Comparison of Three Methods of Orthodontic Anchorage: A Prospective Study

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Abstract

This study aimed to compare the effectiveness of three methods of anchorage, transpalatal arch (TPA), modified TPA-Nance (TPA-Nance) and mini-implant (MI) in the treatment of patients with malocclusion that requires reinforced anchorage.

Thirty-six orthodontic patients with anchorage requirement were recruited and they were equally divided into three groups. The respective mode of anchorage reinforcement was issued after the extraction of maxillary first premolars.

This followed by the provision of upper and lower fixed appliances. The primary outcome was anchorage loss during maxillary canine retraction. The secondary outcomes were time taken to achieve Class I canine relationship bilaterally and cost of the appliance.

There was statistically significant difference in anchorage loss between the three groups (P<0.001). The amount of anchorage loss seen in TPA group was 2.19 mm (SD 0.53) and 2.25 mm (SD 0.56) for right and left molar respectively, while TPA-Nance showed 1.23 mm (SD 0.22) and 1.25 mm (SD 0.21) anchorage loss on right and left molar respectively.

On the other hand, MI showed anchorage loss of 0.33 mm (SD 0.23) for right molar and 0.11 mm (SD 0.17) for left molar. These results suggested that all the anchorage regimes are effective for reinforcing orthodontic anchorage.

Clinical article (J Int Dent Med Res 2019; 12(1): 185-191)

Keywords: orthodontic anchorage, Transpalatal arch, Modified TPA-Nance appliance, Mini implant, Anchorage loss.

Received date: 15 August 2018 **Accept date:** 20 September 2018

Introduction

The aim of orthodontic treatment is to achieve Andrew's six keys of occlusion.[1] To achieve these goals in extraction cases, the orthodontist must understand the integral relationship between the anchorage balance, extraction pattern and treatment mechanics that mainly involves canine retraction and space closure. Anchorage control plays an important role in the management of orthodontic patients in order to obtain good functional and facial esthetics.[2] Anchorage can be defined as the resistance to unwanted tooth movement and it can be classified into minimum, moderate or maximum based on the space requirement.[2]

Before the development of mini-implants, retraction of upper anterior teeth into the extraction space was performed via attaching the anterior teeth to the maxillary and mandibular posterior teeth. However, the force applied to the molar teeth tends to protract the molar forward and this unwanted effect is called anchorage loss[3], which is one of the detrimental effects that can challenge the success of orthodontic treatment.[4]

Many appliances and techniques were available to overcome this problem, for instance, Nance holding arch, transpalatal bars, extra oral traction, multiple teeth at the anchorage segment and differential force.[5–7] In recent years, mini-implant has gained acceptance in the orthodontic community and is considered as an absolute source of orthodontic anchorage.[8–10]

However, there is a lack of study to assess the effectiveness of modified TPA-Nance appliance. Therefore, this study was conducted to compare the effectiveness between transpalatal arch (TPA), modified TPA-Nance (TPA-Nance) and mini-implant (MI) for anchorage reinforcement by looking at the amount of mesial molar movement

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or anchorage loss. Additionally, the treatment duration and cost of the appliance were also quantified.

Materials and methods

This prospective study was conducted at the postgraduate orthodontic clinic in Faculty of Dentistry, Universiti Teknologi MARA (UiTM) Sungai Buloh campus and Puncak Perdana campus, Malaysia. The study protocol was approved by the UiTM Research Ethics Committee (Ref: 600-IRMI (5/1/6)).

For the study eligibility, the following inclusion criteria were applied:

i. Age 18 – 30 years old at the start of treatment.
ii. Intra-oral findings, which include:
    a. Overjet 6 mm to 8 mm.
    b. Class II ½ unit or more canine relationship.
    c. Moderate to severe crowding on the upper arch.
    d. Mesially angulated maxillary canines.
    e. Proclined upper incisors.
    f. Upper centerline shift of less than 4 mm.
iii. Orthodontic treatment plan does not require distal movement of maxillary molars.

