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Comparative efficiency of Class II malocclusion treatment with the pendulum appliance or two maxillary premolar extractions and edgewire appliances

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SUMMARY The objective of this study was to compare, on study models and initial cephalograms, the efficiency of Class II malocclusion treatment with the pendulum appliance, and with two maxillary premolar extraction protocol. The sample consisted of 48 treated Class II malocclusion patients: group 1 comprised 22 patients (7 males, 15 females) treated with the pendulum appliance, with an initial mean age of 14.44 years and group 2, 26 patients (14 males, 12 females) treated with two maxillary premolar extractions at an initial mean age of 13.66 years. To compare the efficiency of each treatment protocol, the occlusal outcomes were evaluated on dental casts using the Peer Assessment Rating (PAR) Index and the treatment time (TT) of each group was calculated on clinical charts. The degree of treatment efficiency was calculated as the ratio between the percentage of occlusal improvement, evaluated through the PAR index, and TT. Statistical analysis was undertaken by means of *t*-tests.

The findings demonstrated that the two maxillary premolar extraction protocol provided the occlusal outcomes in a shorter time (group 1: 45.7 months, group 2: 23.01 months) and, therefore, demonstrated greater treatment efficiency than the pendulum appliance.

Introduction

Class II malocclusions can be treated using a variety of treatment protocols including extractions, functional appliances, maxillary molar distalization, and/or surgical–orthodontic procedures. The choice of treatment depends on the characteristics associated with the malocclusion, such as the amount of antero-posterior discrepancy, age, patient compliance, psychological implications, stability, financial conditions, treatment time (TT), and degree of treatment efficiency (Tung and Kiyak, 1998; Linklater and Fox, 2002; Proffit and Tulloch, 2002; Petrone *et al.*, 2003; Janson *et al.*, 2004, 2007).

Treatment of a Class II malocclusion, without crowding in the mandibular arch or cephalometric discrepancy, can be performed with distalization of the maxillary molars or with maxillary premolar extractions (Graber, 1969; Hilgers, 1992). Non-extraction treatment with intraoral distalizers is nowadays commonly used in such cases (Gianelly, 1998; Bussick and McNamara, 2000; Chiu *et al.*, 2005; Kinzinger *et al.*, 2006). These distalizers are considered to require minimal patient cooperation. The pendulum has proven to be an effective distalizer to correct Class II malocclusions (Burkhardt *et al.*, 2003; Chiu *et al.*, 2005).

Efficiency is defined as the capacity to produce the best result in the least time (Hornby, 1993). Studies have demonstrated that maintaining the Class II antero-posterior molar relationship requires less anchorage and less patient compliance than correcting it to a Class I molar relationship (Bryk and White, 2001; Janson *et al.*, 2004). Additionally, TT is also longer and treatment efficiency is less in complete Class II malocclusion non-extraction treatment as compared with two maxillary premolar extraction therapy (Janson *et al.*, 2007). Because the pendulum appliance does not require patient cooperation to distalize the posterior segments, it was speculated that this characteristic could positively influence TT and efficiency as compared with two maxillary premolar extractions. To date, no study has evaluated treatment efficiency with the pendulum appliance. Thus, the purpose of this investigation was to test the following null hypothesis: there is no difference in the treatment efficiency of Class II malocclusions treated with the pendulum appliance or with two maxillary premolar extractions.

Materials and methods

The sample was retrospectively selected from the files of the Orthodontic Department at Bauru Dental School, University of São Paulo. The initial and final dental study models, lateral radiographs, and records of all patients who initially presented with a bilateral Angle Class II malocclusion (molar relationship) and who were treated with the pendulum appliance or with two maxillary premolar extractions and fixed edgewise appliances, were selected and divided into two groups. Sample selection was based exclusively on the initial antero-posterior dental relationship, regardless of any other dentoalveolar or skeletal characteristic. Additionally, the patients should have all permanent teeth up to the first molars and absence of dental anomalies of number, size, and form. Group 1 comprised 22 patients (7 males, 15 females), with an initial mean age of 14.44 years, treated with the pendulum appliance and group 2, 26 patients (14 males, 12 females) with an initial mean age of 13.66 years and a complete Class II antero-posterior molar relationship, treated with two maxillary premolar extractions and fixed appliances. Because of the retrospective design of the study, the basis for assigning a given patient to a respective treatment protocol could not be determined, as in other studies (Bishara *et al.*, 1995; Burkhardt *et al.*, 2003; Chiu *et al.*, 2005; Janson *et al.*, 2006a). To eliminate susceptibility bias, all the available patients from the archive who met the inclusion criteria, with matching ages, in both groups were selected.

