Original Article

Comparison of anterior retraction and anchorage control between en masse retraction and two-step retraction: *A randomized prospective clinical trial*

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ABSTRACT

Objectives: The purpose of this two-arm parallel trial was to compare en masse (ER) and two-step retraction (TSR) during space closure.

Materials and Methods: Forty-eight adult patients with bimaxillary protrusion who were planned for treatment with extraction of four first premolars were enrolled. All patients were randomly allocated in a 1:1 ratio to either the ER (n = 24) group or the TSR (n = 24) group. The main outcome was the amount of posterior anchorage loss in the molars and the retraction of the incisors between ER and TSR; the difference in incisor and molar inclination was a secondary outcome. Lateral cephalometric radiographs and oblique cephalometric radiographs at 45° were taken before retraction (T1) and after space closure (T2). Cephalograms were digitized and superimposed on the anatomic best fit of the maxilla and mandible by one operator who was blinded to the treatment group.

Results: Neither incisor nor molar crown movements showed any significant differences between the ER and TSR. There were no significant differences in the tipping of incisors and molars between the two groups.

Conclusions: No significant differences existed in the amount of retraction of incisors and anchorage loss of molars between ER and TSR. Changes in incisor and molar tipping were similar, with the crowns showing more movement than the apex. (*Angle Orthod.* 2019;89:190–199.)

KEY WORDS: En masse retraction; Two-step retraction; Anchorage loss; Retraction; Space closure; Orthodontics

INTRODUCTION

The closing of extraction spaces can be performed using two main retraction techniques: en masse retraction (ER) or two-step retraction (TSR). For space closure achieved by ER, incisors and canines are retracted in just one step and as if it were a single block.[1] In TSR, the first step involves independently retracting the canines until they reach full contact with the second premolar; then they are incorporated into the posterior block of teeth composed of the second premolar and first and second molars. In the second step, this posterior block is used as an anchorage unit to retract the incisors.[2–5]

The choice between these two methods is the clinician's preference,[6] but most orthodontists decide to use TSR in cases in which posterior anchorage control is critical.[4] Traditionally, it has been believed that independent canine retraction is considered to produce less mesial force for posterior teeth and could

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Table 1. Baseline Skeletal and Dental Characteristics of Subject Pretreatment Between the Two Groups[a]

Variable	Mean (SD)			
	ER (n = 24)	TSR (n = 24)	*P*-Value	Sig
SNGoMe, °	30.6 (6.3)	27.9 (6.8)	.166	ns
PFH/AFH, mm	66.4 (5.0)	68.5 (6.4)	.207	ns
PgNperp, °	1.0 (6.7)	1.2 (8.1)	.458	ns
Overjet, mm	3.3 (1.3)	3.6 (1.2)	.405	ns
Overbite, mm	0.9 (2.0)	1.5 (1.5)	.211	ns
L1-Apo, mm	7.1 (2.7)	6.1 (2.6)	.188	ns
U1-Apo (mm)	10.5 (2.4)	9.9 (3.0)	.429	ns
FMA, °	24.7 (5.2)	21.9 (6.8)	.116	ns
Convexity (NA-Apo), °	7.1 (4.0)	6.9 (3.1)	.817	ns
Lower lip to E-plane, mm	4.5 (3.8)	3.1 (3.2)	.159	ns

[a] SD indicates standard deviation; Sig, significance; and ns, not significant by the Student's *t*-test at $P < .05$.

yield less anchorage loss.[1–3] However, others[4,7,8] believe that TSR is complicated because it requires a longer treatment time. They claim that performing separate canine retraction doesn't change the overall effect on posterior anchorage loss[5,6] and, in addition, that when canines are retracted individually, they tend to tip and rotate more than they do with ER.[2,7–9]

Despite the clinical relevance, there is insufficient evidence in the literature that compares the two techniques in relation to the control of anchorage loss and amount of anterior retraction during space closure. In fact, only one systematic review was found.[10] Most studies included in this qualitative review provided insufficient information because subjects were in an active growing phase. Additionally, only maxillary teeth were evaluated and compared according to different types of anchorage reinforcement (miniscrews, headgear, or conventional anchorage). Currently, there is only one study[6] conducted without the use of anchoring devices. However, in that study, the movement of the molars was evaluated from lateral cephalograms, which may have induced measurement errors because of superimposition of contralateral molars.[11] In lateral cephalograms, bilateral objects are projected on the same plane. Degree of distortion of the lateral structures depends on facial morphology and is also influenced by the angle between the lateral part of the mandible and the film.[12] Therefore, lateral cephalograms do not have sufficient accuracy to evaluate posterior tooth movement, and the measurements are less reliable than assessments, previously shown to be adequate, using oblique cephalometric radiographs taken at 45°.[13]

No randomized clinical trials (RCTs) have compared the magnitude of anchorage preservation and amount of anterior retraction between two space closure methods utilizing oblique cephalograms. The purpose of this study was to investigate and compare ER and TSR in the maxillary and mandibular arches during the orthodontic space closure phase without auxiliary anchorage devices. The null hypothesis was that there would be no difference in anterior retraction and posterior anchorage control between ER and TSR.

MATERIALS AND METHODS

This prospective, RCT was approved by the Ethics Committee on Human Research of the School of Dentistry at Araraquara, São Paulo State University (ethical approval 01/09). Subjects were recruited between February and October of 2010. The following selection criteria were applied: male and female Brazilian subjects, age above 18 years, presence of all permanent teeth (except third molars), Class I bimaxillary protrusion malocclusion with mild to moderate crowding in the upper and lower incisors (tooth size–arch length discrepancy of $\leq$ 4 mm) with a treatment plan to extract the four first premolars, no previous orthodontic treatment history, no systemic diseases, and good oral hygiene. All patients had similar skeletal and dental characteristics at the start of treatment (Table 1; Figure 1). Subjects were excluded if they had missing teeth, periodontal disease, or dental malformations. The patients were randomized in a 1:1 ratio to either the ER group or the TSR group (Table 2) using a simple randomization technique.