Orthodontic treatment plan requires extraction of maxillary first premolars and two mandibular premolars.

Exclusion criteria included the presence of poor oral hygiene, had previous orthodontic treatment or extractions, any dental or craniofacial anomalies (such as cleft lip and palate), hypodontia, orthognathic cases, extractions of permanent maxillary first molars, active periodontal disease, allergy towards lignocaine or nickel, crossbite that need correction.

The sample size was calculated based on the findings of previous studies[6,9,11] using the alpha significance level of 0.05 and confirmed with "n4Studies" application version 1.4.0 (Thailand). The sample size for each group was 12 subjects, which gave a power of 80% to detect a difference of 2.0 mm of anchorage loss between TPA, TPA-Nance and MI groups after considering a 10% drop-out rate.

Selected subjects were interviewed and provided with the information about this study. Once they agreed to participate, verbal and written consent was obtained followed by allocations into three groups; Group A: TPA, Group B: TPA-Nance and Group C: MI. At this point, upper arch alginate impression was taken as baseline records (T_0).

Thirty-six subjects were recruited and they were equally divided into three groups; TPA, TPA-Nance and MI based on the treatment plan that was planned and agreed between the clinician and subject. The following orthodontic treatment procedures were undertaken:

Group A: Molar bands (3M Unitek™ Narrow Contoured Molar Bands, California) were fitted on both the permanent maxillary first molars a week after separation. The upper alginate impression (Kromopan, Lascod, Italy) was taken over the bands and sent to the laboratory for casting and fabrication of the TPA. A technician (SH) was assigned to fabricate the TPA, which was made with a 1.0 mm stainless steel (SS) wire soldered to the palatal surface of molar bands with a U-loop facing posteriorly and it was placed 2.0 mm away from the palatal vault[12] (**Figure 1**). It was cemented using a glass ionomer luting cement (GC Fuji 1, Tokyo, Japan) a week later.

Group B: The clinical procedures involved in the fabrication of TPA-Nance were in similarity with the construction of TPA. However, the laboratory procedures were different, in which the technician (SH) incorporated an acrylic button (Orthoplast Vertex, Netherland) on the anterior palatal vault and soldered together with the 1.0 mm SS wire as the transpalatal arch onto the molar bands (3M Unitek™ Narrow Contoured Molar Bands, California, United States) (**Figure 2**). It was cemented using the glass ionomer luting cement (GC Fuji 1, Tokyo, Japan) one week later.

Group C: All MIs were inserted by a single operator (ZZ) using a standard technique. Prior to insertion, an intra-oral periapical radiograph was taken to assess the interdental space, root angulations and the amount of inter-radicular bone present between the permanent maxillary second premolar and first molar.[13] A guided bar was in place to facilitate MI insertion. Self-drilling titanium MI (1.6 mm diameter and 8 mm length; ORLUS®, Korea) was used. A few drops of local anesthesia (4% articaine hydrochloride with adrenaline 1:200,000; 1.7 ml, 3M Ubistesin™ forte, Australia) was administered to reduce patient discomfort during the insertion of MI.[14] Then, the MI was inserted between the permanent maxillary second premolar and first molar at the mucogingival junction (**Figure 3**), followed by taking an intra-oral periapical radiograph to confirm the MI position.

Upon insertion of the allocated anchorage regimes, extractions of the permanent maxillary first premolars bilaterally were carried out. All subjects were treated using a pre-adjusted Edgewise fixed appliance with McLaughlin, Bennett and Trevisi (MBT) prescription on a 0.022" x 0.028" bracket slot metal brackets (3M-Unitek, Monrovia, California).

After the alignment and leveling stages, a 0.019" x 0.025" SS archwire was placed as the working archwire for at least four weeks. At this point, the permanent maxillary canines were retracted into Class I relationship using elastomeric powerchain with 150 gram of force[15] measured using the Correx Force Gauge (Haag-Streit, Switzerland) at 0.01 gram accuracy prior to maxillary incisor retraction. The subjects were reviewed at four-weekly interval.

