Effectiveness of lingual versus labial fixed appliances in adults according to the Peer Assessment Rating index

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Introduction: The purpose of this study was to compare the effectiveness of lingual treatment and labial fixed appliances in the treatment of adult orthodontic patients. **Methods:** We conducted a retrospective study of 72 patients. The Peer Assessment Rating (PAR) index was measured at the start (T0) and end (T1) of treatment. Significant differences between treatment means were determined by means of analysis of variancewith the Bonferroni correction or with the use of Fisher exact test. **Results:** The lingual group had a mean pretreatment age of 28.6 ± 6.7 years, and the labial group had a pretreatment age of 26.6 ± 9.5 years. This difference was statistically not significant. The mean pre- and posttreatment PAR scores in the labial group were 22.9 ± 6.2 and 2.1 ± 2.3, respectively, and the mean pre- and posttreatment PAR scores in the lingual group were 26.5 ± 8.3 and 2.3 ± 2.5. There were no significant differences between the treatment groups. **Conclusions:** Lingual and labial appliances produced similar reductions in PAR scores. There was no difference in the posttreatment PAR scores between the lingual and labial treatment groups. Further studies involving larger sample sizes and longer follow-up periods are required to confirm the results obtained. (Am J Orthod Dentofacial Orthop 2019;155:819-25)

Orthodontic treatments classically have been evaluated on a subjective basis, although they can also be analyzed objectively in a clinical setting or through state board examinations.[1] Different indices have been developed for assessing dental malocclusion and the outcomes of orthodontic treatment.[1-3] Clinical outcomes after orthodontic treatment are often measured with the use of occlusal indices to establish the overall standard of care. Occlusal indices are measured from study models taken before and after completion of treatment.[4] The use of indices should ensure uniform interpretation and application of criteria. The use of precise criteria is essential, requiring a quantitative objective method of measuring malocclusion and efficacy of treatment.[5]

The Peer Assessment Rating (PAR) index was developed to record the malocclusion at any stage of treatment. The index was formulated over a series of 6 meetings in 1987 with a group of 10 experienced orthodontists. More than 200 dental casts representing developmental as well as pretreatment and posttreatment stages were examined and discussed until agreement was reached regarding the individual features that would be assessed in obtaining an estimate of alignment of occlusion.[5] PAR scores are measured from plaster study models taken before and after treatment to establish a mean reduction in the score; a mean improvement of >70% represents a very high standard of treatment. Ideally, the number of patients in the "worse or no improvement" category should be <5%.[4] The PAR is a very comprehensive index that measures malocclusion on all 3 spatial planes based on 8 components that are weighted to obtain the overall score.[5] The index has been used in a number of studies[6-11] to assess the long-term stability of treatment[7] and the treatment stability in patients with Class II[6] and Class III malocclusions.[10]

Lingual appliances offer a more esthetic effect, because the brackets are placed on the lingual surface

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of the teeth and are therefore much less visible. However, orthodontic treatment is influenced by a series of dynamic, esthetic and functional factors that can prolong the final phase and the duration of treatment.[11,12] Few studies to date[13] have analyzed outcome quality after treatment with lingual orthodontics, and even fewer studies[14] have compared outcome quality between labial and lingual orthodontics.[15] The present retrospective study was therefore carried out to compare the outcome quality of orthodontic treatment performed with the lingual and labial techniques, based on the PAR index.

PARTICIPANTS AND METHODS

After approval by the Institutional Review Board of the University of Valencia (H1475013776580), a cohort of 97 consecutive orthodontic patients received fixed orthodontic appliances (labial or lingual), starting treatment from 2010 to 2014 in Valencia, Spain. The study protocol was designed in compliance with Strengthening the Reporting of Observational Studies in Epidemiology (STROBE).[16] All of the patients were treated by 2 clinicians with more than 15 years of experience. Both orthodontists followed the same treatment protocols. These orthodontic patients were selected according to the following inclusion criteria: no previous orthodontic treatment, availability of initial and final treatment casts, availability of radiographic records, panoramic x-rays, and lateral cranial teleradiography before and after treatment, and absence of defects or alterations of the casts capable of complicating the study measurements. Patients not meeting the above criteria were excluded. Of the initial 97 patients, 12 were excluded because the initial and/or final treatment casts were not available, 8 were excluded because radiographic records were not available, 3 were excluded because they had received previous orthodontic treatment, and 2 were excluded because the study casts proved to be defective (Fig 1).