Pendulum appliance protocol

The appliance design was similar to that described by Hilgers (1992) with the springs bent upright, as described by Byloff *et al.* (1997). The appliance was left *in situ* until an overcorrected Class I molar relationship was achieved. The average distalization time was 5.85 months [standard deviation (SD) = 1.82]. After removal of the pendulum appliance, a Nance button was used and pre-adjusted edgewise appliances placed to initiate levelling and alignment. During the use of the rectangular arch, sequential retraction of the second premolars followed by the first premolars was initiated with elastomeric chains and with cervical headgear worn at night. After retraction of the first premolars, the Nance button was removed for retraction of the anterior teeth. At this stage, in addition to the cervical headgear, Class II elastics were also used for anchorage reinforcement. After retraction, ideal archwires were inserted for finishing.

Two maxillary premolar extraction protocol

The two maxillary premolar extraction approach included the use of extraoral headgear to reinforce anchorage associated with fixed edgewise appliances. Class II elastics were also used to help maintain the Class II molar relationship. Orthodontic mechanics included fixed edgewise appliances, with 0.022 × 0.028 inch conventional brackets and a wire sequence characterized by an initial 0.015 inch twist flex or a 0.016 inch nitinol, followed by 0.016, 0.018, 0.020, and 0.021 × 0.025 or 0.018 × 0.025 inch stainless steel wire. A deep bite was corrected with an accentuated and reverse curve of Spee. The anterior teeth were retracted *en masse* with a rectangular wire and elastomeric chains for overjet and Class II canine correction. Extraoral appliances were indicated to reinforce anchorage and maintain Class II molar relationship. When necessary, Class II elastics were used to help maintain the Class II molar relationship.

Data collection

The patients' records were used to determine their initial age, gender, date of the start of treatment, date of treatment completion, and total TT.

The Peer Assessment Rating (PAR) Index was calculated on the pre- and post-treatment dental study models, according to the American weightings suggested by DeGuzman *et al.* (1995). The initial peer assessment rating (IPAR) corresponds to the initial severity of the malocclusion, while the final peer assessment rating (FPAR) demonstrates the final occlusal status reached as a result of orthodontic treatment. The improvement in malocclusion was calculated as the difference between IPAR and FPAR (PARchange), and the percentage PAR reduction (PcPAR) was calculated as the ratio between PARchange and IPAR (PcPAR = PARchange/IPAR × 100), which represents the

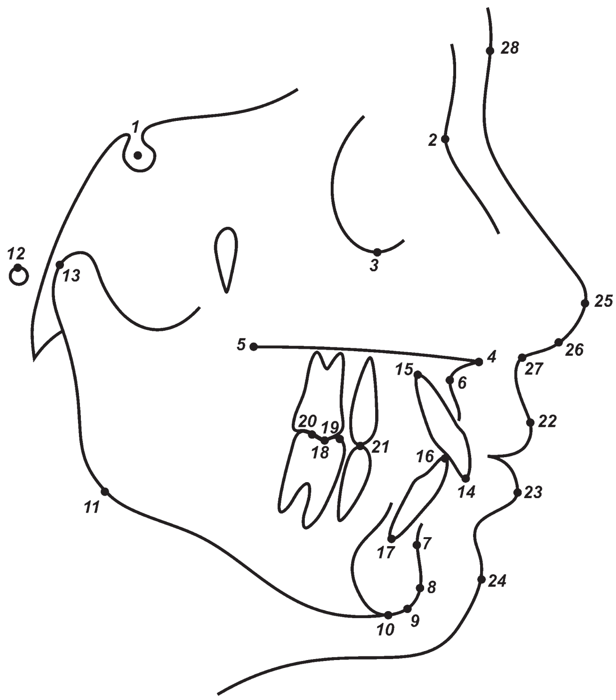

Figure 1 Cephalometric landmarks: (1) S: sella turcica; (2) N: nasion; (3) Or: orbitale; (4) ANS: anterior nasal spine; (5) PNS: posterior nasal spine; (6) A: subspinale; (7) B: supramentale; (8) Pog: pogonion; (9) Gn: gnathion; (10) Me: menton; (11) Go: gonion; (12) Po: porion; (13) Co: condylion; (14) MxIE: maxillary central incisor edge; (15) MxIA: maxillary central incisor apex; (16) MdIE: mandibular central incisor edge; (17) MdIA: mandibular central incisor apex; (18) MxMMC: maxillary first molar mesial cusp; (19) MdMMC: mandibular first molar mesial cusp; (20) OCM1: occlusal contact of the first molars; (21) OCPM: occlusal contact of the premolars; (22) LS: labrale superius; (23) LI: labrale inferius; (24) Pog': soft tissue pogonion; (25) Pr: pronasale; (26) Cl: columella; (27) Sn: subnasale; (28) Gl: glabella.