All 48 patients received conventional orthodontic treatment with the same type of fixed appliances. Conventional 0.022-inch straight-wire brackets (Ovation-GAC, Bohemia, NY) were bonded from second premolar to second premolar. Upper and lower 0.022-inch tubes were soldered to bands fitted on the first and second molars. Leveling and aligning was conducted until 0.020-inch stainless-steel (SS) wires could be passively inserted into the brackets. Second premolar to second molars were tied together with 0.010-inch ligature wire. At that time, each patient had the four first premolars extracted. Seven to 14 days after extraction, space closure was started.

In the ER group, all anterior teeth were tied together with 0.010-inch ligature wire and retracted in a single

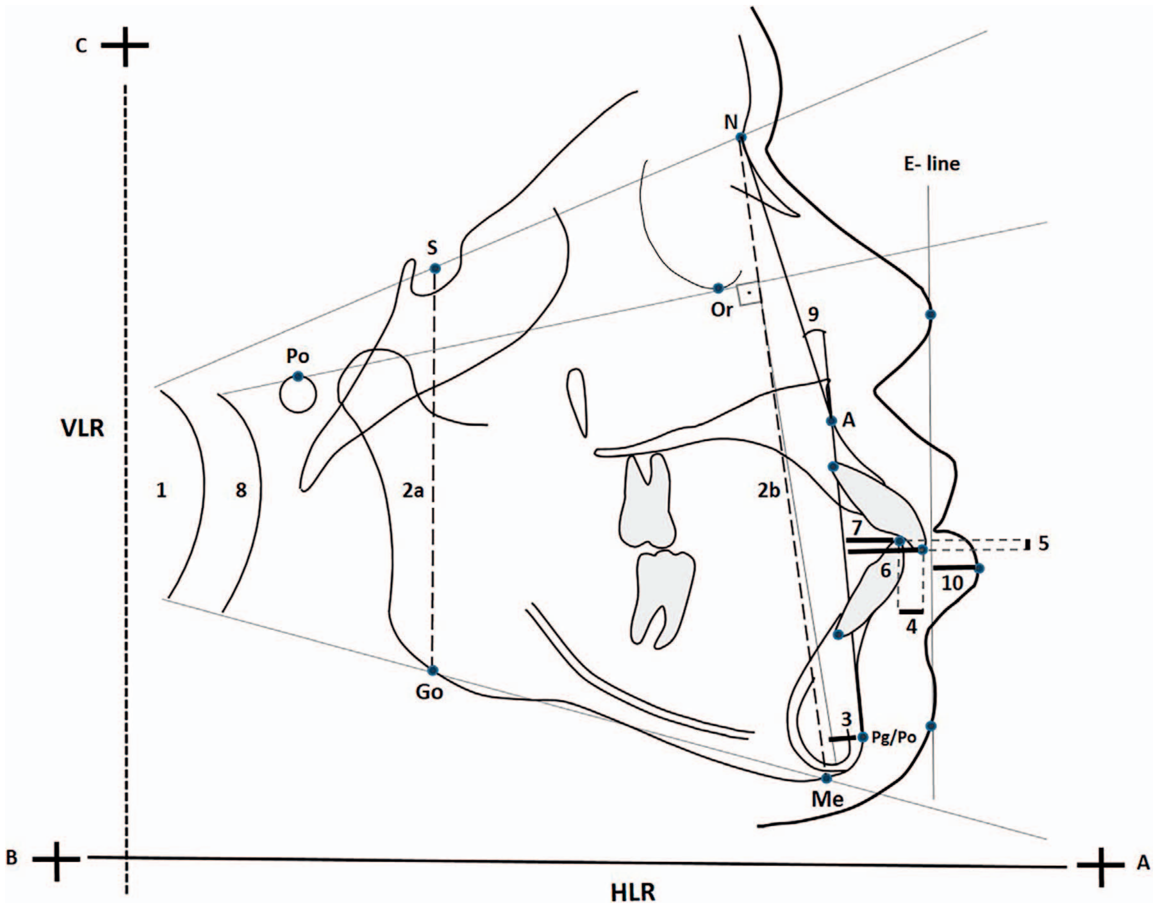

Figure 1. Cephalogram illustrating the landmarks and planes used. (1) SNGoMe; (2) PFH/AFH; (3) PgNperp; (4) Overjet; (5) Overbite; (6) L1-Apo; (7) U1-Apo; (8) FMA; (9) NA-Apo; (10) Lower Lip to E-Plane. Points: (A) Anterior reference point; (B) posterior reference point; and (C) posterior and superior reference point. Lines: HRL and VRL.

step. Archwires used were 0.017 × 0.025-inch SS, and nickel-titanium (NiTi) closed-coil springs were attached from the hooks of the first molars to hooks soldered to the archwires between the lateral incisor and the canine and activated to 200 g (GAC International Inc, Bohemia, NY, USA). In the TSR group, an 0.020-inch SS arch wire with flush omega loops tied back to the first molars was used for the retraction of the canine. NiTi closed-coil springs activated to 100 g were secured from the hooks of the first molars to the hooks of the canine brackets with 0.010-inch ligature wire. After retraction of canines, they were tied to the posterior teeth using 0.010-inch ligature wire. For the incisor retraction, 0.017 × 0.025-inch SS wires were inserted, and NiTi closed-coil springs were attached from the cervical hook of the first molars to soldered hooks located distal to the lateral incisor and activated to 100 g. No auxiliary devices, such as transpalatal arches, headgear, miniscrews, or elastics, were used in either group during the retraction phase. The patients were evaluated every 4–5 weeks, and the springs were reactivated until the spaces were closed.

