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ORIGINAL ARTICLE E-ONLY AJO-DO

Did the coronavirus disease 2019 pandemic affect orthodontic treatment outcomes? A clinical evaluation using the objective grading system and Peer Assessment Rating index

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Introduction: This study aimed to compare the treatment outcome of patients whose orthodontic treatment was completed before or during the coronavirus disease 2019 pandemic. **Methods:** Pretreatment and posttreatment models of 100 patients treated with fixed orthodontic appliances were evaluated using the peer assessment rating (PAR) index. Posttreatment models and panoramic radiographs were measured and scored with the objective grading system (OGS). All patients had their treatment plans before the coronavirus disease 2019 pandemic, but the orthodontic treatment finishing date was before (prepandemic: group 1, n = 50) or during (pandemic: group 2, n = 50) the pandemic. Intergroup comparisons were tested with an independent samples *t* test or Mann-Whitney U test. Chi-square test statistics and Fisher exact test were used to compare categorical variables. **Results:** Significant higher posttreatment weighted maxillary alignment score was found in group 2. However, no significant difference was found between the groups concerning the mean total weighted PAR reduction (29.8 ± 9.9 vs 25.6 ± 8.7) and posttreatment total weighted PAR scores (1 vs 2). The PAR index score improvement (%) was similar between the groups (93.7 ± 7.1 vs 89.9 ± 13.0). No statistically significant difference was found between the groups for the total OGS score (32 vs 33). A lower score for marginal ridge height (4 vs 3) and a higher score for buccolingual inclination (7 vs 11), and a lower score for occlusal relationship (3 vs 1) were found in group 2. Canceled appointments (1.1 ± 0.7 vs 4.8 ± 1.6) and the number of missed appointments (0.6 ± 0.5 vs 1.1 ± 0.8) were statistically higher in group 2, whereas the total number of appointments (27.3 ± 8.8 vs 21.8 ± 5.4) were statistically less. The treatment duration was comparable in both groups. **Conclusions:** Reduced and irregular appointments during the pandemic resulted in significantly higher posttreatment weighted maxillary alignment and worsening of the buccolingual inclination. However, the PAR score improvement, total OGS score, and treatment duration were not affected. (Am J Orthod Dentofacial Orthop 2022;162:e44-e51)

In December 2019, a pneumonia pandemic of unknown etiology occurred in Wuhan City, Hubei province, China. The Chinese Centre for Disease Control and Prevention identified a new coronavirus as the cause and was named the coronavirus disease 2019 (COVID-19) pandemic by the World Health Organization.[1,2] Observations suggest that patients of all age groups are generally susceptible to COVID-19. However, patients with confirmed patients or close contact with asymptomatic carriers, including health care workers and other patients in hospitals and/or clinics, have been reported to have a higher risk of infection.[3] The dentistry specialty is among the risky occupational groups because of the aerosol and droplets splashes from the oral cavity, as it requires treatment in proximity to patients.[4,5] Because dental clinics are risky for COVID-19 transmission, routine dental procedures were suspended for a while, except for emergency procedures.[6]

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Studies have revealed that although patients undergoing orthodontic treatment know that the COVID-19 virus is dangerous, they are willing to continue the treatment, not prolong it.[7] Because orthodontic patients could not wait until the end of the pandemic because of the problems that might occur by prolongation of the treatment and the economic consequences made it necessary for orthodontic clinics to reopen after the permission of the authorities in the light of newly published guidelines. Poor oral hygiene,[8] reduced cooperation because of emotional stress,[9] and decreased doctor-patient communication[10,11] are factors that will negatively affect the outcome of orthodontic treatment. To minimize these problems during a pandemic, it is recommended to maintain doctor-patient communication with teleorthodontics[12,13] and keep in contact with the doctor by taking pictures or videos when necessary. However, not all orthodontic procedures can be controlled in this way, and orthodontists were caught unprepared against a pandemic and each physician tried to help their patients according to their conditions.