The labial group consisted of 42 patients: 36 female (85.7%) and 6 male (14.3%). The mean age of this group was 26.6 ± 9.5 years. This group was treated with the use of Victory series (3M Unitek, Monrovia, Calif) conventional preadjusted bracket systems with a 0.018-inch slot. The sequence of archwires used in the labial technique was: 0.016-inch nickel titanium alloy archwire, followed by 0.016 × 0.022-inch nickel titanium alloy (NiTi) archwire, followed by 0.016 × 0.022-inch stainless steel (SS) archwire. The lingual group consisted of 30 patients: 21 female (70%) and 9 male (30%). The mean age of this group was 28.6 ± 6.7 years. This group was treated with the use of the Incognito system (3M Unitek). The sequence of archwires used in the lingual technique was: 0.012″ or 0.014″ SE-NiTi, followed by 0.016″ × 0.022″ SE-NiTi and 0.016″ × 0.024″ SS, and complemented by 0.018″ × 0.018″ TMA archwires. The intermaxillary elastics protocol was based on the use of 3/16″ intermaxillary elastics with medium force. The intermaxillary elastics were used bilaterally for 6 months and were withdrawn only for eating and oral hygiene.

The following variables were recorded from patient case history: treatment group (lingual or labial), duration of treatment time between initial and final casts, age, dentition, and sex. The final patient models were obtained on the day of removal.

All PAR index measurements were made at 2 time points: T0 (before treatment) and T1 (after treatment). The PAR index ruler was used to score the casts.[5] The measurements included: alignment of the upper and lower anterior sectors, buccal occlusion on 3 planes (anteroposterior, transverse, and vertical), buccal occlusion total, overjet, overbite, and midline alignment. The degree of improvement is organized into 3 categories: "worse–no different," "improved," and "greatly improved." There must be ≥30% PAR score reduction and <22 PAR points reduction as a result of treatment for a case to be assigned as "improved," and a change of ≥22 points for it to be assigned as "greatly improved."

One investigator (F.A.A.) was previously calibrated by the British Orthodontic Society for the PAR index (certificate 3DPFA201186). Fifteen sets of records were randomly selected and remeasured by the same investigator (F.A.A.) after an interval of 4 weeks. The error of the method was estimated with the use of the intraclass correlation coefficient (ICC) and Dahlberg formula.[17] For the categoric classification of the PAR index ("worse–no different," "improved," and "greatly improved"), we used the Cohen kappa (κ) statistic. An ICC <0.30 represents "poor" agreement, 0.31-0.50 "fair" agreement, 0.51-0.70 "moderate" agreement, 0.71-0.90 "good" agreement, and >0.91 "excellent" agreement, according to Fleiss.[18] Kappa values of <0.0, 0.00-0.20, 0.21-0.40, 0.41-0.60, 0.61-0.80, and 0.81-1.00 are, respectively, indicative of poor, slight, fair, moderate, substantial, and almost perfect agreement.[19]

Because the use of labial or lingual orthodontic appliances does not allow blinding of the patient, we adopted a double-blind approach in which both the investigator and the statistician analyzing the results did not know which treatment group the patient belonged to. An individual not related to the study placed the study casts (initial and final) in a box with the panoramic and lateral cranial radiographs used for the measurements and eliminated all information capable of linking the contents to one study group or the other, with the aim of blinding the investigator. The statistician

