type, the miniplates are placed on the infrazygomatic crest or the lateral nasal walls of the maxilla, thus abandoning the intraoral appliance. The TAD-anchored MP with intermaxillary elastics is even more comfortable and convenient, without facemask, and affords active treatment 24 hours per day. Between 92.5% and 97.0% miniplates are stable during the process of treatment.[26] Most patients think the surgical experience is better than expected, although postsurgical swelling or cheek irritation might appear, and clinicians believe that miniplates successfully simplify maxillary protraction.[27]

TAD-anchored MP has been reported as successful active treatment for 10- to 12-year-old patients with moderate or even severe maxillary deficiency, gaining significant anterior displacement of nasomaxillary complex, and meanwhile reducing or avoiding dentoalveolar compensations.[8,12–15,17,18,21] It has been used to treat anterior open bite as well.[15] Furthermore, the effects of TAD-anchored MP are stable in 11 to 38 months of follow up.[8,9,14,16,23] However, although TAD-anchored MP seems to be a prospective therapy in the late mixed dentition, many of its conclusions are based on case reports, and uncertainties remain such as whether it could cause maxillary molar extrusion and incisor proclination or not.[18,19,24,25]

Therefore, this systematic review was aimed to address two questions: (1) Could TAD-anchored MP result in maxillary advancement? (2) Could TAD-anchored MP produce greater maxillary advancement than tooth-anchored MP and/or reduce some dental side effects?

Table 1. Ovid MEDLINE Search: 1948 to Present With Daily Updates

Search History	No. of Results
1. Malocclusion, Angle Class III/th [therapy]	1,112
2. Exp child/ or child.mp.	1,517,107
3. Bone plates.mp. or exp bone plates/	10,934
4. Implants.mp.	98,710
5. Bone screw.mp. or exp bone screws/	14,765
6. Skeletal anchorage.mp.	146
7. Onplant.mp.	3,026
8. 3 or 4 or 5 or 6 or 7	120,720
9. 1 and 2 and 8	23

MATERIALS AND METHODS

Search Strategy and Study Collection

An electronic literature search was performed in PubMed (1970-September 2011), MEDLINE (1948–September 2011), Google Scholar (1970-September 2011), Embase (1980-September 2011), CNKI (1982-September 2011), and Cochrane Central Register of Controlled Trials (CENTRAL; to July 2011) with no language limitation. The search strategy is given in Table 1. In addition, the relevant articles of four journals (*Angle Orthodontist*, *European Journal of Orthodontics*, *Seminars in Orthodontics*, and *American Journal of Orthodontics, and Dentofacial Orthopedics)* were searched. All available titles and abstracts were read and those related to TAD-anchored MP were chosen by two reviewers. If the information offered by titles and abstracts was blurry, full texts were further carefully inspected.

Selection Criteria

The retrieved articles were assessed by two reviewers independently for eligibility, and any disagreement was solved through discussion or turn to the third reviewer for help. The inclusion and exclusion criteria are listed in Table 2. Studies not fulfilling the inclusion criteria were removed from further study.

Quality of the Studies

To identify the methodologic soundness of the selected articles, two reviewers independently graded them following the criteria by Antczak et al.[28] and Jadad et al.[29] The quality criteria was as follows: (1) study design (randomized controlled trials = 3 points; prospective controlled trials = 2 points; retrospective trials = 1 point); (2) adequate sample size = 1 point; (3) adequate selection description = 1 point; (4) valid measurement methods = 1 point; (5) use of method error analysis = 1 point; (6) adequate blinding in measurements = 1 point; and (7) adequate statistic provided = 1 point; (8) confounders included in

Table 2. Inclusion and Exclusion Criteria for the Retrieved Studies

Inclusion Criteria
1. Studies analyzing the effectiveness of temporary anchorage device (TAD) maxillary protraction
2. Randomized clinical trials (RCTs), controlled clinical trials (CCTs), and prospective studies
3. Cephalometric measurements about the skeletal and dentoalveolar changes
4. Sample size $\geq$ 10
Exclusion Criteria
1. Animal studies
2. Case reports, descriptive studies, review articles, letters, and opinion articles
3. No control groups

analysis = 1 point. Each article was classified as low (0–5 points), medium (6–8 points), or high (9–10 points). Conflicts between reviewers were resolved by discussion or turn to the third person for help.