Quality control in orthodontics is important to set goals, establish standards, and achieve a measurable finish of treated patients and educational purposes. Different quantitative indexes have been developed to evaluate dental malocclusion, orthodontic need, and treatment outcome.[14-17] One of these indexes is the peer assessment rating (PAR) index[17] which has been widely used to assess treatments objectively in a variety of circumstances.[18-20] The PAR is an occlusal index that measures how much a patient deviates from ideal occlusion by comparing pretreatment and posttreatment dental casts.[17] Each component of the PAR index is assigned with weightings to reflect their importance and produce a weighting PAR index score.[21] A greater reduction in the mean percentage of the weighted PAR scores implies a greater degree of improvement (ie, the success of the treatment is achieved).[17] The PAR index has shown excellent validity and reliability.[22,23] However, it is not a precise system that can be used to quantify tooth positions. Therefore, a more detailed index called the objective grading system (OGS) was formed by the American Board of Orthodontics (ABO). The OGS index evaluates objectively posttreatment dental cast and panoramic radiographs. The final occlusion is assessed using 8 different criteria. A lower score indicates a better final occlusion.[24]

The devastating effects of the pandemic raise the question of whether delayed and irregular appointments affect the treatment outcomes of patients receiving orthodontic treatment. Therefore, this study aimed to compare the treatment outcome, using the PAR index and OGS, on patients whose orthodontic treatment was completed before or during the COVID-19 pandemic. The null hypothesis is no differences between the posttreatment total weighted PAR scores or the OGS scores of orthodontic patients who were finished before or during the pandemic.

MATERIAL AND METHODS

The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Research Ethics Committee of Trakya University Faculty of Medicine (approval no. TÜTF-BAEK 2021/305).

Study sample selection was made from 175 patients (prepandemic, 103; pandemic, 72) who met the inclusion criteria. Patients meeting the inclusion criteria were individually numbered within their group and then randomly selected using a Web-based randomization tool (www.randomizer.org). This study included 100 patients who finished their orthodontic treatment between 2019 and 2021 at the Department of Orthodontics, Faculty of Dentistry, Trakya University. The sample was divided into 2 groups: (1) prepandemic (group 1): 50 randomly selected patients debonded from January 2019 to March 2020; and (2) pandemic (group 2): 50 randomly selected patients debonded from April 2021 to September 2021. Clinical activities were suspended from March 2020 to July 2020.

The following inclusion criteria were set: (1) availability of pretreatment and posttreatment 3-dimensional (3D) models, (2) absence of defect on the 3D model that would interfere with the measurements, (3) no previous orthodontic treatment history, and (4) teeth in the permanent dentition having normal morphology.

Exclusion criteria were (1) clear aligner patients, (2) orthognathic surgery patients, (3) cleft patients, (4) removable appliances, and (5) lingual braces.

All patients were treated with fixed 0.022-in slot McLaughlin Bennett Trevisi prescription braces. All patients were finished by the physician's decision.

All 3D models were obtained by scanning plaster models. The impressions were taken with a plastic tray using alginate material (Zetalgin; Zhermack Group, Rovigo, Italy) and poured with type IV gypsum (Fuji Rock; GC Europe, Leuven, Belgium). The plaster models were scanned by the Maestro 3D model scanner (AGE Solutions, Pisa, Italy) and transferred to the computer. Three-dimensional reverse modeling software (version 1.01; Orthomodel Inc, Istanbul, Turkey) was used for millimetric measurements. The screen used for measurement was

21.5-in in size. The measurements were made on the digital models at 2-time points; pretreatment and posttreatment. The PAR comprised 8 components: maxillary alignment, mandibular alignment, anteroposterior, transversal, vertical, overjet, overbite, and centreline measurement. British weightings (United Kingdom) were applied to the components described by Richmond et al.[23]

The improvement in the PAR scores (success of treatment) is categorized as (1) greatly improved if there is >22 point reduction in the score, (2) improved if there is a percentage reduction of >30%, and (3) worse or no difference if the reduction is < 30% in PAR score.

For OGS measurements, posttreatment study casts and panoramic radiographs were scored. The first 7 criteria of the OGS index: alignment and rotation, marginal ridges, buccolingual inclination, overjet, occlusal contacts, occlusal relationship, and interproximal contacts were measured on the study cast using an ABO gauge, and the root angulation was measured on panoramic radiographs as described by Casko et al.[24] After a total number of case points was calculated which indicates the relative deviation from the ideal. A patient that lost >30 points will usually fail the ABO clinical examination, whereas a patient who lost <20 points will pass. A patient who lost 20-30 points is considered maybe (borderline).

