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ORIGINAL RESEARCH

The Impact of the COVID-19 Pandemic on Orthodontic Adult Patients' Characteristics and Decision on Orthodontic Appliance

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Purpose: There is an overall paucity of data examining the specific details of orthodontic patients' patterns or orthodontic service disruptions possibly influenced by COVID-19 pandemic. Therefore, this study aimed to explore the impact of the COVID-19 pandemic on orthodontic clinic disruption regarding the change in adult patients' characteristics and decisions of orthodontic treatment devices.

Patients and Methods: A retrospective sample of 311 patients receiving orthodontic treatment from 2018 to 2022 were collected and divided into two groups: before (n = 167) and during (n = 144) the COVID-19 pandemic. Demographics, dental indices, the index of complexity outcome and need (ICON), and the degree of treatment difficulty were analyzed.

Results: There were fewer students among patients during the COVID-19 pandemic than before (24.5% versus 35.9%, P = 0.036). Compared with patients before the pandemic, more patients selected ceramic brackets or Invisalign during the pandemic (P = 0.022). There were higher percentage of class I dental malocclusions among patients during than before the COVID-19 pandemic (P = 0.044). Moreover, the ICON score and the score of the degree of treatment difficulty were both significantly lower for patients during than before the COVID-19 pandemic (63.9±14.0 versus 58.3±15.3, P=0.001 and 7.4±2.6 versus 6.8±2.6, P=0.049, respectively).

Conclusion: The COVID-19 pandemic influenced the characteristics and decisions of orthodontic patients. Those who still came to the orthodontic clinic despite the COVID-19 outbreak may have been those with less malocclusion severity and treatment difficulty. Besides, during the time of covid-19 pandemic, more patients chose ceramic bracket and Invisalign as their orthodontic treatment device rather than conventional or self-ligating metal brackets.

Keywords: COVID-19, pandemic, orthodontic, Invisalign, bracket, dental malocclusion, sagittal skeletal relationship, index of complexity outcome and need, degree of treatment difficulty

Introduction

The COVID-19 pandemic has drastically altered society in many ways, causing widespread illness and death, economic decline, and major changes in daily life. All medical professions were affected and a significant negative influence on dental care was also noticed. Studies showed the use of protective equipment like hair caps, face shields, and environmental disinfection protocols has significantly improved in dental practice after COVID-19 outbreak.[1,2] There have already been a variety of studies exploring the impact of the Covid-19 pandemic on dentistry including the aspect of the dentists and the patients.[3] However, in orthodontic field specifically, there have been few studies on similar topics regarding the influence of the pandemic on the orthodontic patients' pattern change in decision making and concerns.

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Overarching categories in clinical adaptations for orthodontic practices during the COVID-19 pandemic include infection control, social distancing, appliance type, psychological impact, and teleorthodontics in treatment disruption. According to data from previous pandemics, psychological discomfort may continue long after the pandemic is gone.[4] Since non-urgent dental procedures were postponed during the epidemic in many countries including Taiwan, the patients may be anxious about attending their appointments, worried about the lengthening and delay of their treatment, or even deterioration of their oral health. Xiong et al[5] found that the type of appliance, duration of return dental visits, and communication with the orthodontist all had an impact on this distress. Naveda et al and Al-Fadhily et al[6,7] analyzed the self-reported perceptions, pain, and emergencies of orthodontic patients during the quarantine period with an electronic questionnaire. They found a strong significant association between pain intensity and orthodontic emergencies with the most encountered problem being broken or movable bracket. Lamb et al[8] found that orthodontists increased clear aligners use during the pandemic in response to patient demand. Another two studies[9,10] investigated the impact caused by the coronavirus pandemic on patient care, psychological state, and financial income, but the findings were solely from the perspectives of orthodontists. A systematic review by Alam et al[11] further gathered the results of the impact of COVID-19 on orthodontic treatment. This review concluded that there was a significant impact on every sphere of the patients' lives like previously mentioned, but the level differed between orthodontic patients during the first wave, early stage, and later stage of the pandemic. Most of these studies focused on the categories mentioned above. Nevertheless, there were still no studies yet examining the specific details of orthodontic patients' characteristic patterns possibly influenced by the pandemic at in-person appointments.