Data Extraction

Trials that fulfilled the inclusion criteria were put into the computer database. The following points were extracted: author and year of publication; study design; number, age, and gender of subjects; the details of the intervention; follow-up; and outcomes.

Statistical Analysis

Selected studies were classified into two comparisons to evaluate the effectiveness of TAD-anchored MP depending on types of intervention. Two comparisons were conducted: (1) TAD-anchored MP vs untreated control, to answer if this new technique is really effective; and (2) TAD-anchored MP vs tooth-anchored MP, to answer if it is better than the traditional technique.

The following effects were evaluated: (1) skeletal effects, including maxillary advancement (A-VR) and

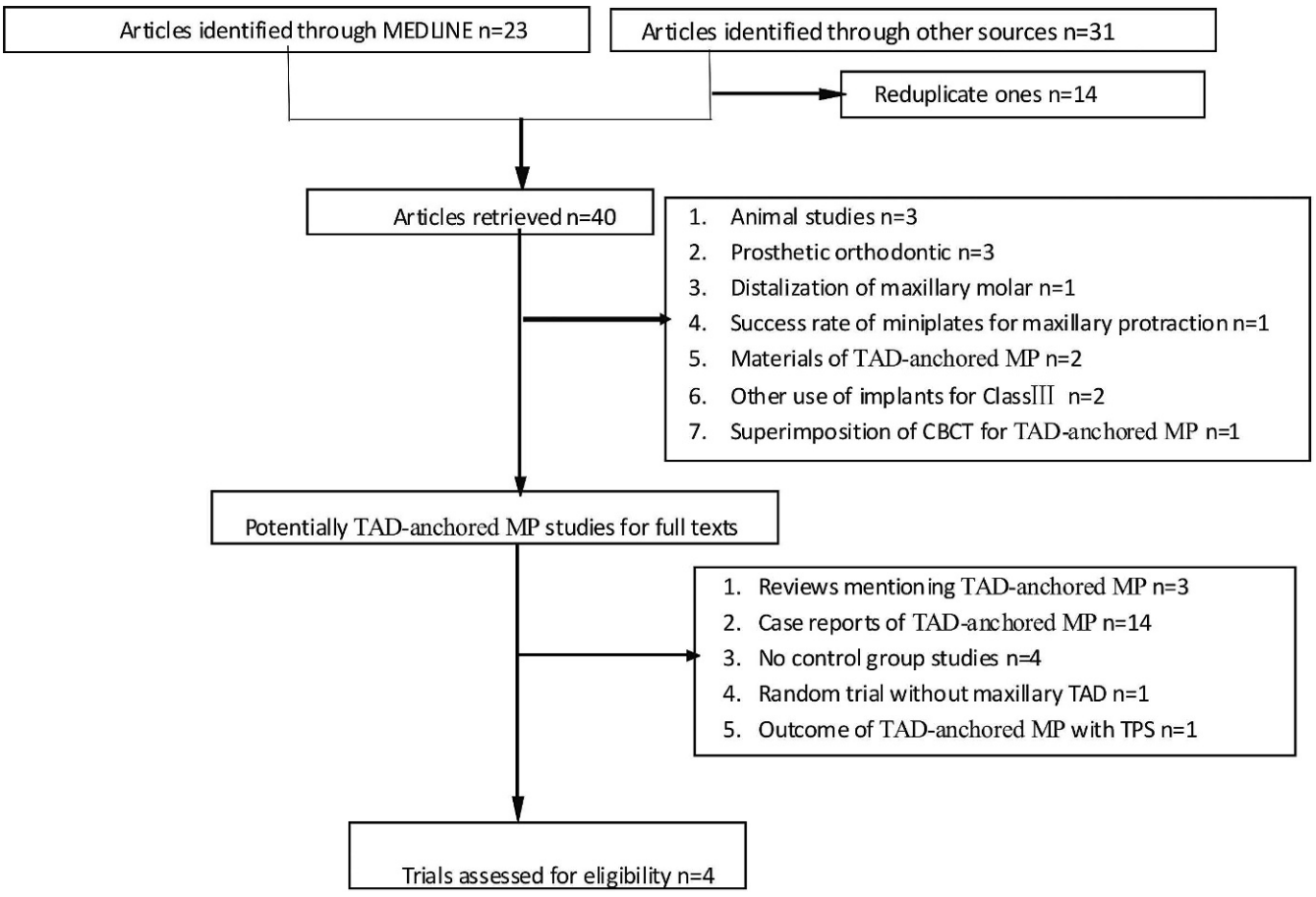

Figure 1. Flow diagram of the study selection.

Table 3. Characteristics of Included Studies[a]

Author (Year)	Study Design	Subjects Number M/F; Age ± SD, y	Interventions	Magnitude, g	Duration, mo	Follow-up	Maxillary Advancement, mm
Cevidanes et al.[24] (2010)	Prospective controlled	I: 10/11; 11.83 ± 1.83 II: 14/20; 8.25 ± 1.83	I: Class III elastics II: Extraoral elastics	I: 150–250, 24 h/d II: 300–500, 14 h/d	12	No	I: 2.5 more than II
De Clerck et al.[25] (2010)	Prospective controlled	I: 11/10; 11.10 ± 1.8 III: 11/7; 9.8 ± 2.83	I: Class III elastics III: Untreated control	I: 150–250, 24 h/d III: No	12	No	I: 4 more than III
Sar et al.[19] (2011)	Prospective controlled	I: 10/5; 10.91 ± 1.22 II: 8/7; 10.31 ± 1.52 III: 7/8; 10.05 ± 1.14	I: Extraoral elastics II: Extraoral elastics III: Untreated control	I: 400, 16 h/d II: 400, 16 h/d III: No	I: 6.78 II: 9.45 III: 7.59	No	I: 2.3, 0.45/mo II: 1.83, 0.24/mo