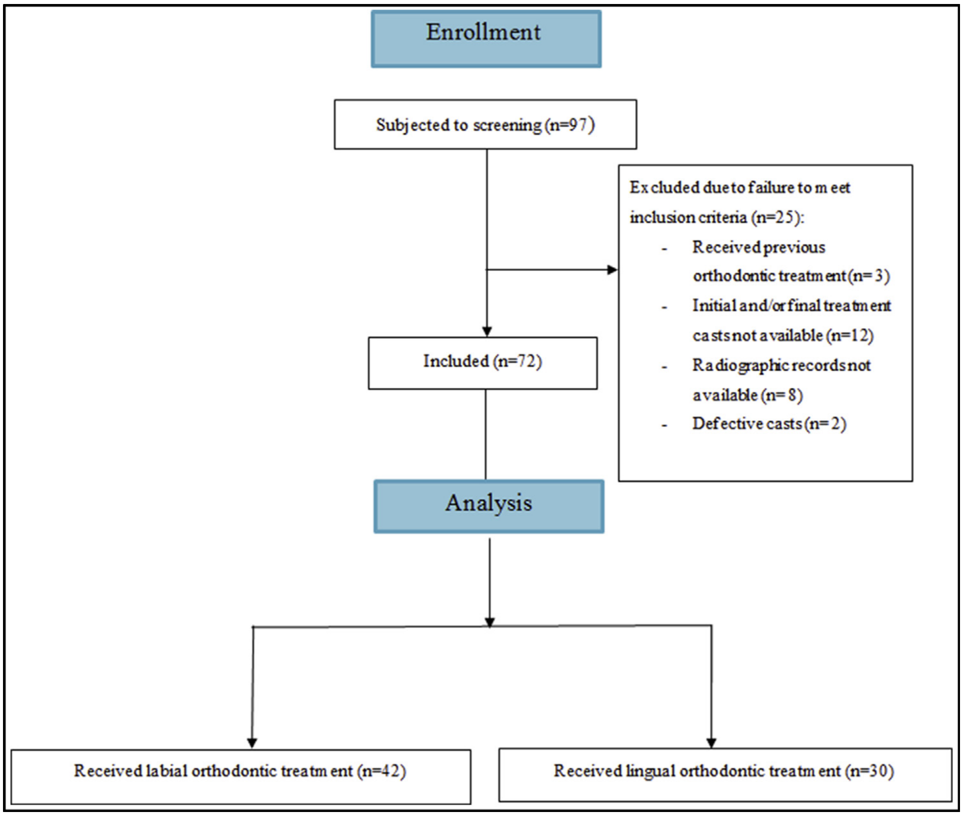

Fig 1. Study patient flowchart.

in turn was blinded by only assigning a number to each patient according to the treatment received (1 for labial orthodontics and 2 for lingual orthodontics). The link between number and type of treatment was concealed during the data analysis.

Statistical analysis

Differences between treatment means were assessed by means of analysis of variance (ANOVA F test) with Bonferroni correction, or with the use of the Fisher exact test when necessary. We used the Kolmogorov-Smirnov test to assess normality of the variation of the PAR Index. For the individual components of the PAR index, considering the much more limited range of the values (more discrete scale) and the lower reliability of the assumed distribution, we decided to directly adopt a nonparametric approach (Brunner-Langer model).[20] We worked with the variable "vPAR" of the database, and therefore weighted means have been obtained. Various degrees of importance were attached to the 5 major components of the PAR Index. We multiplied the individual scores for each PAR index component by the weightings: upper and lower anterior segments (×1), left and right buccal occlusions (×1), overjet (×6), overbite (×2), and centerline (×4). These values were then been summed to establish the weighted score.[5] We used multiple linear regression models to determinate the influence of the independent variables on the final value of the PAR index. To determine whether factors such as patient age, sex, or duration of the treatment influence the change in PAR index obtained, we generated a multiple linear regression model with "variation of PAR index" as dependent variable and the type of treatment, duration of treatment, sex, and age as independent variables. Statistical significance was considered to be indicated with $P \leq 0.05$. A preliminary power analysis based on 1-way ANOVA with comparison of the 2 groups (statistical power $[1 - \beta] = 0.80$; $\alpha = 0.05$; effect size = 0.9) indicated that a total sample of 42 patients would be needed. The statistical analysis was performed with the use of the SPSS version 15.0 statistical package for Microsoft Windows (SPSS, Chicago, Ill) and R version 3.0.2 (R Foundation for Statistical Computing, Vienna, Austria).[21]

RESULTS

For a test such as the Student *t* test with a level of confidence of 95% and considering a size of the effect to be determined of d = 0.70 (medium-large), the statistical power of the test was 0.83 for the sample size of our study.

A total of 72 patients completed the study: 42 treated with labial appliance and 30 treated with lingual appliance. The agreement assessments were ICC = 0.98 and κ = 1.0 at T0 and ICC = 0.88 and κ = 1.0 at T1. The differences between the 2 groups according to age, sex, type of dentition, and duration of treatment are presented in Table I. There were no significant differences in any of these variables between the 2 groups.