Table 1 Skeletal, dental, and soft tissue cephalometric variables.

Skeletal cephalometric variables
- Maxillary
  1. SNA: SN to NA angle
  2. Co–A: condylion to point A
  3. A-Nperp: point A to Nasion-perpendicular
- Mandibular
  4. SNB: SN to NB angle
  5. Co–Gn: condylion to gnathion
  6. Go–Gn: gonion to gnathion
  7. Co–Go: condylion to gonion
  8. Pog–Nperp: Pog point to nasion perpendicular
- Maxillo-mandibular
  9. ANB: NA to NB angle
  10. Wits: distance between the perpendicular projections of points A and B on the functional occlusal plane
  11. Co–A/Co–Gn: maxillo-mandibular difference
  12. NAPog: NA to APog angle (convexity angle)
- Vertical components
  13. FMA: Frankfort mandibular plane angle
  14. SN.GoGn: SN to GoGn angle
  15. SN.PP: SN to palatal plane angle
  16. LAFH: distance from anterior nasal spine to menton

Dental cephalometric variables
- Maxillary
  17. U1.PP: maxillary incisor long axis to palatal plane angle
  18. U1.NA: maxillary incisor long axis to NA angle
  19. U1–NA: distance between the most anterior point of the crown of the maxillary incisor and the NA line
- Mandibular
  20. IMPA: incisor mandibular plane angle
  21. L1.NB: mandibular incisor long axis to NB angle
  22. L1–NB: distance between the most anterior point of the crown of the mandibular incisor and the NB line
- Dental relationship
  23. Overjet: distance between the incisal edges of the maxillary and mandibular central incisors, parallel to the occlusal plane
  24. Overbite: distance between the incisal edges of the maxillary and mandibular central incisors, perpendicular to the occlusal plane
  25. Molar relationship: distance between the mesial cusps of the maxillary and mandibular first molars, parallel to the functional occlusal plane

Soft tissue cephalometric variables
  26. Tegumental convexity: angle between Pog'.Sn.Gl
  27. Nasolabial angle: angle between Cl.Sn.LS
  28. H–nose: distance from the most anterior point of the nose to the H line
  29. LS–E: distance from the most anterior point of the upper lip to the E line (Pog'–Pr)
  30. LI–E: distance from the most anterior point of the lower lip to the E line (Pog'–Pr)

improvement in the initial malocclusion severity (O'Brien *et al.*, 1995).

The treatment efficiency index (TEI) was evaluated by determining the relationship between PcPAR and TT in months, expressed by TEI = PcPAR/TT.

Cephalometric evaluation

The lateral cephalograms were traced on acetate paper, and the cephalometric tracings and landmark identifications were performed by a single investigator (CRMPV) and then digitized with a Numonics AccuGrid XNT, model A30TL.F digitizer (Numonics Corporation, Montgomeryville, Pennsylvania, USA; Figure 1, Table 1). The data were stored on a computer and analysed with the Dentofacial Planner 7.02 (Dentofacial Planner Software, Toronto, Ontario, Canada), which corrected the image magnification factors.

The dental casts of 20 randomly selected patients from both groups were re-measured and their radiographs retraced, re-digitized and re-measured by the same examiner (CRMPV), after a period of 1 month. The accidental error was calculated according to the formula of Dahlberg (1940) and the systematic error with a dependent *t*-test, at $P < 0.05$.

Statistical analyses

Means and SDs for each variable were calculated to enable characterization of the groups. Group compatibility in relation to gender distribution, Class II type, and the antero-posterior severity of the Class II malocclusions were evaluated by chi-square tests. An independent *t*-test was used to evaluate the compatibility between the initial cephalometric characteristics, the initial age, and the occlusal characteristics of the groups at the initial and final treatment stages. An independent *t*-test was also used to compare the groups regarding PAR change, PcPAR, TT, and TEI. The results were considered to be statistically significant at $P < 0.05$.