Lateral and oblique cephalometric radiographs at 45° of the right and left sides were taken 7 to 14 days before extractions (T1) and after all extraction spaces were closed (T2). Tracings of all radiographs were made using a 0.3-mm mechanical pencil on 0.03-mm-thick tracing paper (GAC International Inc). Three reference points were placed on cephalometric tracings at T1 (Figure 1). Two horizontal reference points (A and B) were marked on the functional occlusal plane to define the horizontal reference line (HRL). Point A was located in the anterior region of the tracing and point B was located in the posterior region of the tracing. Point C was marked above the orbit contour and posterior to the tracing to determine a vertical

Table 2. Descriptions of Demographics of Two Groups[a]

Group	n	Sex: Female	Sex: Male	Starting Age Mean (SD), y	Age Range, y
ER	24	14	10	23.9 (3.43)	19–32
TSR	24	15	9	22.0 (4.8)	18–34

[a] SD indicates standard deviation; ER, en masse retraction; and TSR, two-step retraction.

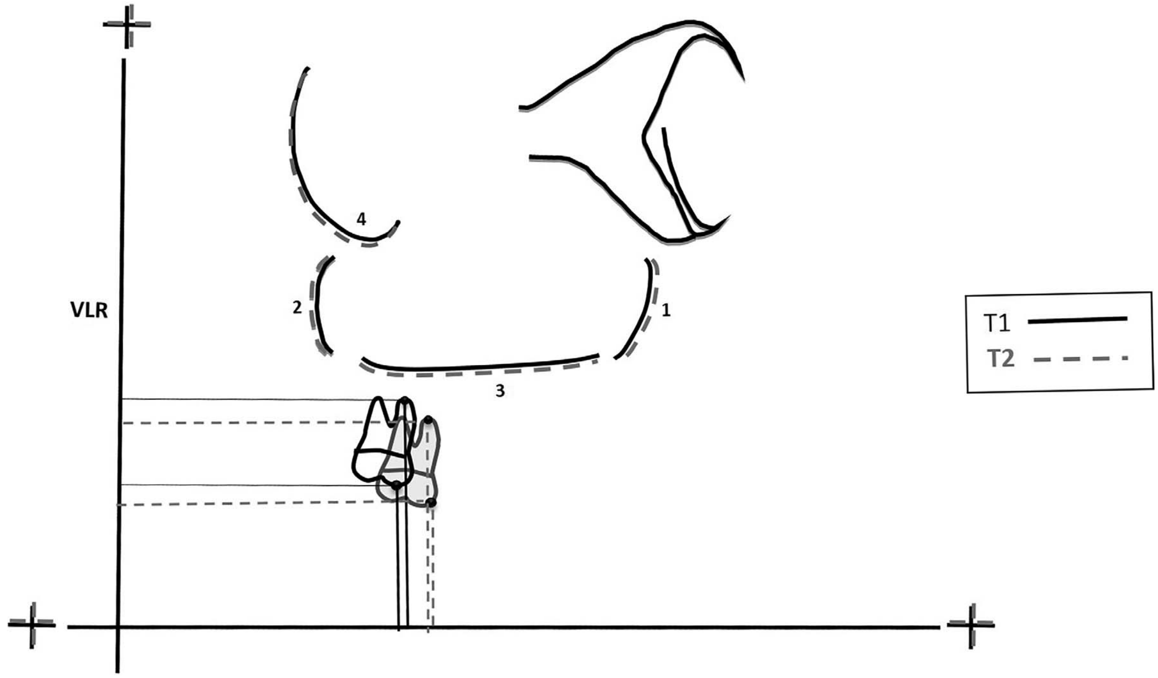

Figure 2. Maxillary superimposition in the oblique cephalogram. (1) Inner cortical plate of the anterior part of the maxilla opposite to the canine region; (2) posterior contour of infrazygomatic crest; (3) nasal floor; and (4) orbital floor.

reference line (VRL) perpendicular to HRL. Four points were marked on the incisors in each lateral cephalogram tracing (Figure 1) and another four points on the molars in each oblique cephalogram tracing (Figures 2 and 3). T1 and T2 tracings were superimposed to transfer the three reference points from the T1 to the T2 cephalograms. Oblique cephalogram tracings[13] were superimposed for evaluation of the upper (Figure 2) and lower (Figure 3) molar movements. The same method was used in the lateral cephalogram tracings[14] for the evaluation of upper (Figure 4) and lower (Figure 5) incisor movements. All landmarks were digitized