In the group of patients treated with labial orthodontics, the mean ± SD pretreatment PAR (T0) was 22.9 ± 6.2 (range 12-38) and the mean posttreatment PAR (T1) was 2.1 ± 2.3 (range 0.0-9.0). In the group of patients treated with lingual orthodontics, the mean T0 PAR was 26.5 ± 8.3 (range 13-51) and the mean T1 PAR was 2.3 ± 2.5 (range 0.0-8.0). There were no significant differences between the treatment groups ($P = 0.051$). To assess the influence of the atypical cases in the group of patients treated with lingual orthodontics (Fig 2), we reestimated the model excluding the atypical cases, and found the tendency toward statistical significance in the treatment groups to disappear ($P = 0.198$). The difference between the patients treated with labial and lingual orthodontics was statistically significant at T0 ($P = 0.036$). The difference between the 2 treatment groups at T1 was not significant ($P = 0.754$). The percentage reduction of the PAR index was similar in both groups (90.4% for labial orthodontics and 91.5% for lingual; $P = 0.069$). Great improvement was seen in 95.2% of the cases treated with labial orthodontics. Specifically, 4.8% of the patients showed an improvement. The percentage improvement in the patients treated with lingual orthodontics was 100%.

The multiple linear regression model showed the independent variables sex and duration of treatment to exert no influence on the decrease in PAR index obtained ($P = 0.876$ and $P = 0.992$, respectively). The age of the patient had a significant impact on the decrease in PAR index achieved with treatment ($P = 0.028$). After reestimating the model to exclude the independent variables sex and duration of treatment, these were seen to exert no influence upon the variation obtained, and therefore did not act as confounding variables. After reestimating the model (Table II), the age of the patient was seen to continue exerting a significant influence ($P = 0.024$). Table III presents the results obtained in relation to the different parameters of the PAR index at both T0 and T1. There were no significant differences in either of these variables between the 2 groups (change from T0 to T1 by group). Regarding the patients subjected to labial orthodontic treatment, statistically significant results were obtained at T1 in relation to the variables upper anterior segments, lower anterior segments, buccal occlusion transverse, buccal occlusion total, overjet, overbite, and midline. In the patients subjected to lingual orthodontic treatment, statistically significant results were obtained at T1 in relation to all of the variables except vertical buccal occlusion. The observed changes in each of the parameters from T0 to T1 were similar in the 2 treatment groups (Table III).

Table I. Comparison of baseline characteristics between labial and lingual groups

Characteristic	*All (n = 72)*	*Labial (n = 42)*	*Lingual (n = 30)*	P
Age (y)	27.4 ± 8.4	26.6 ± 9.5	28.6 ± 6.7	0.332
Sex				0.106
Female	57 (79.2%)	36 (85.7%)	21 (70%)	
Male	15 (20.8%)	6 (14.3%)	9 (30%)	
Dentition				1.0000
Mixed 2nd phase	1 (1.4%)	1 (2.4%)	0 (0%)	
Permanent	71 (98.6%)	41 (97.6%)	30 (100%)	
Treatment duration (y)	2.57 ± 0.81	2.43 ± 0.72	2.78 ± 0.90	0.069

DISCUSSION

The purpose of this study was to compare the effectiveness of lingual treatment versus labial fixed appliances in the treatment of orthodontic patients. The difference between the pre- and posttreatment scores reflects the success or degree of improvement. As the score tends toward 0, the deviation from normal is less. Obviously, a score of 0 is not always achievable because of the complexity of the case, but generally a measure of ≤10 indicates an acceptable alignment and occlusion, and ≤5 suggests an almost ideal occlusion.[5] In this study, the mean posttreatment PAR was 2.1 and 2.3 points in patients treated with labial and lingual orthodontics, respectively. According to range, the cases with the highest scores in the posttreatment measurements corresponded to scores of <10 (9 points for labial orthodontics and 8 points for lingual orthodontics). This indicates an almost acceptable occlusion according to Richmond et al.[5]

A previous study[14] measured the PAR index to compare 24 patients treated with lingual orthodontics and 25 patients treated with labial orthodontics. In the pretreatment measurements, the mean index in the group of patients with labial orthodontics was 25 ± 9.6 versus 28 ± 7.2 in the lingual orthodontics group. No statistically significant differences were observed between the 2 types of treatment. The results of our study are consistent with those.[14] Another study[10] measured the PAR index in a sample of 45 patients