Table 2 Results of the systematic and accidental error evaluation.

Measurements	First measurement (n=20)		Second measurement (n=20)		Systematic errors	Accidental errors
	Mean	SD	Mean	SD	P	Dahlberg
Occlusal index						
Peer Assessment Rating score	11	7.00	11.25	7.09	0.13	0.52
Skeletal cephalometric variables						
Maxillary component						
SNA (degree)	82.92	3.25	82.82	3.16	0.75	0.79
Co–A (mm)	85.64	6.03	85.74	5.80	0.75	0.82
A–Nperp (mm)	1.44	2.93	1.10	3.21	0.12	0.59
Mandibular component						
SNB (degree)	77.75	2.80	77.64	2.83	0.63	0.62
Co–Gn (mm)	108.04	6.03	108.01	6.04	0.90	0.75
Go–Gn (mm)	70.06	4.35	70.54	4.49	0.16	0.92
Co–Go (mm)	51.92	3.67	51.56	3.58	0.35	1.03
Pog–Nperp (mm)	−4.24	4.16	−4.62	4.45	0.24	0.86
Maxillo-mandibular relationship						
ANB (degree)	5.19	1.54	5.17	1.61	0.86	0.29
Wits (mm)	3.96	2.01	3.83	1.93	0.61	0.70
Co–A/Co–Gn (mm)	79.26	2.71	79.38	2.43	0.59	0.59
Vertical components						
FMA	25.93	4.83	26.08	5.24	0.63	0.83
SN.GoGn	32.46	5.89	32.21	6.11	0.42	0.83
SN.PP	6.30	4.16	6.26	4.01	0.84	0.52
LAFH	64.71	5.00	64.46	5.04	0.30	0.65
Dental cephalometric variables						
Maxillary dentoalveolar component						
U1.PP (degree)	108.36	6.02	108.60	6.72	0.73	1.77
U1.NA (degree)	19.17	7.93	19.50	8.21	0.57	1.53
U1–NA (mm)	3.20	2.61	3.14	2.43	0.74	0.42
Mandibular dentoalveolar component						
IMPA (degree)	94.20	4.06	94.52	4.41	0.47	1.19
L1.NB (degree)	26.51	5.88	26.62	6.15	0.82	1.23
L1–NB (mm)	5.37	2.67	5.04	2.61	0.00*	0.36
Dentoalveolar relationships						
Overjet (mm)	4.45	1.20	4.70	1.13	0.07	0.38
Overbite (mm)	4.80	1.97	4.58	2.03	0.02*	0.27
Molar relationship (mm)	1.09	0.86	1.18	0.91	0.58	0.41
Skeletal and soft tissue profile						
NAPog (degree)	8.04	4.04	7.96	4.52	0.80	0.82
Teg. Conv (degree)	15.80	4.28	16.17	4.23	0.21	0.80
Nasolabial angle (degree)	101.85	15.65	103.98	13.12	0.14	3.94
H–nose (mm)	2.56	4.01	3.08	3.56	0.05	0.74
LS–E (mm)	−1.46	2.24	−1.80	1.96	0.04*	0.47
LI–E (mm)	−0.31	3.29	−0.36	3.28	0.80	0.48

$^*P < 0.05$.

Results

For the occlusal evaluation, there was no statistically significant systematic error and the accidental error was within acceptable limits. For the cephalometric evaluation, only three statistically significant systematic errors were detected: L1–NB, P=0.00; overbite, P=0.02; and LS–E, P=0.04. The range of accidental errors varied from 0.27 to 3.94, with 24 variables below 1 degree or 1 mm, 5 below 2 degrees or 2 mm, and only 1 variable above this level (Table 2).

The groups were comparable regarding gender distribution, type of Class II malocclusion, maxillary component, maxillo-mandibular relationships, vertical components, mandibular dentoalveolar component, skeletal and soft tissue profile, initial age, and final PAR score (Tables 3–5). However, the maxillary premolar extraction group had a greater Class II antero-posterior discrepancy, a more retruded mandible, greater maxillary incisor proclination and protrusion, overjet, molar Class II relationship, and malocclusion severity than the pendulum group.

The results showed a greater PARchange, PcPAR, and TEI for group 2. TT was greater in group 1 (Table 5).