Cha et al.[20] (2011)	Retrospective comparative	I: 10/15; 11.0 ± 1.4 II: 9/16; 10.8 ± 0.9	I: Extraoral elastics II: Extraoral elastics	I: 400, 14–16 h/d II: 400, 14–16 h/d	I: 9.2 II: 8.5	No	I: 3.42 II: 2.13

[a] F indicates female; M, male; I, temporary anchorage device anchored MP; II, tooth-anchored MP; and III, untreated control.

mandibular plane angle (MP-HR); and (2) dentoalveolar effects, including inclination of maxillary incisors (U1-PP), extrusion of the maxillary first molars (U6-PP), and mesialization of the maxillary first molars (U6-HRmx). These measurements were taken into evaluation because in our opinion they are the indicators that might be affected by the different mechanisms between the TAD-anchored MP and the tooth-anchored MP. Other measurements, like the length of the mandible, were considered irrelevant.

Statistical heterogeneity and meta-analysis were performed using Review Manager 5.01. If there was heterogeneity, subgroup analysis was performed, and if the subgroup analysis failed, the intervention effects were described. If there was no heterogeneity ($P > .10$, $I^2 < 50\%$), the fixed-effects model was used or the random-effects model was followed.

RESULTS

Description and Methodologic Quality of Included Studies

The search process yielded 40 articles, four of which qualified based on the inclusion criteria.[19,20,24,25] The flow of the selection process is shown in Figure 1. Summary characteristics of included studies are given in Table 3. Three articles exhibited medium or high quality; only one article exhibited low quality (Table 4).

In the four articles, two articles[19,25] included comparison 1, resulting in a combined sample size of TAD-anchored MP (n = 61) vs untreated control (n = 33); three articles[19,20,24] included comparison 2, resulting in a combined sample size of TAD-anchored MP (n = 61) vs tooth-anchored MP (n = 74).