Therefore, this study aimed to explore the impact of the COVID-19 pandemic on orthodontic patients' characteristics difference and decision-making trends for orthodontic treatment devices in order to gain a better understanding of the shifting landscape of orthodontic care during these unprecedented times.

Material and Methods

Institutional Review Board Statement

This study adhered to the Declaration of Helsinki and was approved by the Medical Ethics Committee of Chang Gung Memorial Hospital, Taiwan. The Institutional Review Board number assigned to the study was 202300607B0.

Informed Consent Statement

This was a retrospective study based on the assessment of existing data. The Medical Ethics Committee of Chang Gung Memorial Hospital, Taiwan waived the requirement for informed consent from the patients. All personal data were available only to the investigators and were secured by delinking the recognition information from the main dataset.

Patients

From 2018 to 2022, a total of 311 patients who received orthodontic treatment at Chang Gung Memorial Hospital were recruited for this study. The patients were divided into two groups representing the time before (January 2018 to January 2020, n = 167) and during (February 2020 to February 2022, n = 144) the COVID-19 pandemic based on their date of first orthodontic clinic visit. Each patient received a comprehensive overview of all the available orthodontic appliances. Patients were completely independent in deciding whether to proceed with treatment and could choose from metal brackets (conventional brackets: Roth's prescription, TOMY, Japan; and self-ligating brackets: "Genius" self-ligating brackets, MEM, Taiwan), porcelain brackets (self-ligating brackets: Clippy-C, TOMY, Japan) or clear aligners (Invisalign, Align Technology). Demographic information was obtained by questionnaire filled by the patients. Pretreatment intraoral photographs, dental casts, and radiographs were utilized to evaluate various dental measurements and indices as described below.

Inclusion and Exclusion Criteria

All adult patients aged 18 years or above were enrolled. Patients who had a prior orthognathic operation, dentofacial trauma, craniofacial deformity, or lack of complete orthodontic records were excluded from the analysis.

Assessment of the Decayed, Missing, and Filled Teeth (DMFT) Index

The DMFT index is a measure of an individual's dental caries status and an indicator of deteriorating oral hygiene, which is calculated by adding the numbers of decayed, missing due to caries, and filled teeth. In this study, we employed full-mouth bitewing and periapical radiographs to examine the DMFT index. This method was chosen because it offered greater convenience for reconfirmation and greater precision under repeatability conditions.

Assessment of Sagittal Skeletal Relationship

The anterior-posterior skeletal relationship between the maxilla and the mandible was classified into Class I, Class II, or Class III based on Steiner's[12] analysis by analyzing the lateral cephalometric films.[13]

Assessment of Dental Malocclusion Type

The dental malocclusion type of each orthodontic patient was classified as molar Class I, Class II, or Class III based on Angle's classification.[13]

Assessment of the ICON

The ICON was developed to predict treatment needs; with higher score indicating higher treatment need and complexity. Five highly predictive occlusal traits (dental aesthetics, upper arch crowding, the presence of crossbite, anterior vertical relationship, and buccal segment anteroposterior interdigitation) were assessed. Numeric values are assigned to each occlusal trait based on a standard protocol using study models and intraoral photos.[14]

Assessment of Orthodontic Treatment Difficulty

In our study, we utilized the scoring chart developed by the Taiwan Association of Orthodontists to evaluate treatment difficulty. This chart encompasses four scoring systems: skeletal analysis (S), dental analysis (D), facial analysis (F), and model analysis (M). The skeletal, dental, and facial analyses were scored by assessing the cephalometric films. The model analysis was scored by measuring study models. All the measurements were then compared to the norm of the Taiwanese population. The scoring chart was presented in Supplementary Table 1.

Statistical Analysis

The same examiner conducted all the measurements and the assessments. Continuous variables were presented as the means and standard deviations, while categorical variables were presented as numbers and percentages. Independent *t* tests were used to compare quantitative variables between the two groups, while chi-square tests were used for categorical variables. All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 25.0. (Armonk, NY, USA, 2017). The significance level for all tests was set at a p value <0.05.