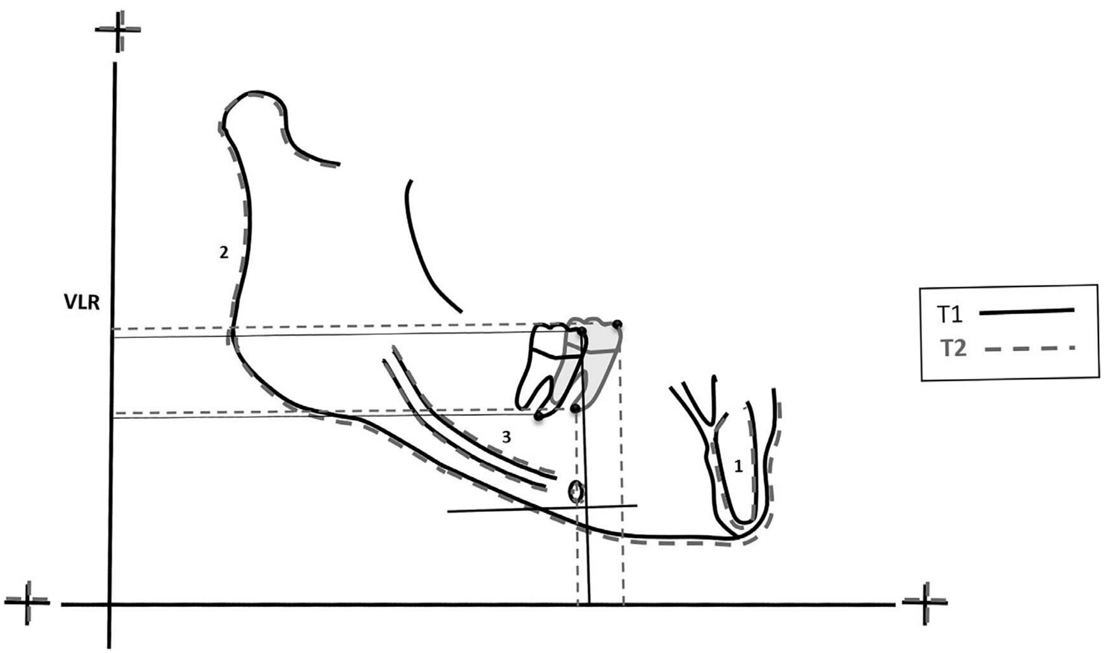

Figure 3. Mandibular superimposition in the oblique cephalogram. (1) Inner cortical structure of the symphysis; (2) mandibular corpus; and (3) mandibular canal and foramen.

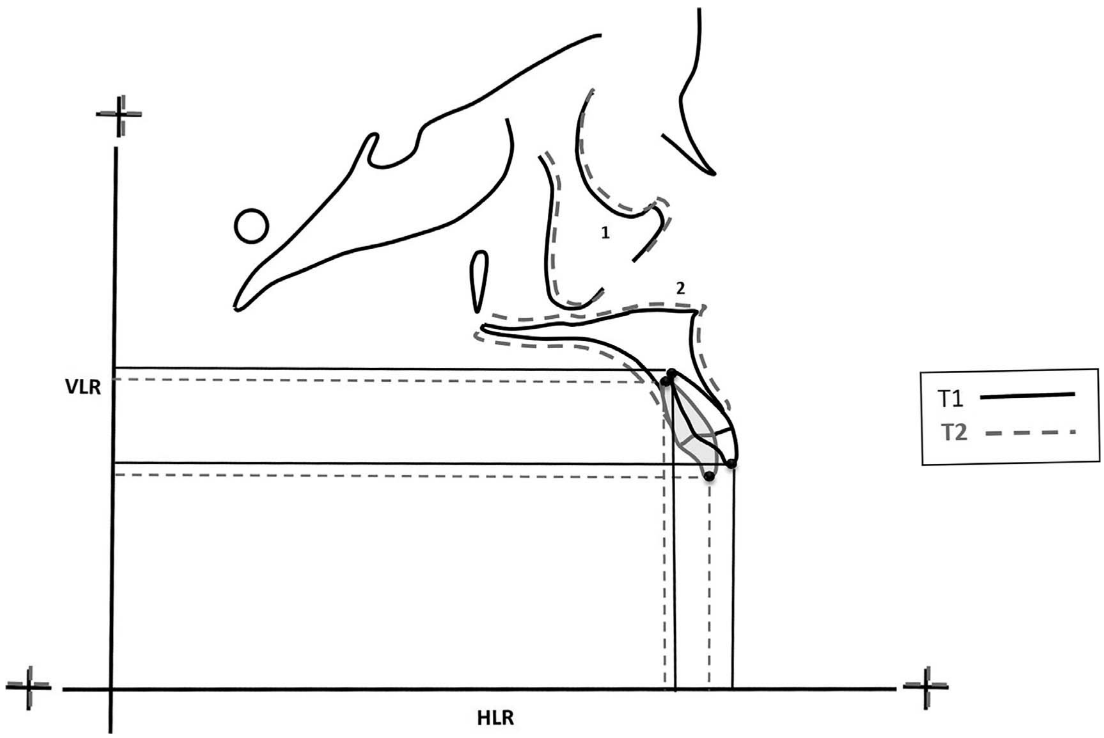

Figure 4. Maxillary superimposition in the lateral cephalogram. (1) Orbital inferior contour; and (2) superior contour of the nasal cavities.

using DentoFacial Planner Plus (version 2.0; Toronto, Canada). The distances from the points in the molars (Figures 2 and 3) and incisors (Figures 4 and 5) to VLR and HLR were transferred to a Microsoft Excel spreadsheet in which T2 values were subtracted from T1 values. These calculations allowed measurement of the horizontal and vertical movements. Additionally, the inclinations of these teeth were measured using angles formed by the cusp and apex points at T1 and T2. The investigator and the patients were blinded