The data were collected by a single researcher (H.A.), and the models were blindly assessed by another researcher (P.M.). The PAR index measurements were completed first, and after 2 months, the OGS measurements were determined.

The sample size was calculated on the basis of previous data in the literature.[19] A type I error of 0.05 and a power of 90%, a sample size of a minimum of 46 subjects per group would be required. G*Power software (version 3.1.9.6; University of Düsseldorf, Düsseldorf, Germany) was used to calculate the sample size.[25]

Statistical analysis

All statistical analyses were performed with SPSS software (version 25; IBM Corp, Armonk, NY). The statistical significance level was taken as 0.05 in all tests. The normality of the data was assessed using the Shapiro-Wilk and Kolmogorov-Smirnov tests. Intergroup comparisons were tested with an independent samples *t* test or Mann-Whitney U test according to the normality of the data. Chi-square test statistics and Fisher exact test were used to compare categorical variables when appropriate. For the assessment of intraexaminer reliability, 30 randomly selected models were scored 2 weeks later, and the intraexaminer reliability of the data was evaluated by intraclass correlation coefficient (ICC).

RESULTS

Intraexaminer reliability was found excellent for total weighted PAR scores (ICC, 0.996; 0.992-0.998) and OGS scores (ICC, 0.968; 0.935-0.985).

Sample characteristics for both groups are presented in Table I. Patients' age and gender, angle classification, treatment duration, and extraction therapy were not statistically significant. Group 2 had significantly fewer appointments and more canceled and missed appointments than group 1 (P <0.001). The distribution of the subjects by total weighted PAR index scores pretreatment and posttreatment and by OGS score are shown in Tables II and III, respectively, showing no significant differences between the 2 groups. The number of failed, borderline, and passed patients were similar in both groups (Table III).

PAR score reduction and improvement (%) between the groups are presented in Table IV. The mean total weighted PAR score reduction was less in group 2 than for group 1 (25.6 ± 8.7 vs 29.8 ± 9.9; P >0.05). No statistical differences were found regarding the mean improvement rate in percentage between the groups (93.7 ± 7.1 vs 89.9 ± 13.0; P >0.05).

Pretreatment and posttreatment weighted PAR scores of the groups are shown in Table V. Pretreatment maxillary alignment, transversal, and centerline were significantly lower for group 2 than for group 1 (P <0.05). However, a statistically significant difference was not found between the groups for the pretreatment total weighted PAR score (32 vs 30). There were no statistically significant differences in posttreatment weighted PAR scores between the groups, except for maxillary alignment, which had a higher score in group 2 (P <0.05). In addition, posttreatment total weighted PAR scores were similar: 1 for group 1 and 2 for group 2 (P >0.05).

Table VI shows the comparison of the OGS scores between the groups. Similar total OGS score was found in both groups (32 vs 33) with no statistically significant difference (P >0.05). The only significant differences between the groups were marginal ridge, buccolingual inclination, and occlusal relationship. A lower score for marginal ridge height was measured in group 2, indicating smaller or fewer height discrepancies between adjacent marginal ridges (4 vs 3; P <0.05). A higher score for buccolingual inclination was found in group 2 (7 vs 11; P <0.05), indicating a worsening of the buccolingual inclination. A higher score for occlusal relationship was measured in group 1 (3 vs 1; P <0.05), indicating that posterior teeth deviated more from an ideal anteroposterior position.