Results

Demographics

The patients had a median age of 28.7±8.2 years, with the majority being female (76.8%), and few reported having systemic diseases (Table 1). Compared with patients before the COVID-19 pandemic, fewer students were noted among patients during the pandemic (35.9% versus 24.5%, P = 0.036).

Types of Orthodontic Devices

Table 2 demonstrated that most patients chose metal brackets (50.8%), followed by Invisalign (21.9%) and ceramic brackets (15.1%) as their orthodontic treatment devices. Compared with patients before the COVID-19 pandemic, more patients chose ceramic brackets or Invisalign, but fewer patients chose metal brackets during the pandemic (P = 0.022).

Table 1 Baseline demographics of Orthodontic Patients Stratified by Year of First Visit as Before or During the COVID-19 Pandemic (n = 311)

Variable	All patients (n = 311)		Patients before the COVID-19 pandemic (n = 167)		Patients after the COVID-19 pandemic (n = 144)		P value
	Mean	SD	Mean	SD	Mean	SD	
Age (year)	28.7	8.2	28.3	8.0	29.1	8.4	0.392†
Height (cm)	163.2	7.4	163.0	7.5	163.4	7.2	0.571†
Weight (kg)	57.4	10.6	57.3	11.2	57.4	9.9	0.966†
Body mass index (kg/m2)	21.5 ± 3.3		21.5 ± 3.4		21.5 ± 3.3		0.854†
Female sex, n (%)	239 (76.8)		127 (76.0)		112 (77.8)		0.788†
Student, n (%)	95 (30.6)		60 (35.9)		35 (24.5)		0.036*‡
Hospital employee, n (%)	62 (19.9)		27 (16.2)		35 (24.3)		0.088‡
Diabetes mellitus, n (%)	3 (1)		1 (0.6)		2 (1.4)		0.597‡
Hypertension, n (%)	2 (0.6)		1 (0.6)		1 (0.7)		1.000‡
Smoking habits, n (%)	3 (1)		0 (0)		3 (2.1)		0.098‡
Alcohol consumption, n (%)	1 (0.3)		1 (0.6)		0 (0)		1.000‡
Betel nut chewing, n (%)	0 (0)		0 (0)		0 (0)		1.000‡
Bruxism, n (%)	11 (3.5)		6 (3.6)		5 (3.5)		1.000‡

Note: *P < 0.05, †Independent *t* tests, ‡Chi-square tests.
Abbreviation: SD, standard deviation.

Table 2 Orthodontic Bracket Type Chosen by the Patients Stratified by Year of First Visit as Before or During the COVID-19 Pandemic (n = 311)

Variable	All patients (n = 311)	Patients before the COVID-19 pandemic (n = 167)	Patients after the COVID-19 pandemic (n = 144)	P value
No treatment, n (%)	38 (12.2)	21 (12.6)	17 (11.8)	0.022*‡
Metal brackets, n (%)	158 (50.8)	97 (58.1)	61 (42.4)	
Ceramic brackets, n (%)	47 (15.1)	19 (11.4)	28 (19.4)	
Invisalign, n (%)	68 (21.9)	30 (18.0)	38 (26.4)	

Note: *P < 0.05, ‡Chi-square tests.

DMFT Index

The mean DMFT index value was 8.2±6.2, which included 1.2±1.6 for decayed teeth, 0.7±1.7 for missing teeth, and 6.3±4.9 for filled teeth, as presented in Table 3. There were no significant differences in the DMFT index between the groups.

Sagittal Skeletal Relationship and Dental Malocclusion Type

Table 4 showed that Class II was the most common (48.5%), followed by Class I (35.3%) and Class III (16.2%). There were no significant differences in the sagittal skeletal relationship observed between the groups (P = 0.265). As for dental malocclusion type (Table 5), Angle's Class I was the most common (42.8%), followed by Angle's Class II (29.6%) and

Table 3 Decayed, Missing, and Filled Teeth (DMFT) Index of the Orthodontic Patients Stratified by Year of First Visit as Before or During the COVID-19 Pandemic (n = 311)

Variable	All patients (n = 311)		Patients before the COVID-19 pandemic (n = 167)		Patients after the COVID-19 pandemic (n = 144)		P value
	Mean	SD	Mean	SD	Mean	SD	
Decayed	1.2	1.6	1.2	1.7	1.2	1.6	0.933†
Missing	0.7	1.7	0.8	1.8	0.7	1.5	0.782†
Filled	6.3	4.9	5.9	4.8	6.8	4.9	0.072†
DMFT index	8.2	6.2	7.8	6.1	8.7	6.2	0.171†

Note: †Independent *t* tests.
Abbreviation: SD, standard deviation.