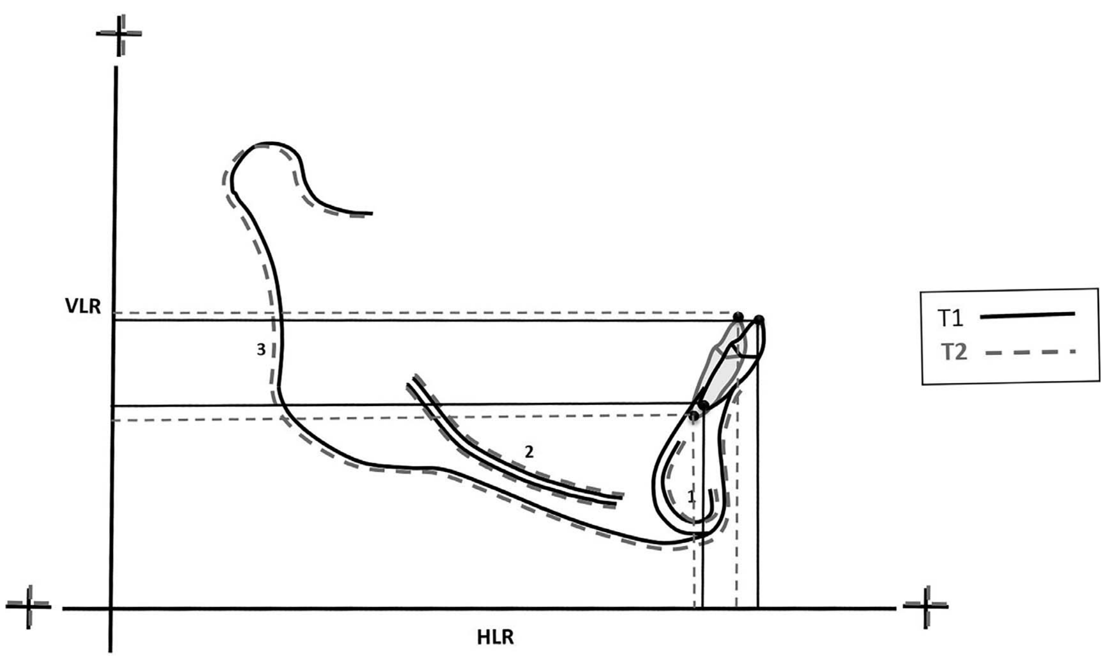

Figure 5. Mandibular superimposition in the lateral cephalogram. (1) The anterior contour of the symphysis; (2) the inferior alveolar canal; and (3) posterior contour of the ascending ramus.

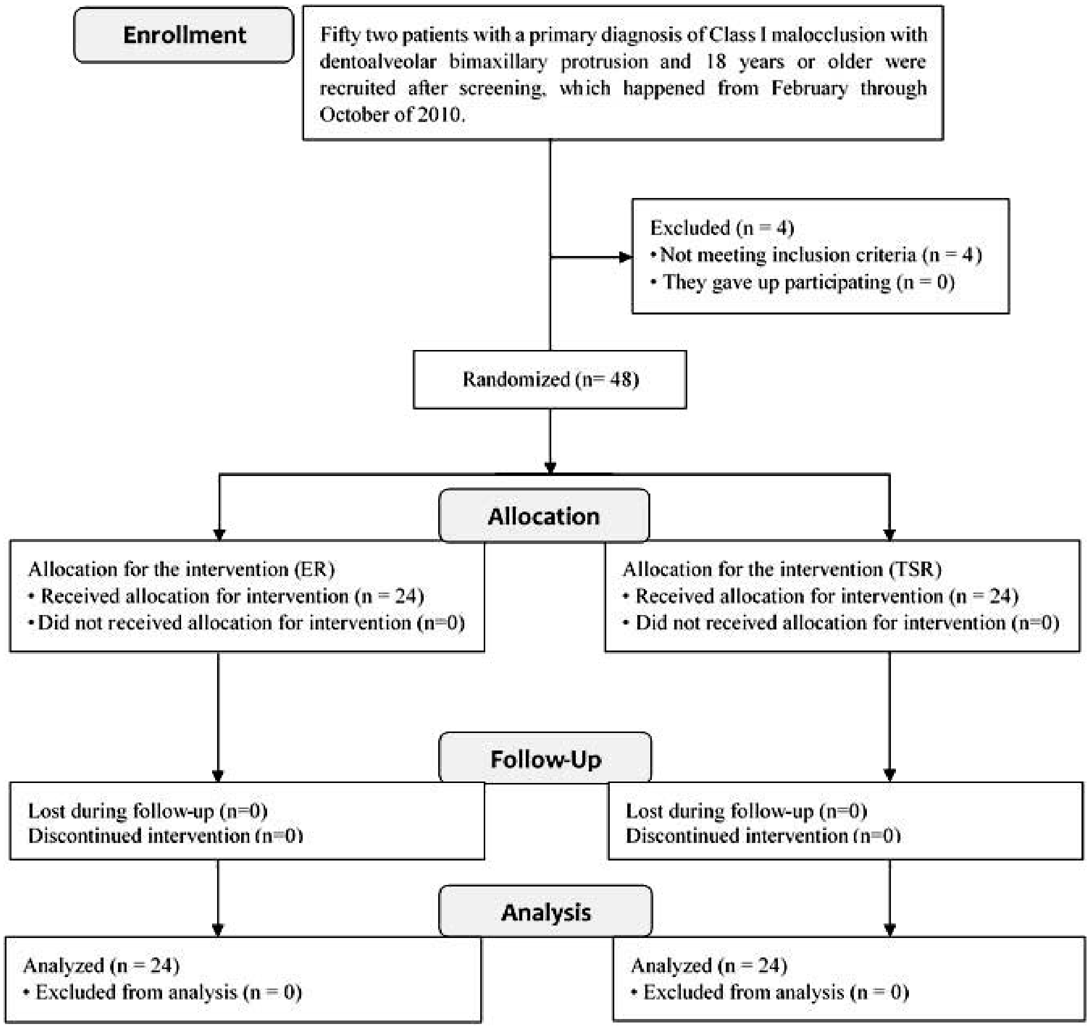

Figure 6. CONSORT flow chart showing patient flow.

during the allocation and during the cephalometric analysis; however, it was impossible to blind them to the treatment method used.

Statistical Analysis

A single examiner traced, superimposed, and digitized all radiographs. All data were measured twice at an interval of 4 weeks. Reliability was evaluated using intraclass correlation coefficients (ICCs) and estimated by means of confidence intervals. Strong intraexaminer reliability was found (ICC = 0.98). Normality of the distribution of variables was confirmed by the Kolmogorov-Smirnov test. The Student's *t*-test was used to compare the means between the two groups. This test was preceded by the Levene test and was corrected when the hypothesis of homoscedasticity of the variable was rejected. The significance level of all tests was established at .05.

RESULTS

The CONSORT diagram shows the flow of subjects through the trial (Figure 6). The baseline data for the patients in the treatment groups were similar between groups (Tables 1 and 2).

Table 3 and Figure 7 describe the mean for incisor displacement during space closure and provide comparison between the two groups. Maxillary and mandibular incisor crown movements and tipping showed no significant differences between the two groups for the horizontal and vertical displacements. However, the apex of the upper incisor in the ER group moved more (−1.98 ± 1.08) in the horizontal direction than it did in the TSR group (−1.21 ± 0.87).