Because group 2 had a statistically greater initial malocclusion severity than group 1, subgroups with similar initial malocclusion severity were also compared to evaluate

Table 3 Results of chi-square test to evaluate the compatibility of gender distribution, types of Class II malocclusion, and the severity of initial molar antero-posterior discrepancy between the groups.

Variables	Group 1 (*n*=22) (pendulum)	Group 2 (*n*=26; maxilary premolar extraction)	χ^2	*P*
Gender distribution				
Male	7	14	2.35	0.125
Female	15	12		
Types of Class II malocclusion				
Class II division 1	19	22	0.03	0.864
Class II division 2	3	4		
Antero-posterior discrepancy				
Complete Class II	6	26	28.36	0.000*
Three-quarter unit Class II	6	0		
Half unit Class II	6	0		
Quarter unit Class II	4	0		

*$P < 0.05$.

whether this could have compromised the investigation. The results showed that PARchange and PcPAR were similar between the subgroups, but still group 1 had a statistically greater TT and consequently group 2 had a greater TEI than group 1 (Table 6).

Discussion

Sample selection and compatibility of the groups

The investigated cases were selected primarily on the basis of presenting a bilateral Class II malocclusion, independently of associated cephalometric skeletal characteristics. Usually, it is not the skeletal characteristics of a Class II malocclusion that determines whether it should be treated with or without extractions, but rather the developmental stage of the patient, since maxillary premolar extractions have been preferentially used in non-growing Class II malocclusion patients (Proffit *et al.*, 1992; Baumrind *et al.*, 1996). Subjects who began treatment with a distalizer and whose treatment plan was then changed to two maxillary premolar extractions were excluded and only those who were to undergo extractions at the start of treatment were selected to avoid treatment re-evaluation interfering with TT (Skidmore *et al.*, 2006).

Cephalometrically, group 2 had a more retruded mandible, with labially tipped and protruded maxillary incisors, a greater overjet, and a more severe Class II molar relationship, confirming the greater occlusal malocclusion severity in this group (Tables 3–5). These factors would increase Class II treatment difficulty (Wheller *et al.*, 2002; Janson *et al.*, 2004). However, the skeletal maxillo-mandibular relationship and the vertical components were similar between the groups, and consequently, these characteristics should not influence the results (Burkhardt *et al.*, 2003; Chiu *et al.*, 2005).

It may be argued that these patients should not have been treated with either of these two protocols because of their slight mandibular deficiency (Table 4). However, other studies have investigated patients treated with these protocols, with similar cephalometric characteristics (Bishara *et al.*, 1995; Burkhardt *et al.*, 2003; Chiu *et al.*, 2005). Besides, this study was not concerned as to whether an adequate treatment protocol was used but rather which could provide the greater occlusal changes in the shortest time. This is also the reason why the dentoskeletal and soft tissue cephalometric changes were not evaluated. The initial cephalogram was included only to provide additional information regarding some dentoalveolar and skeletal aspects of the two groups.

Occlusal results

The final occlusal status was similar between the groups (Table 5). However, the amount of PARchange and PcPAR was statistically greater in group 2. This occurred because the initial malocclusion severity was greater in group 2. As both groups had a similar final occlusal result, the amount and percentage of occlusal changes would be greater in group 2. TT was statistically less and the TEI was statistically greater in group 2 in relation to group 1. It could be argued that the greater initial malocclusion severity of group 2 could have contributed to these results because it would allow a greater percentage PAR reduction to be obtained with treatment. As the TEI increased with an increase in PcPAR, this might be considered as the reason for the greater TEI. However, this is not the case because a greater malocclusion severity would tend to increase treatment difficulty and consequently TT (Turbill *et al.*, 2001; Janson *et al.*, 2006a; Skidmore *et al.*, 2006), but even with a greater initial malocclusion severity (and greater treatment difficulty), the TT was less in group 2. This demonstrates that the extraction protocol was significantly more efficient than the non-extraction protocol. To eliminate any concern, subgroups with a similar initial malocclusion severity were further compared. Group 1 still showed a longer TT and consequently a greater TEI for group 2, despite the similar PARchange and PcPAR between the groups (Table 6). This reinforces the fact that the main reason for the greater TEI in group 2 was the shorter TT.