Table 4 Sagittal Skeletal Relationship of the Orthodontic Patients Stratified by Year of First Visit as Before or During the COVID-19 Pandemic (n = 311)

Variable	All patients (n = 311)	Patients before the COVID-19 pandemic (n = 167)	Patients after the COVID-19 pandemic (n = 144)	P value
Class I, n (%)	109 (35.3)	55 (33.1)	54 (37.8)	0.265‡
Class II, n (%)	150 (48.5)	79 (47.6)	71 (49.7)	
Class III, n (%)	50 (16.2)	32 (19.3)	18 (12.6)	

Note: ‡Chi-square tests.

Table 5 Dental Malocclusion Type of the Orthodontic Patients Stratified by Year of First Visit as Before or During the COVID-19 Pandemic (n = 311)

Variable	All patients (n = 311)	Patients before the COVID-19 pandemic (n = 167)	Patients after the COVID-19 pandemic (n = 144)	P value
Angle's Class I, n (%)	133 (42.8)	63 (37.7)	70 (48.6)	0.044*‡
Angle's Class II, n (%)	92 (29.6)	59 (35.3)	33 (22.9)	
Angle's Class III, n (%)	86 (27.7)	45 (26.9)	41 (28.5)	

Note: *P < 0.05, ‡Chi-square tests.

Angle's Class III (27.7%). Compared with patients before the COVID-19 pandemic, there were higher percentages of Angle's Class I but lower percentages of Angle's Class II or III during the pandemic (P = 0.044).

ICON Score

Table 6 showed that the mean ICON score was 61.3±15.1. The ICON scores were lower during than before the pandemic (63.9±14.0 versus 58.3±15.3, P = 0.001). Among the variables included in the ICON assessment, the crossbite (0.6±0.5 versus 0.4±0.5, P < 0.001) and the buccal segment anteroposterior (2.4±1.4 versus 1.3±1.3, P < 0.001) variables had significantly lowered.

Table 6 Index of Complexity Outcome and Need (ICON) of the Orthodontic Patients Stratified by Year of First Visit as Before or During the COVID-19 Pandemic (n = 311)

Variable	All patients (n = 311)		Patients before the COVID-19 pandemic (n = 167)		Patients after the COVID-19 pandemic (n = 144)		P value
	Mean	SD	Mean	SD	Mean	SD	
Aesthetic	5.9	1.2	6.0	1.1	5.9	1.3	0.562†
Upper arch crowding	1.8	1.6	1.9	1.5	1.8	1.6	0.390†
Crossbite	0.5	0.5	0.6	0.5	0.4	0.5	< 0.001***†
Incisor open bite	0.6	0.4	0.1	0.3	0.1	0.5	0.664†
Incisor overbite	0.5	0.8	0.5	0.8	0.6	0.8	0.587†
Buccal segment anteroposterior	1.9	1.5	2.4	1.4	1.3	1.3	< 0.001***†
ICON	61.3	15.1	63.9	14.0	58.3	15.3	0.001**†

Note:**P < 0.01, *** P < 0.001, †Independent *t* tests.
Abbreviation: SD, standard deviation.

Degree of the Treatment Difficulty Score

Table 7 showed that there were lower scores in patients during the pandemic than before the COVID-19 pandemic (7.4 ±2.6 versus 6.8±2.6, P = 0.049). Among the four scoring systems, the scores for skeletal analysis (2.3±1.0 versus 2.0±1.1, P = 0.007) and facial analysis (1.0±0.8 versus 0.7±0.7, P = 0.001) had significantly decreased during the pandemic.