Figure 1. TPA was cemented in the mouth

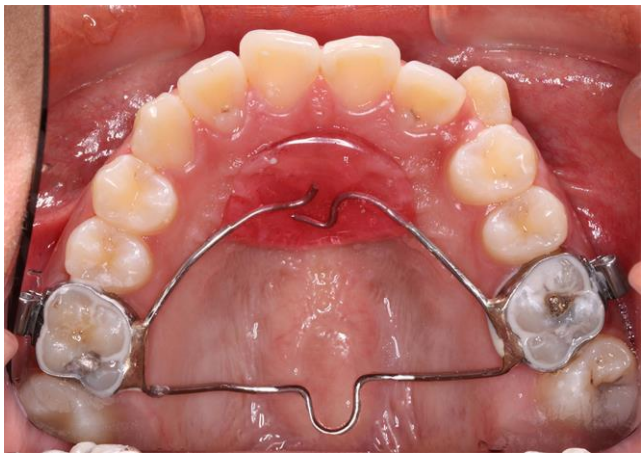

Figure 2. TPA-Nance was cemented into the mouth

Figure 3. MI was placed in between the permanent maxillary second premolar and first molar

Once Class I canine relationships were obtained bilaterally, all the anchorage regimes were discontinued and removed to avoid observer bias. The upper arch alginate impression was taken a week after for T_1 measurement. This allows the healing of the soft tissues and establishes normal anatomical structures.[11]

The primary outcome measure in this study was the mesial movement of the permanent maxillary first molars. The secondary outcome measures were the duration of treatment and cost of the appliance.

Construction of a TPA and TPA-Nance consists of a clinical fee and a laboratory fee. The overall cost for a TPA and TPA-Nance is RM 150 and RM170 per subject respectively. Comparatively, a patient with MIs will be charged RM 300 although it does not involve any laboratory fee because in any subject, two MIs were used (RM 150 for each MI).

Study cast measurement. Study casts were taken at two-assessment time: T_0, before the insertion of the allocated anchorage regime and T_1, after achieving Class I canine relationship bilaterally. The primary outcome measure was the mesial movement of permanent maxillary first molar. Landmarks on the maxillary dental casts (T_0 and T_1) were marked using a 0.3 mm graphite pencil under adequate lighting to confirm the details and configuration on the palatal rugae.

The landmarks used to measure the anchorage loss were medial part of the third

palatal rugae on right and left and mesial fossa of right and left permanent maxillary first molars.[16] Each study cast was photographed using a DSLR digital camera (Canon EOS D80 DSLR camera, Japan), which was mounted on a tripod with a fixed distance.[16,17] The photographs of the study casts were digitized using Viewbox software version 4.0 (dHAL Software, Greece). Anchorage loss was measured by the difference between T_0 and T_1 measurements.[5,18] (**Figure 4**).

Method error. It was impossible to blind the clinicians as well as patients to the treatment method. During the dental cast measurements, the assessor was blinded to the treatment allocation. Each model was measured three times in random order with one-week interval to reduce measurement error. Intra-examiner calibration and the reliability coefficient for study model measurements were assessed using intra-class correlation coefficient.

Statistical methods. All the data analysis was performed using the Statistical Package for Social Science (SPSS) version 21.0 (IBM, Armonk, New York). Descriptive analysis was used to analyze socio-demographic data such as age, gender, type of malocclusion, crowding, overjet and canine relationship. Analysis of Variance (ANOVA) was carried out to compare the mesial movement of permanent maxillary first molar and duration of treatment among the study groups. Post-hoc test (Tukey test and Dunnett T3 test) were also being used to compare the mean difference between the groups.