Skeletal Effects

Maxillary advancement. A meta-analysis was undertaken in terms of A-VR.[19] As significant heterogeneity existed (comparison 1: $I^2 = 84\%$, $P = .01$; comparison 2: $I^2 = 70\%$, $P = .04$), we used the random-effects model to aggregate the data. On the basis of current available evidence, the total pooled WMD value (95% CI) of A-VR was 3.08 mm (1.61, 4.56; $P < .0001$) in comparison 1 (Figure 2) and 1.41 mm (0.47, 2.35; $P = .003$) in comparison 2 (Figure 3), indicating that TAD-anchored MP was effective for patients in the late mixed dentition, and it achieved larger maxillary advancement than tooth-anchored MP.

Mandibular plane angle. MP-HR angle was used to evaluate mandibular rotation. De Clerck et al.[25] showed that this angle decreased, while Sar et al.[19] thought it increased slightly in comparison 1. The total pooled WMD value (95% CI) of MP-FH angle was -1.39° (-2.47, -0.31; $P = .01$) in comparison 2 (Figure 4), indicating mandibular plane angle was

Table 4. Quality Evaluation of the Selected Trials

Author (Year)	Study Design	Sample Size	Selection Description	Valid Measurement Methods	Method Error Analysis	Blinding in Measurement	Adequate Statistics	Confounding Factors	Total Score	Judged Quality Standard
Cevidanes et al.[24] (2010)	2	1	1	1	1	1	1	1	9	High
De Clerck et al.[25] (2010)	2	1	1	1	1	1	1	1	9	High
Sar et al.[19] (2011)	2	0	1	1	1	1	1	1	8	Medium
Cha et al.[20] (2011)	1	1	0	1	0	0	1	0	4	Low

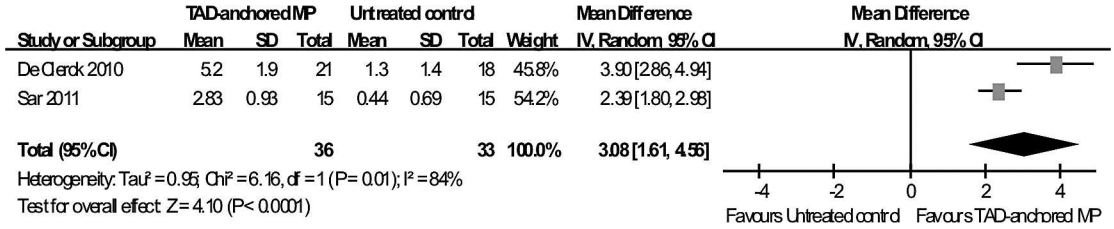

Figure 2. TAD-anchored MP vs untreated control for meta-analysis results in A-VR (mm).

controlled better by TAD-anchored MP intervention than by tooth-anchored MP.

Dentoalveolar Effects

Inclination of maxillary incisors. A significant difference did exist between the two groups in terms of U1-NL angle at the initial observation, which made it hard to say whether TAD-anchored MP influenced the proclination of maxillary incisors compared with untreated control.[25] So, inclination of maxillary incisors was not undertaken with meta-analysis in comparison 1. De Clerck et al.[25] reported the inclination of the maxillary incisors of TAD-anchored MP had no significant difference, whereas Sar et al.[19] showed maxillary incisors had significant linguoclination in comparison 1. The WMD value (95% CI) is -2.29° (-4.41, -0.17; $P = .03$) in comparison 2 (Figure 5), showing a significant proclination of maxillary incisors of the tooth-anchored MP group.

Extrusion and mesialization of maxillary first molars

Two trials were included in meta-analysis. As no significant heterogeneity existed ($I^2 = 0\%$, $P = .55$), fixed-effects model was used to aggregate the data in Figure 6. The outcomes showed that the maxillary molar demonstrated significant extrusion in the tooth-anchored MP group, indicating extrusion of maxillary molars was well avoided by TAD-anchored MP. No meta-analysis was done due to the significant heterogeneity. Cha and Ngan[20] thought that the tooth-anchored MP made significant mesialization of maxillary first molars, while Sar et al.[19] did not offer adequate data about this.