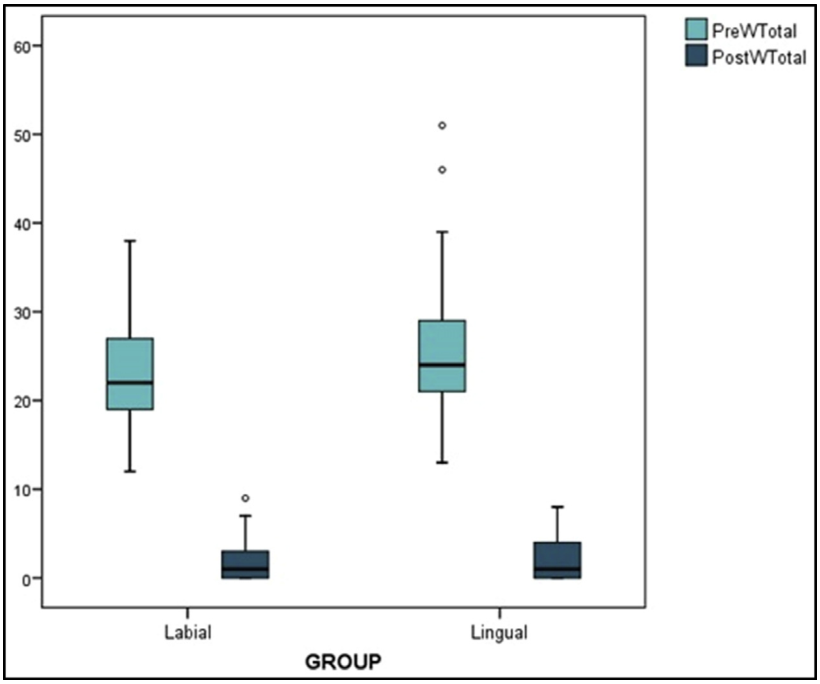

Fig 2. Box-plot of the PAR index weighted according to treatment group.

Table II. Evolution of the PAR index according to group adjusted to age: results of the multiple linear regression model

					95% CI for coefficient	
Factor	*Coefficient*	*SE*	*t*	P	*Lower*	*Upper*
Age	0.224	0.097	2.314	0.024*	0.031	0.416
Group	−3.031	1.641	−1.848	0.069	−6.304	0.242

*$P < 0.05$.

treated with labial orthodontics. The pretreatment measurement results were greater than those found in the present study (30.2 vs 22.9), although the posttreatment mean was similar (2.9 vs 2.1). In contrast to our results, Bichara et al[10] recorded statistically significant differences ($P = 0.029$). A 30% reduction in weighted PAR scores is required for a case to be considered as improved.[1] A study[4] involving 40 patients treated with labial orthodontics recorded mean PAR indexes of 30 for the casts analyzed before treatment and 7 for the casts analyzed after treatment. The mean percentage improvement of these patients was 77%. In the present study, the percentage improvement among the patients treated with labial orthodontics was 95% versus 100% in the patients treated with lingual orthodontics. Another study[9] involving measurement of the PAR index in 54 casts found the casts with a high pretreatment index to show greater index reduction after treatment, and therefore greater percentage improvement the longer the duration of treatment—with the exception of the occlusal index. A study[8] of 50 patients found 42% showed great improvement. In turn, 58% of the patients showed improvement. Because the PAR index was specifically used to measure the degree of improvement afforded by each of the orthodontic treatments, this finding indicates that lingual orthodontic treatment is at least as effective as labial orthodontics.

Such patients could be more demanding during treatment—a fact that would moreover result in greater reductions in PAR index and longer treatment duration in the lingual orthodontics group versus the labial treatment group. Fitting the brackets to the lingual surface facilitates patient visualization of the teeth on the labial side—this being more difficult in the case of labial orthodontics. The posttreatment measurements showed similar values with both types of treatment; although the cases treated with lingual orthodontics initially presented a greater PAR index, the final posttreatment index was similar to that found in the labial orthodontics group. From the treatment perspective, this indicates that lingual orthodontics are as effective as labial orthodontics. The difference in the results may be due to the great value attributed by the PAR index to overjet (multiplied by 6), which could explain the more favorable outcome with lingual orthodontics. Other factors that

Table III. Pretreatment and posttreatment PAR scores (mean ± SD) between labial and lingual appliances groups