Table I. Sample characteristics

Characteristics	*Prepandemic (group 1)*		*Pandemic (group 2)*		P *value*
Age, y	17.2 ± 5.2		15.9 ± 3.6		$t = 0.160$
Total tx duration, mo	31 (8-53)†		29 (6-42)†		U = 0.689
Total no. of appointments	29 (9-43)†		21 (6-34)†		U = 0.001
Active tx duration during pandemic, mo	–		11.1 ± 2.2		–
Active appointment no. during pandemic	–		10.4 ± 1.8		–
No. of appointments missed by the patient	1 (0-2)†		1 (0-3)†		U = 0.001
No. of appointments canceled by the clinic	1 (0-2)†		5 (0-8)†		U ≤ 0.001
	n	%	*n*	%	
Gender					0.461
Male	9	18	12	24	
Female	41	82	38	76	
Extraction					0.422
Yes	25	50	21	42	
No	25	50	29	58	
Angle classification					
Class I	24	48	19	38	0.600
Class II	21	42	25	50	
Class III	5	10	6	12	

Tx, treatment.
†Median (minimum-maximum).

Table II. Distribution of the subjects by weighted total PAR index score

	Prepandemic (group 1; n = 50)		*Pandemic (group 2; n = 50)*		
Total PAR	*n*	%	*n*	%	χ^2
Pretreatment					
0-22	10	20	14	28	0.611
23-30	13	46	13	26	
>31	27	54	23	46	
Posttreatment					
0-5	45	90	43	86	0.538
>5	5	10	7	14	

Table III. Distribution of the subjects by OGS score

	Prepandemic (group 1; n = 50)		*Pandemic (group 2; n = 50)*		
OGS	*n*	%	*n*	%	P *value*†
<20	2	4	2	4	0.937
20-30	21	42	19	38	
≥31	27	54	29	58	

†Fisher exact test.

Table IV. Comparison of the PAR score reduction and improvement after treatment between the groups

	Prepandemic (group 1)			*Pandemic (group 2)*			
PAR	*Minimum*	*Maximum*	*Mean ± SD*	*Minimum*	*Maximum*	*Mean ± SD*	P *value*
Total score reduction	9	51	29.8 ± 9.9	9	42	25.6 ± 8.7	$U = 0.66$
Improvement (%)	77	100	93.7 ± 7.1	26	100	89.9 ± 13.0	$t = 0.68$

SD, standard deviation.

Table V. Comparison of the pretreatment and posttreatment weighted PAR scores between the groups

	Pretreatment			*Posttreatment*		
	Group 1	*Group 2*		*Group 1*	*Group 2*	
PAR	*Med (Min-Max)*	*Med (Min-Max)*	P *value*	*Med (Min-Max)*	*Med (Min-Max)*	P *value*
Maxillary alignment	9 (4-15)	7 (0-13)	U = 0.001	0	0 (0-2)	U = 0.002
Mandibular alignment	6 (0-17)	5 (0-13)	U = 0.554	0 (0-2)	0 (0-5)	U = 0.111
Anteroposterior	2 (0-4)	2 (0-4)	U = 0.278	1 (0-3)	0 (0-4)	U = 0.079
Transversal	1 (0-6)	0 (0-6)	U = 0.040	0 (0-2)	0 (0-6)	U = 0.053
Vertical	0 (0-2)	0 (0-2)	U = 0.107	0 (0-2)	0 (0-1)	U = 668
Overjet	12 (0-24)	12 (0-24)	U = 0.275	0 (0-6)	0 (0-18)	U = 0.707
Overbite	2 (0-6)	2 (0-8)	U = 0.713	0 (0-2)	0 (0-2)	U = 0.171
Centreline	1 (0-8)	0 (0-8)	U = 0.001	0 (0-4)	0 (0-2)	U = 0.310
Total PAR	32 (9-51)	30 (11-43)	U = 0.094	1 (0-9)	2 (0-26)	U = 0.244

Min, minimum; *Max*, maximum.

Table VI. Comparison of the OGS scores between the groups

	Group 1	*Group 2*	
OGS	*Median (Minimum-Maximum)*	*Median (Minimum-Maximum)*	P *value*
Alignment	6 (1-11)	7 (0-13)	U = 0.140
Marginal ridge	4 (0-11)	3 (0-10)	U = 0.002
Buccolingual inclination	7 (0-18)	11 (0-20)	U = 0.000
Occlusal contacts	4 (0-13)	4 (0-11)	U = 0.638
Occlusal relationship	3 (0-10)	1 (0-20)	U = 0.035
Overjet	6 (0-23)	5 (0-18)	U = 0.156
Interproximal contacts	0 (0-4)	0 (0-3)	U = 0.525
Root angulation	3 (0-7)	2 (0-8)	U = 0.148
Total OGS	32 (14-59)	33 (0-18)	U = 0.860