DISCUSSION

Nomenclature of the TAD-anchored MP

Different nomenclature has been used for this novel approach of maxillary protraction, including bone-anchored maxillary protraction, skeletal, rigid, or absolute anchorage. Miniscrews have been shown as relatively stable rather than absolute anchorage.[30,31] Therefore, ''rigid'' or ''absolute'' is not appropriate. ''Bone'' or ''skeletal'' is not appropriate either because ''TAD,'' which includes osseointegrated implants, miniplates, onplants, and miniscrews, is just in contrast to ''tooth,'' both of which are seated in ''bone'' and used as the point of force application for MP. Therefore, here we suggest the nomenclature of TAD-anchored MP for the novel technique, in contrast to tooth-anchored MP for the traditional technique.

Heterogeneity of Included Studies

Generally, no less than four trials were needed to be aggregated for meta-analyses in the Cochrane database.[32] In this review, only two or three studies were followed in meta-analysis. Considering that three of four selected trials were prospective and controlled with adequate sample size, meta-analysis was still conducted.

Heterogeneity of selected studies mainly exists in the interventions and outcomes. In this review, differences in the interventions could hardly be avoided, eg, in TAD-anchored MP, the maxilla was protracted either by intermaxillary or by extraoral elastics, possibly leading to different directions of the protraction force. Such confounding factors should be

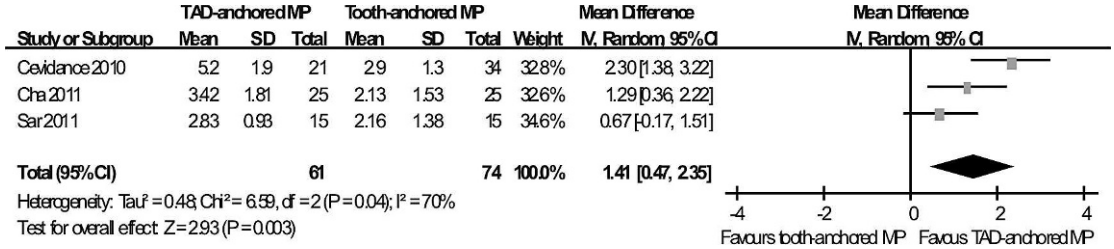

Figure 3. TAD-anchored MP vs tooth-anchored MP for meta-analysis results in A-VR (mm).

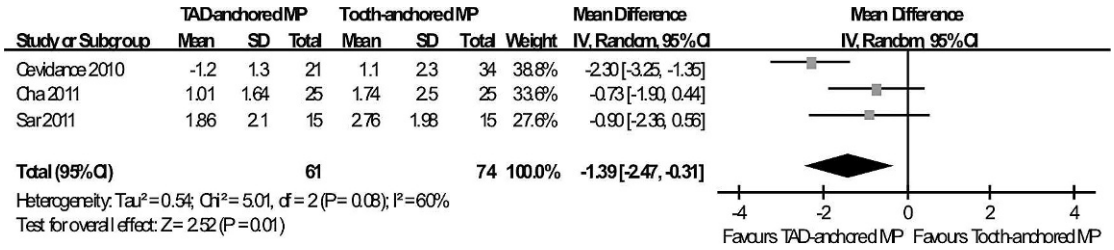

Figure 4. TAD-anchored MP vs tooth-anchored MP for meta-analysis results in MP-HR (degree).

taken into consideration when more high-quality trials are available in future.

However, all trials shared the same characteristic—maxillary miniplates. Therefore, sensitive cephalometric measurements related to maxillary miniplates or maxillary anchored tooth were evaluated, such as maxillary advancement, mandibular plane angle, inclination of maxillary incisors, and extrusion and mesialization of the maxillary first molars.