Table 4 and Figures 8 and 9 show the mean for molar displacements, left and right, during space closure and the comparison between the two groups. On both sides, maxillary and mandibular molar crown movements showed no significant differences in

Table 3. Descriptive Statistics Between En Masse Retraction (ER) and Two-Step Retraction (TSR) Groups for the Displacement of Upper and Lower Incisors[a]

	Mean (SD)			*t*-Test			
Variable	ER (n = 24)	TSR (n = 24)	Mean Difference (SD)	*t*	DF	*P*-Value	Sig
Upper incisor							
Tipping, °	−10.2 (3.16)	−11.73 (3.31)	−1.52 (0.93)	−1.63	48	.11	ns
Crown/vertical, mm	−1.4 (0.82)	−1.62 (0.74)	0.22 (0.23)	0.98	48	.333	ns
Apex/vertical, mm	−1.45 (0.82)	−1.5 (0.83)	0.05 (0.24)	0.23	48	.821	ns
Crown/horizontal, mm	−4.51 (0.55)	−4.62 (2.06)	0.1 (0.44)	0.24	48	.812	ns
Apex/horizontal, mm	−1.98 (1.08)	−1.21 (0.87)	−0.78 (0.28)	−2.74	48	.009	*
Lower incisor							
Tipping, °	−9.64 (3.06)	−9.87 (2.27)	0.23 (0.78)	0.29	48	.77	ns
Crown/vertical, mm	0.69 (0.6)	0.75 (0.39)	0.06 (0.15)	0.43	48	.673	ns
Apex/vertical, mm	1.97 (0.68)	1.93 (0.76)	−0.04 (0.21)	−0.18	48	.858	ns
Crown/horizontal, mm	−4.66 (0.66)	−4.88 (0.54)	0.21 (0.17)	1.23	48	.227	ns
Apex/horizontal, mm	−1.51 (0.82)	−1.5 (0.88)	−0.01 (0.25)	−0.03	48	.973	ns

[a] SD indicates standard deviation; Sig, significance; and ns, not significant.

* Significant differences by the Student's *t*-test at $P < .05$.

Negative values indicate distal movement for all incisors (horizontal) and extrusion movement for upper incisor (vertical); Positive values indicate extrusion movement for lower incisor (vertical).

horizontal and vertical displacements and in tipping between the ER and TSR groups. The mean displacement of the apex was higher in the TSR group for vertical movement of the apex of the right maxillary molar (–0.79 ± 0.52) and the right mandibular molar (1.08 ± 0.61) and also for the horizontal movement of the apex of the left mandibular molar (2.62 ± 0.7).

DISCUSSION

In this study, there was no significant difference between the right and left sides for both maxillary and mandibular molars (Table 4).

In the horizontal direction, contrary to the belief of the majority of orthodontists,[1–3] the results showed that there was no statistically significant difference in the amount of anchorage loss between ER and TSR. The mean anterior displacement of the maxillary first molar was 2.97 ± 0.34 mm, with the apex advancing 2.43 ± 0.68 mm. For mandibular first molars, the displacement was 2.71 ± 0.38 mm for the crown and 2.64 ± 0.61 mm for the apex. One previous study[6] had similar findings. That study was also conducted without the use of anchoring devices, but lateral cephalograms were used to evaluate tooth movement. The current

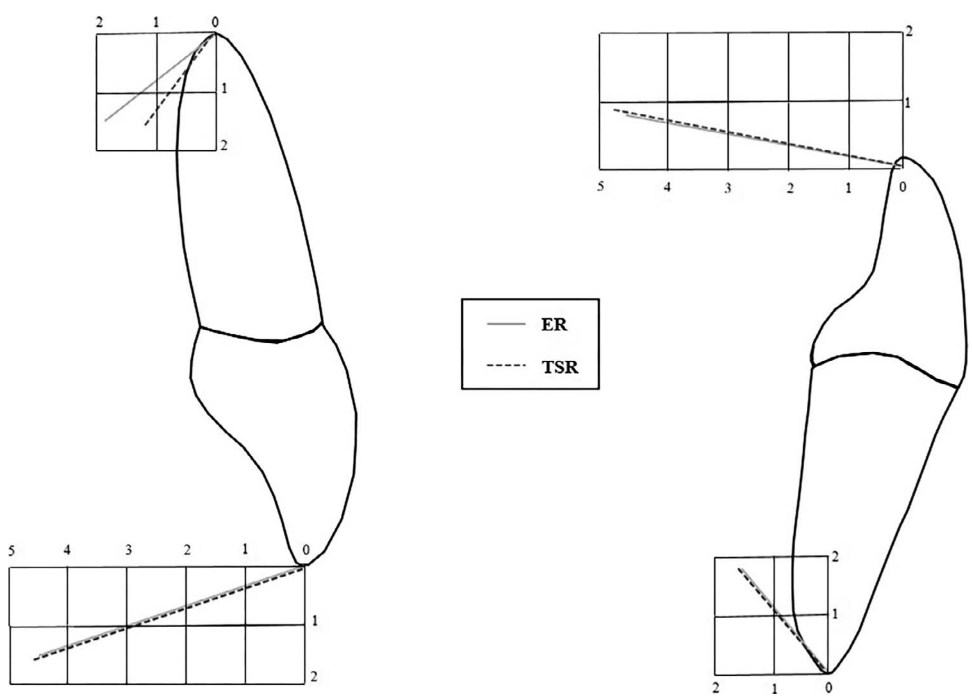

Figure 7. Results of the movements of incisors during ER and TSR.