DISCUSSION

This study aimed to compare the treatment outcome of orthodontic patients whose treatment was finished before or during the COVID-19 pandemic, using the PAR index and the OGS. The main finding of this investigation was that the pandemic and the lock-down did not affect the posttreatment total weighted PAR score, although a significant high posttreatment weighted maxillary alignment score was found in group 2. The total OGS score was also nonsignificant between the groups. The null hypothesis can therefore be accepted.

Because the PAR index measures alignment components and occlusal improvement that is influenced mainly by the initial orthodontic treatment phase, which in this study occurred outside the COVID-19 pandemic period; therefore, the OGS is more stringent in assessing treatment outcome was additionally used. The total OGS score between the groups was similar, and the only significant differences were measured in buccolingual inclination, occlusal relationship, and marginal ridge (Table III). The buccolingual inclination is related to torque control in posterior teeth, and high scores indicate a deficiency in placing adequate torque in the buccal segments. Although the malocclusion distribution between the groups was similar, a possible explanation for the higher buccolingual inclination score might have been influenced by the higher number of Class II and III malocclusions in the pandemic group. The occlusal relationship measures the sagittal correction of the dentition, although the prepandemic group had more Class I malocclusions, higher occlusal relationship scores were found in the pandemic group indicating a better sagittal dental relationship.

Marginal ridge discrepancies are related to settling the occlusion after treatment, which might be a possible explanation for the lower scores because the models were taken at debanding, in contrast to the ABO that allows final models to be taken up 1 year after debanding.[26,27] The degree of improvement or success is in the PAR index reflected by the difference between the pretreatment and posttreatment. A score close to 0 means that the deviation from normal is less, but

because this is not always achievable, a measure of ≤5 suggests an almost ideal occlusion, and ≤10 indicates an acceptable alignment.[23] In this study, similar posttreatment total weighted PAR scores were obtained between the 2 groups: 1 vs 2, which indicates acceptable alignment and occlusion according to Richmond et al[23] (Table V). The mean total PAR score reduction was similar between groups, and no statistical differences were found regarding the mean improvement rate in percentage between the groups: 93.7 ± 7.1% vs 89.9 ± 13% (Table IV). To the best of our knowledge, there are no studies comparing treatment outcomes of patients treated before and during the pandemic. Despite that, the obtained results from this study are consistent with previous studies assessing the PAR index differences between pretreatment and posttreatment.[20,28-31] A reduction of 30% in weighted PAR scores is considered a significant improvement in the standard of an occlusion. A reduction of 22 weighted PAR points is considered greatly improved,[17] whereas improvements <30% are declared worse or no different. The majority of the patients in this study were improved or greatly improved, but 54%-58% failed the OGS, and only 4% would pass with certainty (Table IV). These results agree with others who did not find a correlation between the PAR score and the OGS, implying that prediction from the OGS scores cannot be made for the possible percentage improvement in the PAR index.[19,30]

A recent study conducted during the pandemic shows that more than one third of orthodontic patients experienced mental distress. The level of anxiety was affected by multiple factors such as the type of orthodontic appliance, time since the last check-up, and communication with the orthodontist.[32] Several newly published studies report that the major concern for patients with ongoing orthodontic treatment during the pandemic was the anxiety over the treatment duration.[32-34] Furthermore, patients believe that their treatment was negatively affected by the COVID-19 pandemic because they thought it was delayed.[35] This study found no differences in treatment duration between the groups, measured from the time appliances were placed to the time removed (Table I). Factors that may influence the treatment duration include age, gender, the severity of malocclusion, extractions, and clinician experience.[36] This study shows that PAR reduction or total OGS score were not associated with treatment duration even though group 2 had significantly fewer and irregular appointments and a significantly less total number of appointments, raising the question of whether some control intervals can be partly replaced by teleorthodontics (Table I). Perhaps the effect of the pandemic will accelerate this new ergonomic approach and reduce the number of face-to-face appointments. Another future fundamental change in orthodontics might be the increased use of appliances and techniques requiring fewer visits and emergency appointments.[37]