Maxillary Advancement

The total pooled WMD value (95% CI) of A-VR was 3.08 mm (1.61, 4.56; $P < .0001$) in comparison 1 and 1.41 mm (0.47, 2.35; $P = .003$) in comparison 2, which was in accordance with previous studies.[8–25] However, the maxillary advancement ranged from 1.61 to 8 mm, which depended on the severity of maxillary deficiency and treatment objective.[16–20] In any case, TAD-anchored MP showed a larger maximum potential for maxillary advancement than tooth-anchored MP.

Interestingly, Sar et al.[19] found that TAD-anchored MP was more efficient than tooth-anchored MP, as the rate of maxillary advancement in TAD-anchored MP was nearly twice that in tooth-anchored MP (0.45 vs 0.24 mm per month). A possible reason for this was that TAD-anchored MP imposed the orthopedic force directly on the maxillary sutures without being hampered by periodontal ligament or being consumed by tooth movement.

Side Effects

Compared with untreated control, the change of mandibular plane in the TAD-anchored MP was uncertain. However, when compared with the tooth-anchored MP, the clockwise rotation of the mandible was significantly decreased in the TAD-anchored MP.[19,25] This side effect could be either favorable or adverse for the treatment. It is favorable in low-angle but adverse in high-angle cases. Meta-analysis revealed significantly larger extrusion of the maxillary molars in the tooth-anchored MP, which may well account for the increased mandibular plane angle in this group. The clinical implication was that TAD-anchored MP should be the choice for Class III high-angle cases. Lin et al.[33] agreed that maxillary molars of the tooth-anchored MP extruded 3.8 mm. Therefore, TAD-anchored MP could be tried to treat the patients with maxillary deficiency and long face type.[14,17]

Proclination of the maxillary incisor was significantly larger in the tooth-anchored MP group than in the TAD-anchored MP group. Though this side effect can help correct the anterior crossbite, over-proclination of the maxillary incisor is neither healthy nor esthetic; moreover, advancement of the maxillary bone, rather than the incisors, is what the orthodontists really expect.

The reason might be that tooth-anchored MP was limited to children younger than 10 years of age, while the skeletal effect decreases and the dental effect increased with age when used to treat the children older than 10 years.[1,7]

Cha and Ngan[20] thought the mesialization of the maxillary molar of the tooth-anchored MP group was much more than that of the TAD-anchored MP group. Lin et al.[33] had a similar conclusion that maxillary molars mesialized about 3.4 mm in the tooth-anchored MP group. The result of TAD-anchored MP needs to be verified by more randomized controlled trials and

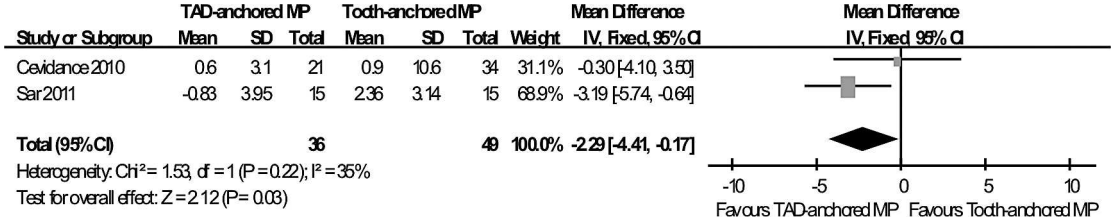

Figure 5. TAD-anchored MP vs tooth-anchored MP for meta-analysis results in U1-PP (degree).

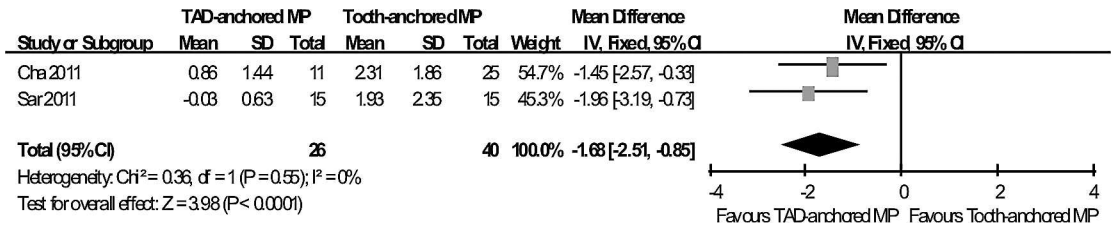

Figure 6. TAD-anchored MP vs tooth-anchored MP for meta-analysis results in U6-VR (mm).

long-term follow-up partly because of the current small sample size.