Table 4. Descriptive Statistics Between En Masse Retraction (ER) and Two-Step Retraction (TSR) Groups for the Displacement of Left and Right Maxillary Molars and Left and Right Mandibular Molars[a]

Variable	Mean (SD)		Mean Difference (SD)	*t*-Test			Sig
	ER (n = 24)	TSR (n = 24)		*t*	DF	*P*-Value	
Left upper molar							
Tipping, °	2.32 (1.91)	2.65 (1.34)	−0.33 (0.48)	−0.68	48	.499	ns
Crown/vertical, mm	−0.61 (0.82)	−0.7 (0.66)	−0.08 (0.21)	−0.39	48	.699	ns
Apex/vertical, mm	−0.61 (0.96)	−0.61 (0.51)	0.0 (0.22)	0.0	48	1.000	ns
Crown/horizontal, mm	3.01 (1.03)	3.53 (2.05)	−0.52 (0.47)	−1.11	48	.275	ns
Apex/horizontal, mm	2.61 (1.61)	2.6 (0.9)	0.01 (0.38)	0.01	48	.991	ns
Right upper molar							
Tipping, °	2.75 (0.71)	3.14 (1.1)	−0.39 (0.27)	−1.47	48	.149	ns
Crown/vertical, mm	−0.49 (0.36)	−0.64 (0.43)	−0.15 (0.11)	−1.31	48	.197	ns
Apex/vertical, mm	−0.5 (0.34)	−0.79 (0.52)	−0.28 (0.13)	−2.23	48	.03	*
Crown/horizontal, mm	2.99 (0.47)	3.39 (2.07)	−0.4 (0.43)	−0.92	48	.361	ns
Apex/horizontal, mm	2.49 (0.92)	2.58 (1.41)	−0.08 (0.34)	−0.24	48	.81	ns
Left lower molar							
Tipping, °	1.83 (0.57)	−1.72 (1.15)	−0.1 (0.26)	−0.4	48	.693	ns
Crown/vertical, mm	0.68 (0.58)	0.66 (0.4)	0.02 (0.15)	0.17	48	.864	ns
Apex/vertical, mm	0.61 (0.43)	0.71 (0.56)	−0.1 (0.14)	−0.69	48	.493	ns
Crown/horizontal, mm	2.73 (0.35)	2.62 (0.39)	0.11 (0.11)	1.05	48	.300	ns
Apex/horizontal, mm	2.14 (0.54)	2.62 (0.7)	−0.48 (0.18)	−2.65	48	.011	*
Right lower molar							
Tipping, °	1.68 (0.63)	1.95 (1.26)	0.27 (0.29)	0.93	48	.359	ns
Crown/vertical, mm	0.76 (0.45)	0.97 (0.59)	−0.3 (0.15)	−1.99	48	.053	ns
Apex/vertical, mm	0.60 (0.60)	1.08 (0.61)	−0.49 (0.18)	−2.78	48	.008	*
Crown/horizontal, mm	3.0 (2.01)	2.7 (0.51)	0.49 (0.42)	1.15	48	.256	ns
Apex/horizontal, mm	2.85 (1.14)	2.95 (1.2)	−0.25 (0.35)	−0.73	48	.469	ns

[a] SD indicates standard deviation; Sig, significance; and ns, not significant.

* Significant differences by the Student's *t*-test at $P < .05$. Positive values indicate mesial movement for all molars (horizontal) and extrusion movement for mandibular molar (vertical); Negative values indicate extrusion movement for upper molar (vertical).

study was the first to evaluate displacement of molars during space closure between the two retraction techniques using oblique cephalograms. Al-Sibaie and Hajeer[9] also found no difference in anchorage loss among space closure techniques, but the findings of their study and ours cannot be directly compared because it used various anchorage devices, the extraction decisions varied for Class I or Class II patients, and some patients in that study were still actively growing.

To obtain a more comprehensive comparison between the two retraction techniques in this study, differences in incisor retraction during space closure were also examined. The results reported in Table 3

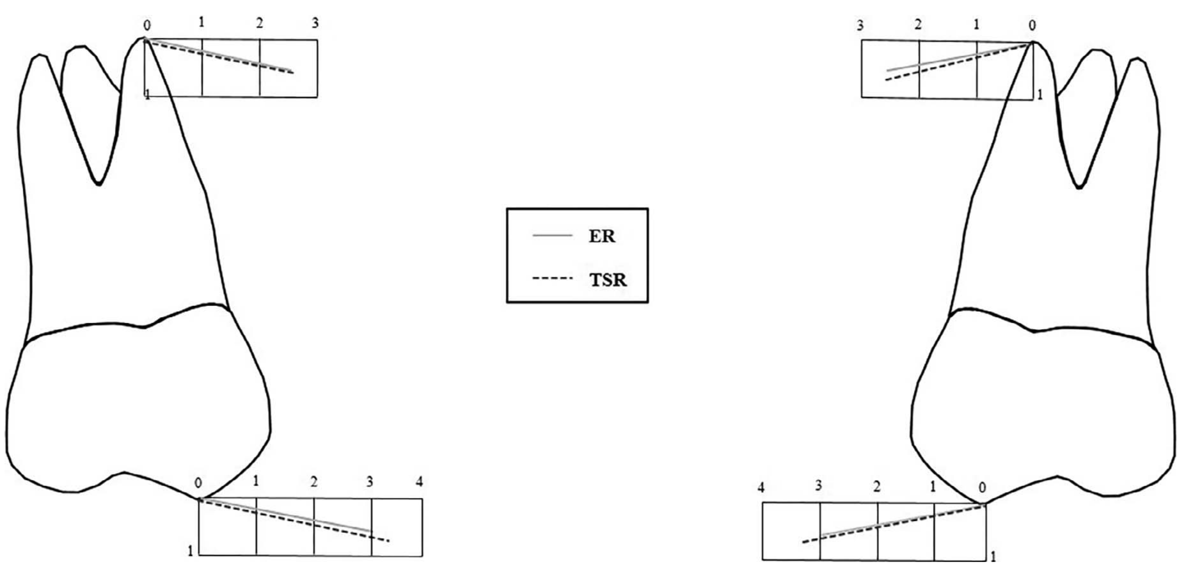

Figure 8. Results of the movements of right and left maxillary molars during ER and TSR.