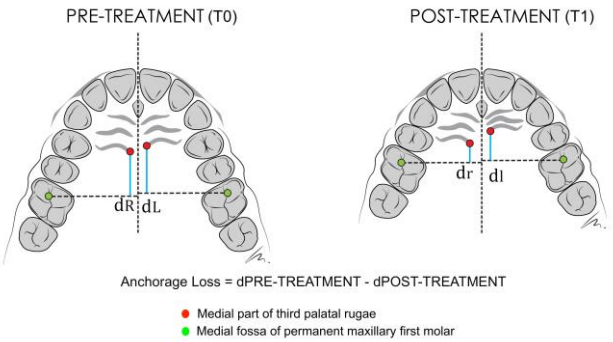

Figure 4. Anchorage loss was measured on the photograph

Results

Socio-Demographic Data. Thirty-six subjects were enrolled and twelve subjects were allocated to each group. Demographic data such as age, gender and type of malocclusion, the severity of crowding, overjet, the inclination of upper incisor and canine relationship for both sides were gathered. The baseline characteristics were similar among the three groups and the summaries are included in **Table 1**.

Amount of Anchorage Loss. The amounts of mesial molar movement are shown in **Table 2** and the comparison between the anchorage regimes is shown in **Table 3**. There was a statistically significant difference comparing the amount of anchorage loss between the three allocated anchorage regimes (*P*<0.001).

Treatment Duration. Figure 5 illustrates the total treatment duration to achieve Class I canine relationship bilaterally among three anchorage groups. Subjects with TPA took the longest treatment duration with 15.8 months (SD 3.5) followed by subjects with TPA-Nance appliance with 13.8 months (SD 2.4). The treatment using MI recorded the shortest treatment duration, where the subjects took only 11.9 months (SD 1.8) to achieve Class I canine relationship bilaterally. It shows statistical significant difference between TPA and MI with almost 4 months difference (*P*<0.05).

Variables	Group A Mean (SD)	Group B Mean (SD)	Group C Mean (SD)
Gender (n)			
Male	1	2	5
Female	11	10	7
Age (years)	24.8 (3)	23 (2.5)	22.8 (2.8)
Crowding (n)			
Moderate	12	8	8
Severe	-	4	4
Overjet (mm)	7.4 (0.7)	7.8 (1.0)	7.5 (1.2)
Upper incisor inclination (^{0})	121.5 (3.5)	121.5 (1.6)	122.9 (4.4)
Canine relationship (n)			
Class II ½ unit	3	5	2
Class II ¾ unit	9	7	10

Table 1. Socio-demographic data at the start of treatment, by treatment group

	Group A (n = 12)	Group B (n = 12)	Group C (n = 12)	*P*-value
Right (mm)	2.19 (0.53)	1.23 (0.22)	0.33 (0.23)	**<0.001**
Left (mm)	2.25 (0.56)	1.25 (0.21)	0.11 (0.17)	**<0.001**

Table 2. Mesial movement on right and left permanent maxillary first molar among three anchorage groups (One-way ANOVA)

	Comparison	Mean difference (95% CI)	*P*-value
Right (mm)	Group A – Group B	0.97 (0.52, 1.41)	**<0.001**
	Group B – Group C	0.89 (0.65, 1.13)	**<0.001**
	Group A – Group C	1.86 (1.4, 2.3)	**<0.001**
Left (mm)	Group A – Group B	1.0 (0.54, 1.46)	**<0.001**
	Group B – Group C	1.14 (0.94, 1.34)	**<0.001**
	Group A – Group C	2.14 (1.68, 2.6)	**<0.001**

Table 3. Post-hoc analysis (Dunnett T3 test) for mesial movement of permanent maxillary first molar between three anchorage groups

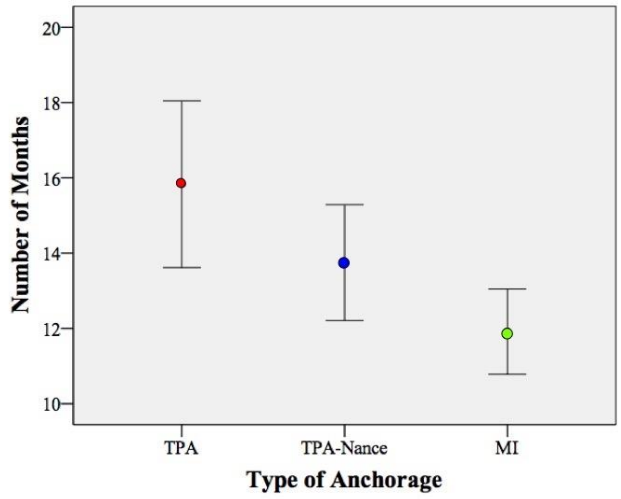

Figure 5. Treatment duration taken to achieve Class I canine relationship between three anchorage regimes