CONCLUSIONS

- Based on the present results, TAD-anchored MP might have greater effect of maxillary advancement.
- Some side effects are reduced by TAD-anchored MP, such as mandibular rotation, extrusion of maxillary molars, and proclination of maxillary incisors.

REFERENCES

1. Kim JH, Viana MA, Graber TM, Omerza FF, BeGole EA. The effectiveness of protraction face mask therapy: a meta-analysis. *Am J Orthod Dentofacial Orthop*. 1999;115: 675–685.
2. Yoshida I, Shoji T, Mizoguchi I. Effects of treatment with a combined maxillary protraction and chincap appliance in skeletal Class III patients with different vertical skeletal morphologies. *Eur J Orthod*. 2007;29:126–133.
3. Mandall N, DiBiase A, Littlewood S, et al. Is early Class III protraction facemask treatment effective? A multicentre, randomized, controlled trial: 15-month follow-up. *J Orthod*. 2010;37:149–161.
4. Masucci C, Franchi L, Defraia E, Mucedero M, Cozza P, Baccetti T. Stability of rapid maxillary expansion and facemask therapy: a long-term controlled study. *Am J Orthod Dentofacial Orthop*. 2011;140:493–500.
5. Hägg U, Tse A, Bendeus M, Rabie AB. Long-term follow-up of early treatment with reverse headgear. *Eur J Orthod*. 2003;25:95–102.
6. Lertpitayakun P, Miyajima K, Kanomi R, Sinha PK. Cephalometric changes after long-term early-treatment with facemask and maxillary intraoral appliance therapy. *Semin Orthod*. 2001;7:169–179.
7. Cha KS. Skeletal changes of maxillary protraction in patients exhibiting skeletal class III malocclusion: a comparison of three skeletal maturation groups. *Angle Orthod*. 2003;73: 26–35.
8. Kircelli BH, Pektas ZO. Midfacial protraction with skeletally anchored facemask therapy: a novel approach and preliminary results. *Am J Orthod Dentofacial Orthop*. 2008;133: 440–449.
9. Singer SL, Henry PJ, Rosenberg I. Osseointegrated implants as an adjunct to facemask therapy: a case report. *Angle Orthod*. 2000;70:253–262.
10. Hong H, Ngan P, Han G, Qi LG, Wei SH. Use of onplants as stable anchorage for facemask treatment: a case report. *Angle Orthod*. 2005;75:453–460.
11. Enacar A, Giray B, Pehlivanoglu M, Iplikcioglu H. Facemask therapy with rigid anchorage in a patient with maxillary hypoplasia and severe oligodontia. *Am J Orthod Dentofacial Orthop*. 2003;123:571–577.
12. Kircelli BH, Pektaş ZO, Uçkan S. Orthopedic protraction with skeletal anchorage in a patient with maxillary hypoplasia and hypodontia. *Angle Orthod*. 2006;76:156–163.
13. Zhou YH, Ding P, Lin Y, Qiu LX. Facemask therapy with miniplate implant anchorage in a patient with maxillary hypoplasia. *Chin Med J*. 2007;120:1372–1375.
14. Cha BK, Choi DS. Maxillary protraction using miniplates as skeletal anchorage. *Hong Kong Dent*. 2010;7:87–93.
15. Baek SH, Kim KW, Choi JY. New treatment modality for maxillary hypoplasia in cleft patients. Protraction facemask with miniplate anchorage. *Angle Orthod*. 2010;80:595–603.
16. Cha BK, Choi DS, Ngan P, Jost-Brinkmann PG, Kim SM, Jang IS. Maxillary protraction with miniplates providing skeletal anchorage in a growing Class III patient. *Am J Orthod Dentofacial Orthop*. 2011;139:99–112.
17. Baek SH, Yang IH, Kim KW, Ahn HW. Treatment of Class III malocclusions using miniplate and mini-implant anchorage. *Semin Orthod*. 2011;17:98–107.
18. Kaya D, Kocadereli I, Kan B, Tasar F. Effects of facemask treatment anchored with miniplates after alternate rapid maxillary expansions and constrictions; a pilot study. *Angle Orthod*. 2011;81:639–646.
19. Sar C, Arman-Özçırpıcı A, Uçkan S, Yazıcı AC. Comparative evaluation of maxillary protraction with or without skeletal anchorage. *Am J Orthod Dentofacial Orthop*. 2011;139:636–649.
20. Cha BK, Ngan PW. Skeletal anchorage for orthopedic correction of growing class III patients. *Semin Orthod*. 2011; 17:124–137.
21. Heymann GC, Cevidanes L, Cornelis M, De Clerck HJ, Tulloch JF. Three-dimensional analysis of maxillary protraction with intermaxillary elastics to miniplates. *Am J Orthod Dentofacial Orthop*. 2010;137:274–284.
22. Baccetti T, De Clerck HJ, Cevidanes LH, Franchi L. Morphometric analysis of treatment effects of bone-anchored maxillary protraction in growing Class III patients. *Eur J Orthod*. 2011;33:121–125.
23. De Clerck HJ, Cornelis MA, Cevidanes LH, Heymann GC, Tulloch CJ. Orthopedic traction of the maxilla with miniplates: a new perspective for treatment of midface deficiency. *J Oral Maxillofac Surg*. 2009;67:2123–2129.
24. Cevidanes L, Baccetti T, Franchi L, McNamara JA Jr, De Clerck H. Comparison of two protocols for maxillary protraction: bone anchors versus face mask with rapid maxillary expansion. *Angle Orthod*. 2010;80:799–806.
25. De Clerck H, Cevidanes L, Baccetti T. Dentofacial effects of bone-anchored maxillary protraction: a controlled study of consecutively treated Class III patients. *Am J Orthod Dentofacial Orthop*. 2010;138:577–581.