The pendulum appliance is considered to require minimum patient compliance to obtain success (Hilgers, 1992). However, to retract the anterior teeth and correct the side-effects produced by the distalizing appliance, extraoral devices are recommended (Gianelly *et al.*, 1991; Hilgers, 1992; Ghosh and Nanda, 1996). Therefore, some

Table 4 Results of independent *t*-test to evaluate the initial cephalometric compatibility between the groups.

Measurements	Group 1 (*n*=22; pendulum)		Group 2 (*n*=26; maxillary premolar extractions)		*P*
	Mean	SD	Mean	SD	
Skeletal cephalometric variables					
Maxillary component					
SNA (º)	82.75	3.16	81.17	3.72	0.125
Co–A (mm)	85.99	5.21	85.92	6.63	0.969
A–Nperp (mm)	1.31	3.03	−0.63	4.00	0.068
Mandibular component					
SNB (º)	78.08	2.76	76.94	2.61	0.149
Co–Gn (mm)	108.34	5.21	108.39	6.60	0.978
Go–Gn (mm)	70.58	4.23	70.06	4.83	0.697
Co–Go (mm)	52.30	3.62	51.12	4.55	0.332
Pog–Nperp (mm)	−3.53	4.76	−6.86	6.10	0.043*
Maxillo-mandibular relationship					
ANB (º)	4.68	1.60	4.23	2.56	0.477
Wits (mm)	3.39	2.31	4.70	2.20	0.050
Co–A/Co–Gn (mm)	79.36	2.39	79.28	3.98	0.928
Vertical components					
FMA	24.71	5.41	26.53	4.91	0.229
SN.GoGn	31.32	6.04	32.57	4.82	0.428
SN.PP	6.41	3.80	4.94	2.88	0.134
LAFH	63.61	4.71	64.79	5.40	0.429
Dental cephalometric variables					
Maxillary dentoalveolar component					
U1.PP (º)	108.98	6.44	114.10	8.57	0.025*
U1.NA (º)	19.83	7.79	27.97	9.68	0.002*
U1–NA (mm)	3.44	2.43	7.21	4.10	0.000*
Mandibular dentoalveolar component					
IMPA (º)	94.71	4.72	93.58	5.89	0.471
L1.NB (º)	26.16	5.22	25.15	6.29	0.554
L1–NB (mm)	4.93	2.38	4.91	2.43	0.981
Dentoalveolar relationships					
Overjet (mm)	4.45	1.20	7.62	2.62	0.000*
Overbite (mm)	4.88	1.85	4.11	2.74	0.266
Molar relationship (mm)	0.93	0.85	3.80	0.73	0.000*
Skeletal and soft tissue profile					
NAPog (º)	7.04	3.81	6.12	6.46	0.559
Teg. Conv (º)	15.40	4.04	17.67	6.05	0.140
Nasolabial angle (º)	103	13.94	111.51	16.75	0.064
H–nose (mm)	2.86	3.52	3.56	3.55	0.504
LS–E (mm)	−1.65	1.99	−2.11	2.25	0.461
LI–E (mm)	−0.46	2.87	−0.07	2.76	0.633

$^*P < 0.05$.

patient compliance is still necessary and it is this dependence that may hinder correction of the malocclusion and increase TT.

As group 1 presented a smaller Class II antero-posterior discrepancy and consequently treatment difficulty, TT should have been less than for group 2 (Table 3). However, generally, non-extraction treatment requires a greater amount of distalization of the posterior and anterior segments (Andrews, 1975). The unfavourable side effects of the pendulum appliance, during molar distalization, include distal molar tipping and protrusion of the anterior teeth that have to be corrected in the second treatment phase, which consists of levelling and alignment and retraction of the anterior teeth (Burkhardt *et al.*, 2003; Chiu *et al.*, 2005). During this phase, extraoral appliances and Class II elastics are recommended to reinforce anchorage (Gianelly *et al.*, 1991; Hilgers, 1992; Ghosh and Nanda, 1996). Therefore, because TT was greater in the pendulum group, it may be inferred that more patient compliance in using extraoral appliances and/or Class II elastics was necessary to finish the cases (Table 5). As removable appliances and/or accessories are used for approximately half the recommended time, more time is required to achieve the treatment objectives (Sahm *et al.*, 1990). Therefore, there is less advantage in using the pendulum appliance, which supposedly would require less patient compliance, when compared with the two maxillary premolar extraction protocol.

Table 5 Results of independent *t*-tests between the groups.