Discussions

Anchorage Loss. The variation in gender was taken into account, where female subjects were predominant with a total of 28 subjects compared to 8 male subjects. This can be due to a high number of female requests for orthodontic treatment compared to the male. Even though there was a statistical significant difference in the distribution of gender, the author did not look at the correlation between gender and anchorage loss. Moreover, based on the previous study, there was no association between gender and anchorage loss.[5]

In this study, the maxillary canine was retracted independently to reduce the retraction load on the allocated anchorage regime.[9,13] However, the results showed statistically significant difference in the effectiveness of the three methods of orthodontic anchorage in maximum anchorage requirement. Thus, none of anchorage reinforcement method prevents the mesial movement of the maxillary molars.

Anchorage loss was significantly greater in the groups using TPA with a mean loss of anchorage of 2.19 mm (SD 0.53) on right and 2.25 mm (SD 0.56) on left permanent maxillary first molar. The results obtained are in agreement with the previous studies[5,8,11,19], which failed to favour the use of the TPA as the sole anchorage mean to retract the maxillary canines.

When single canine retraction was assessed in the combination of TPA with other conventional anchorage means, it is suggested that the anchorage achieved was equivalent to that of the skeletal anchorage.[20,21] However, the results obtained from this study contradicted with the previous studies.[20,21] There was a statistical significant difference in mesial movement of permanent maxillary first molar found in TPA-Nance with a mean difference of 0.89 mm for right and 1.14 mm for left. On the other hand, the amount of anchorage loss in TPA-Nance was lesser compared to TPA.

Meanwhile, in MI group, the results obtained were in agreement with previous studies, where they found anchorage loss in subjects with mini-implant in retracting canine only.[22,23] In this study, the amount of mesial movement of permanent maxillary first molar on right and left was 0.33 mm (SD 0.23) and 0.11 mm (SD 0.17) respectively. This may be contributed by the mesial movement of the molar which was tied to the MI which was used as an indirect anchorage.

Treatment Duration. Secondary outcome measure in this study was treatment duration, which showed a similar finding with previous studies.[11,13] The mean treatment duration in TPA-Nance was lesser compared to TPA by two months. However, MI showed the shortest treatment duration compared to both TPA and TPA-Nance.

Cost. A calculation of cost-effectiveness would include the material cost of the three alternatives. In this study, the MI costs two times that of TPA and TPA-Nance. When compared to the amount of anchorage loss and the cost of the appliance, TPA-Nance would be recommended for canine retraction instead of TPA. The least expensive intervention has demonstrated acceptable in controlling the anchorage, TPA-

Nance would seem to represent good value for money. Cost-effectiveness may be helpful when considering to separate alternative interventions that prove to be equally effective but at a different cost.

Lack of scientific evidence that consider the cost of the appliance when measuring the appliance's effectiveness.[24] This study has shown that the three methods in reinforcing anchorage are applicable for orthodontic treatment. Apart from that, the findings obtained may benefit the orthodontists and provide information to the patients regarding the advantages and disadvantages of the anchorage regimes. Moreover, this study adds to the body of evidence that TPA-Nance is an efficient and effective method in supplementing orthodontic anchorage.

Conclusions

All the anchorage regimes were effective in reinforcing anchorage. However, TPA-Nance might be a suitable alternative method in reinforcing anchorage when taking into consideration the cost, treatment duration and amount of anchorage loss.

Acknowledgements

We would like to thank all the subjects who contributed to this study, the supporting staff and the statistician, for the kind assistance on this paper.

Funding

None.

Conflict of interest

None. No harm was found from the treatments provided with no complaint or complication reported.

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