26. De Clerck EE, Swennen GR. Success rate of miniplate anchorage for bone anchored maxillary protraction. *Angle Orthod*. 2011;81:1010–1013.
27. Cornelis MA, Scheffler NR, Nyssen-Behets C, De Clerck HJ, Tulloch JF. Patients' and orthodontists' perceptions of miniplates used for temporary skeletal anchorage: a prospective study. *Am J Orthod Dentofacial Orthop*. 2008; 133:18–24.
28. Antczak AA, Tang J, Chalmers TC. Quality assessment of randomized control trials in dental research. I. Methods. *J Periodontal Res*. 1986;21:305–314.
29. Jadad AR, Moore RA, Carroll D, Jenkinson C, Reynolds DJ, Gavaghan DJ, McQuay HJ. Assessing the quality of reports of randomized clinical trials: is blinding necessary? *Control Clin Trials*. 1996;17:1–12.
30. El-Beialy AR, Abou-El-Ezz AM, Attia KH, El-Bialy AM, Mostafa YA. Loss of anchorage of miniscrews: a 3-dimensional assessment. *Am J Orthod Dentofacial Orthop*. 2009;136:700–707.
31. Liu H, Lv T, Wang NN, Zhao F, Wang KT, Liu DX. Drift characteristics of miniscrews and molars for anchorage under orthodontic force: 3-dimensional computed tomography registration evaluation. *Am J Orthod Dentofacial Orthop*. 2011;139:e83–e89.
32. Loannidis JP, Patsopoulos NA, Evangelou E. Uncertainty in heterogeneity estimates in meta-analyses. *BMJ*. 2007;335: 914–916.
33. Lin HC, Chang HP, Chang HF. Treatment effects of occipitomental anchorage appliance of maxillary protraction combined with chincup traction in children with Class III malocclusion. *J Formos Med Assoc*. 2007;106:380–391.