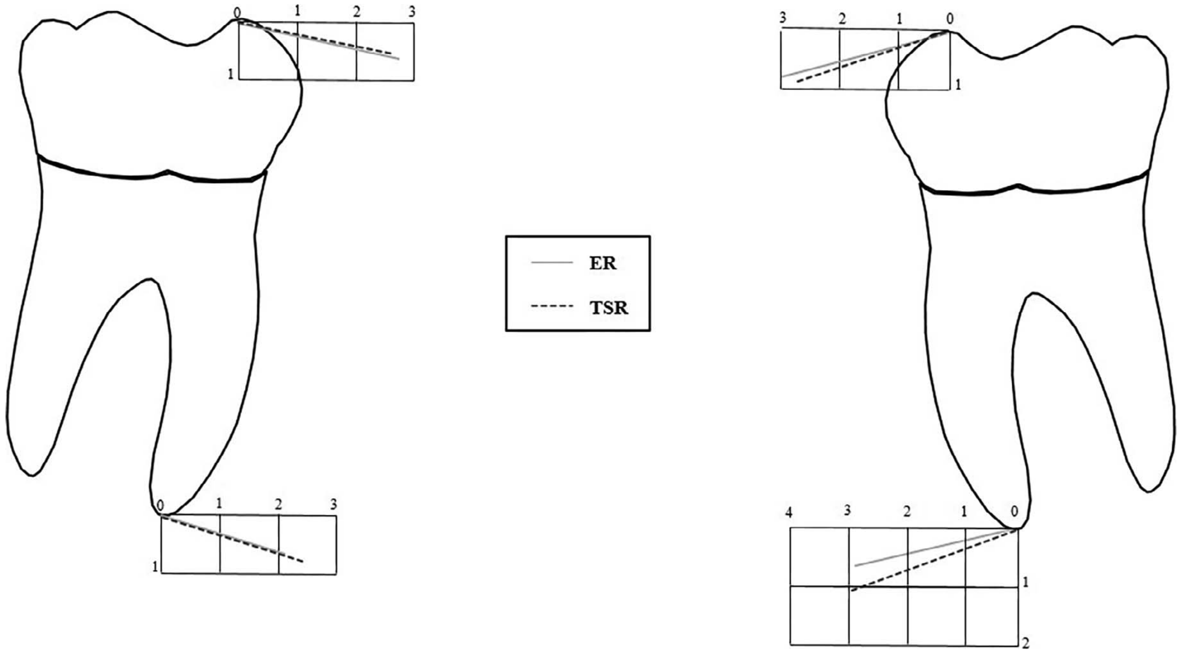

Figure 9. Results of the movements of right and left mandibular molars during ER and TSR.

indicate that there was no difference in horizontal movement between the two groups. In both arches, the incisors moved distally, with a mean displacement of the crown of the upper incisor of 4.37 ± 0.62 mm and with the apex retracting 1.48 ± 0.82 mm. For the lower incisor, mean displacements were 4.77 ± 0.60 mm for the crown and 1.51 ± 0.84 mm for the apex, with differences smaller than 0.02 mm between groups. These results were similar to those of the other RCT.[15]

In the current study, the incisors moved more than the molars during space closure. The crown of the incisor moved more than the apex, resulting in mean tipping of 10.96° ± 3.29° for the upper incisor and 9.76° ± 2.67° for the lower incisor. Similar tipping occurred in the molars but was, on average, 2.71° ± 1.05° in the maxilla and 1.74° ± 0.64° in the mandible. In both arches, these teeth showed extrusive movement. Although some results appear to be statistically significant in the apex region, both groups showed minimal apical displacement of less than 2 mm. Since the line of action of the force produced by the NiTi springs was not applied at the center of resistance of the anterior teeth, an uprighting moment may have resulted on the anterior teeth, causing tipping and extrusion of the incisors.[4] Consistent with the current results,[6,7] extrusive movement was previously reported as a side effect of TSR[6] and was considered too small to be of clinical significance,[7] since it did not compromise the final results of treatment.

Three factors may have contributed to making the results of the current study different from those of previous studies. First, the sample was composed of only adult patients. Xu et al.[7] demonstrated that patients who started treatment before age 13 had significantly more mesial displacement of maxillary first molars (by a mean of 1.2 mm) than did patients who started treatment at older ages. Second, additional anchorage devices were not used during space closure in the current study. Previous studies[8,16] demonstrated that ER combined with mini-implants results in superior anchorage preservation. Third, sliding mechanics were used for space closure in the current study. Therefore, friction may have interfered and modified movement rates,[1,4,17] and tooth rotation may have occurred.[4] On the other hand, if frictionless mechanics using closing loops had been used, differential moments in the active and reactive units may have resulted in more or less anchorage loss.[4]

The treatment plan used in this study involved the alignment and leveling of all teeth with a 0.020-inch SS wire before extraction of premolars, providing standardization of the initial positioning before retraction. This was accomplished to avoid differences that could have influenced the rate of movement during sliding retraction.[18] A round SS wire with low second-order clearance (0.020-inch wire in a 0.022-inch slot)[4] combined with a relatively low force (100 g) was chosen to provide maximum canine translation[19] and less crown tipping during the first step of retraction in TSR.

The results of this study challenge the belief of many orthodontists that TSR is more effective in preventing anchorage loss. Since there was movement of the posterior segment in both techniques, using ER should be considered for closing the extraction spaces unless anterior crowding is present. If more retraction of the anterior teeth is needed to modify the patient's facial profile or for other reasons, additional anchorage reinforcement may be required.

CONCLUSIONS

When comparing the closure of space between ER and TSR, the following was concluded:

- Both methods are effective to achieve space closure.
- No significant differences exist in the amount of retraction of incisors and anchorage loss of molars between the two methods of space closure.
- Magnitudes of incisor and molar tipping were similar between the two space closure methods, with the crowns moving more than the apices.

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