Variables	Group1 ($n=22$; pendulum)		Group 2 ($n=26$; maxillary premolar extractions)		*P*
	Mean	SD	Mean	SD	
Initial age	14.44	1.85	13.66	0.91	0.062
IPAR	15.91	5.12	24.62	7.58	0.000*
FPAR	4.23	3.74	2.92	3.16	0.196
PARchange	11.68	5.50	21.69	8.60	0.000*
PcPAR	72.82	21.83	86.46	15.79	0.015*
TT (months)	45.70	12.18	23.01	6.01	0.000*
TEI	1.69	0.70	4.02	1.37	0.000*

*$P < 0.05$.

Table 6 Results of independent *t*-tests between the subgroups with similar initial malocclusion severity.

Variables	Subgroup 1 ($n=6$; pendulum), complete Class II		Subgroup 2 ($n=21$; maxillary premolar extractions)		*P*
	Mean	SD	Mean	SD	
Initial age	14.62	1.83	13.79	0.90	0.128
IPAR	17.33	4.63	22.05	5.67	0.075
FPAR	4.00	1.26	3.33	3.30	0.636
PARchange	13.33	3.55	18.71	6.12	0.052
PcPAR	77.04	4.33	84.14	16.61	0.315
TT (months)	51.70	13.87	22.77	6.43	0.000*
TEI	1.67	0.84	4.00	1.51	0.001*

SD, standard deviation; IPAR, initial peer assessment rating; FPAR, final peer assessment rating; TEI, treatment efficiency index.
*$P < 0.05$.

TT with the pendulum followed by fixed appliances was greater than the previously reported time of 31.6 (Burkhardt *et al.*, 2003) and 31 (Chiu *et al.*, 2005) months. This probably occurred as the age of the subjects in those studies was 12.3 and 12.6 years, respectively, while in the present investigation, it was 14.44 years. It is known that Class II malocclusion correction is easier in younger patients (Dyer *et al.*, 1991; Harris *et al.*, 1991) and that molar distalization is more efficient when the second maxillary molars are unerupted (Hilgers, 1992; Kinzinger *et al.*, 2004). At 14.44 years of age, a greater percentage of erupted maxillary second molars are present than at younger ages.

Clinical implications

The current results demonstrate that treatment with the pendulum appliance is less efficient than two maxillary premolar extractions. This is because TT with the first was statistically greater than with the second protocol. The reason for the increased TT with the pendulum was the need to retract the anterior segment and to correct the undesirable side effects produced during the posterior segment distalizing phase. To accomplish this, anchorage reinforcement was necessary, which requires patient compliance.

Usually, in treatment with intraoral distalizers, the need to reinforce anchorage with extraoral appliances and Class II elastics to retract the anterior teeth and to correct the undesirable side-effects are not emphasized (Byloff and Darendeliler, 1997; Byloff *et al.*, 1997; Burkhardt *et al.*, 2003; Chiu *et al.*, 2005). Emphasis is only directed to showing the distalizing effects on the maxillary molars (Ghosh and Nanda, 1996; Byloff and Darendeliler, 1997; Byloff *et al.*, 1997). However, Class II treatment is only considered complete when there is a correction of the posterior and anterior segment antero-posterior discrepancy and other irregularities. Then, to completely correct the Class II malocclusion with intraoral distalizers, additional use of compliant-dependent devices have to be used (Gianelly *et al.*, 1991; Hilgers, 1992; Ghosh and Nanda, 1996).

Occlusal severity of Class II malocclusions should also be a concern when planning treatment (Wheller *et al.*, 2002). Non-extraction treatment with intraoral distalizers would have a greater success rate in subjects with a mild Class II antero-posterior discrepancy because there is a smaller antero-posterior discrepancy to be corrected.

It may be argued that the results of the present study tend to show that maxillary bilateral premolar extraction is more efficient than distalization of the maxillary teeth and preservation of the maxillary premolars. However, it should be remembered that Class II subjects treated with distalization are more likely to require maxillary third molar extractions than those who have undergone two maxillary premolar extractions (Janson *et al.*, 2006b). Therefore, with either treatment protocol, it may be necessary to sacrifice two dental units. Although these results may appear unfavourable to the conservative clinician and whilst every effort was made to eliminate any bias, the malocclusion severity of the pendulum group was statistically less than the two maxillary premolar extraction group, there was still a greater treatment efficiency for the later.

Conclusion

The null hypothesis was rejected because the TEI of Class II malocclusion subjects treated with two maxillary premolar extractions was statistically greater than with the pendulum appliance.

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