Significant more appointments canceled by the clinic and patients were observed in group 2, which was caused by the pandemic (Table I). Unfortunately, patients were not contacted via teleorthodontics, which has been of great value and should be a part of the future clinical protocol as orthodontic treatment is an ongoing process that needs consistent evaluation and adjustments. Virtual triage is of great help to differentiate and prioritize orthodontic emergencies that need immediate attention from problems that can be self-aided by a home remedy (ie, minimizing unnecessary visits to the clinic). Furthermore, it is a good communication tool with the patient, facilitating instructions about oral health maintenance, insertion of elastics, and motivation to continue usage of elastics. Routinely and direct communication with patients via teleorthodontics has shown to give less anxiety compared with patients who got notices from Web sites or other patients.[38]

To overcome potential biases associated with matching patients based on only angle classification,[39,40] patients in this study were randomly selected from a consecutive sample that proved to be heterogeneous in terms of initial sagittal malocclusion, gender, age, and extraction therapy (Table I).

Many different indexes are mentioned in the literature, and every index has its advantages and disadvantages.[14-17,41,42] The PAR index and OGS were chosen in this study because they have been extensively used in previous studies by orthodontists in different countries.[18-20,26,27] The PAR index has a good intraexaminer and interexaminer reliability, with ICCs of 0.95 and 0.91, respectively.[23] This is in line with the intraexaminer reliability result found in this study. The shortcomings of the PAR index are that it fails to adequately record incisor torque, posterior alignment, and changes in the arch dimensions.[43] Furthermore, minor deviations from normal (ie, initial scores of <22 points) cannot be greatly improved because the patient is not severe enough pretreatment.[21] Moreover, the PAR index uses a weighting system for several subcomponents of the index, for example, overjet with a weighting of 6, which results in a high pretreatment PAR score in patients with large overjet. For that reason, in patients with high initial PAR scores are easier to realize remarkable changes in the PAR scores.[44] In contrast to the PAR index, the OGS assesses minor discrepancies in tooth position in

all 3 planes (ie, first-, second-, and third-order). The limitation of the OGS is that it only examines the outcome without considering the severity of the malocclusion or the difficulty of treatment.[45] Changes in facial profile or cephalometric parameters that reflect the skeletal component of the malocclusion are also not considered in the quantitative evaluation of both indexes.[23,24,30,44,46] Patient cooperation, which greatly impacts the treatment outcome, is also not considered.

Furthermore, both indexes are dental professional judgments and may not coincide with patient values. Further studies are needed to clarify the effects of the pandemic in orthodontic treatment outcomes on the basis of patient satisfaction. Moreover, because orthodontic practice and patient management must adapt to changes, more attention should be given to teleorthodontics as it is a tool that seems to have come to stay.

Limitations

The results from this study cannot be generalized because the intensity of COVID-19 waves differed around the world, and clinical activities were suspended differently in different countries. In this study, half of the treatment time occurred outside the COVID-19 pandemic period; therefore, the pandemic influence on the whole treatment outcome and treatment time could not be assessed. In addition, because of the retrospective study design, selection bias may be introduced as only subjects with complete records were included. Furthermore, only labial fixed orthodontic treatment patients were evaluated. Clear aligner patients, lingual orthodontics appliances, and orthognathic surgery patients were not evaluated.

CONCLUSIONS

1. Posttreatment weighted maxillary alignment was significantly higher in the pandemic group.
2. The pandemic group had a lower score for marginal ridge height and a higher score for buccolingual inclination.
3. The final total weighted PAR scores and the total OGS score did not differ among patients that removed their fixed appliances during or before the pandemic.
4. Patients in the pandemic group had significantly more canceled appointments and fewer total numbers of booked appointments, but the treatment duration did not differ between the groups.

AUTHOR CREDIT STATEMENT

Pamir Meriç contributed to conceptualization, methodology, resources, supervision, validation, roles/writing-original draft, and writing-review & editing. Julia Naoumova contributed to conceptualization, methodology, supervision, validation, roles/writing-original draft, and writing-review & editing.

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