	Labial (n = 42)		*Lingual (n = 30)*		
Variable	*Pretreatment PAR*	*Posttreatment PAR*	*Pretreatment PAR*	*Posttreatment PAR*	*P value (change by group)*
UAS	6.3 ± 2.5	0.0 ± 0.0†	6.1 ± 2.5	0.0 ± 0.2†	0.506
LAS	5.0 ± 2.8	0.1 ± 0.3†	5.4 ± 3.3	0.0 ± 0.0†	0.506
BOAP	1.7 ± 1.4	1.3 ± 1.3	2.0 ± 1.2	1.3 ± 1.2†	0.394
BOT	0.5 ± 1.1	0.1 ± 0.5*	0.9 ± 1.2	0.2 ± 0.6†	0.061
BOV	0.0 ± 0.0	0.0 ± 0.2	0.0 ± 0.0	0.0 ± 0.0	0.317
BOToT	2.2 ± 2.0	1.4 ± 1.5*	2.9 ± 2.0	1.5 ± 1.5†	0.197
OJ	0.5 ± 0.6	0.0 ± 0.0†	0.9 ± 1.1	0.0 ± 0.0†	0.225
OB	1.3 ± 1.1	0.0 ± 0.2†	0.9 ± 0.9	0.0 ± 0.0†	0.251
Cline	0.0 ± 0.7	0.1 ± 0.4†	1.2 ± 0.6	0.2 ± 0.4†	0.425

*$P < 0.05$; †$P < 0.001$.
UAS, upper anterior segments; *LAS*, lower anterior segments; *BOAP*, buccal occlusion anteroposterior; *BOT*, buccal occlusion transverse; *BOV*, buccal occlusion vertical; *BOToT*, buccal occlusion total; *OJ*, overjet; *OB*, overbite; *Cline*, midline.

have not been analyzed in the present study also must be taken into account, such as the longer chair time required by lingual orthodontic treatments[22] or the experience of the clinician.[23]

Most clinicians and patients are concerned about the duration of active treatment, and it is useful to be able to give an estimate of how long this will be. In this study, duration of treatment was measured from the time the appliances were placed to the day they were removed, which resulted in a difference between the 2 groups of 4 months. These results are consistent with those of other studies.[4,24] Duration of treatment for orthodontic treatment alone can vary widely, and depends to a large extent on the complexity of the case. Factors thought to influence the duration of orthodontic treatment include sex, age, severity of malocclusion, extractions, and the clinician.[4] Interestingly, PAR reduction was not associated with the length of treatment, raising the question of whether a similar result could be achieved in a shorter time to the patient's satisfaction. In our study, 85.7% of the patients treated with labial orthodontics were female versus 70% in the group of patients treated with lingual orthodontics. These results were consistent with those of Deguchi et al[14] (80% female) and Chalabi et al[8] (62% female). In our study, the variables sex and age had no significant impact upon the duration of treatment. The results of the present study are consistent with those published by Luther et al.[25] Another study[26] concluded that age differences do not seem to play a role in the duration of the treatment, provided that patients are in the permanent dentition.

As indicated by Ponduri et al,[4] Dyken et al.[9] reported that a high PAR score before treatment and a large percentage reduction in the score were significantly associated with long durations of treatment. However, the occlusal index scores after treatment were not associated with duration. It is important for clinicians to realize that time spent in detailed finishing is an essential part of the overall treatment, and it is also important to bear in mind that the occlusal result is not the only important outcome in orthodontic treatment.

A particular strength of this study is the fact that both the investigator and the person in charge of the statistical analysis of the data were blinded to the type of treatment received, with the purpose of minimizing bias. Furthermore, the measurements were all made by the same investigator previously calibrated by the British Orthodontic Society for using the PAR index, and intraexaminer reliability was seen to be high for all methods used. Finally, to the best of our knowledge, the study sample in our study is the largest published to date, with a statistical power of 83%. On the other hand, there are several shortcomings in our study, most significantly its retrospective design, which introduces selection bias. In view of the above, as indicated by Papageorgiou et al,[27] historically, a large proportion of evidence concerning the performance of an orthodontic intervention has stemmed from retrospective studies,[28,29] although the contribution of prospective studies has increased in the last decades.[30,31] Concerning research in orthodontics, empirical evidence has shown that the design of clinical trials systematically influences the magnitude and direction of the results, with non–randomized or controlled trials, especially retrospective ones, overestimating treatment effects.[29] In turn, to guarantee the stability of the treatment, it would be advisable to conduct long-term patient follow-up to compare the outcomes with those recorded at T1.

CONCLUSIONS

Because the PAR index was specifically developed to quantify the improvement of malocclusion in an objective and precise manner, it can be concluded with the use of the PAR score that lingual and labial appliances produced similar reductions. There was no difference in the posttreatment PAR scores between the lingual and labial treatment groups. There was no significant difference between the mean treatment times of the labial and lingual groups. Further studies involving larger sample sizes and longer durations of follow-up are required to confirm the results obtained.

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