Discussion

The demographic variables and DMFT index between the patients before and during the pandemic were comparable except a lower percentage of students during the pandemic was found (Table 1–3). This suggested that the subjects of the two study groups had little difference and were optimal for identifying potential predictors and factors affected by the pandemic. The reduction in the number of student patients may be attributed to multifaceted factors. Numerous studies have evaluated the psychological impact of the pandemic on students. For instance, students were more susceptible to infection, resulting in longer quarantine periods as their education evolved into an online learning format.[15,16] Additionally, students experienced increased stress related to their academic activities and decreased self-efficacy.[17,18]

Table 7 Degree of Treatment Difficulty Stratified by Year of First Visit as Before or During the COVID-19 Pandemic (n = 311)

Variable	All patients (n = 311)		Patients before the COVID-19 pandemic (n = 167)		Patients after the COVID-19 pandemic (n = 144)		P value
	Mean	SD	Mean	SD	Mean	SD	
Skeletal score	2.1	1.6	2.3	1.0	2.0	1.1	0.007*†
Dental score	1.8	1.0	1.8	1.0	1.9	1.0	0.601†
Facial score	0.9	0.8	1.0	0.8	0.7	0.7	0.001**†
Model score	2.3	1.4	2.4	1.3	2.3	1.4	0.626†
Total score	7.2	2.6	7.4	2.6	6.8	2.6	0.049*†

Note:*P < 0.05, **P < 0.01, †Independent *t* tests.
Abbreviation: SD, standard deviation,

Also, most students were not financially independent and with the global economic strike, high cost in orthodontic treatment may pose a financial burden. Therefore, the pandemic might not have been an ideal time for students to pursue orthodontic treatment, as it required regular visits and was more focused on self-satisfaction rather than treating illness. Interestingly, the number of hospital employees seeking orthodontic consultations slightly increased after the COVID-19 outbreak (Table 1), possibly due to their convenience for return visits, familiarity with the hospital environment, awareness of the pandemic, stable incomes, and an employee discount. All these might have been the reasons for their higher motivation in seeking orthodontic treatment at hospitals during the pandemic compared to the general public.

According to our study, the patients during the COVID-19 pandemic showed a greater preference for porcelain brackets and Invisalign as their orthodontic appliance than for conventional or self-ligating metal brackets. As shown in Table 2, the percentage of patients who chose ceramic brackets and Invisalign both increased about 8%, while metal brackets decreased around 16% during the coronavirus outbreak. Miao et al reported similar findings to our study indicating a preference toward clear aligners during the pandemic. This preference may be attributed to the observation of worse pain and disability happened when appointments were suspended in fix appliance group[19]. Regarding orthodontic appliance selection during the pandemic, concerns emerged about the negative effects of extended periods and unknown dental conditions if not attending to the clinics.[5] Previous studies showed that clear aligners' flexibility in follow-up appointments, possibility in reduced risk of orthodontic-related emergencies, such as appliance breakage and mucosa injury[20], and ease of remote monitoring may also be the advantages during the time when in-person appointments were limited due to lockdowns and quarantine measures.[6,21] This shift in our finding may also be attributed to the esthetic advantages of the appliances. An intriguing discovery was that orthodontic patients during the pandemic seemed to prioritize esthetic appearance more considering the additional findings in our study mentioned later. This was evident as approximately 97% of patients chose Invisalign for esthetic reasons according to the survey conducted by Meier et al[22].

There were no differences in the skeletal relationship between orthodontic patients before and during the COVID-19 pandemic. Our results showed that the skeletal relationships of the orthodontic patients were mainly Class II, followed by Class I and Class III (Table 4), similar to the results of other literatures.[23,24] However, in terms of dental malocclusion type, patients during the COVID-19 pandemic had a higher proportion of Angle's Class I and a lower proportion of Angle's Class II molar relationships than patients before the COVID-19 pandemic (Table 5). This finding coincided with the later findings of lower ICON score and treatment difficulty score and may be inferred that patients with more severe dental malocclusion during the pandemic may be less willing to visit the orthodontic clinic. In our study, the average prevalence of Angle's Class III malocclusion was 27.7%, which was higher compared to other studies.[25] The relatively higher ratio in our study may be attributed to different races and geographic regions, and also the fact that patients with Angle Class III malocclusion often came to medical centers for more comprehensive treatment and interdisciplinary cooperation.

Our findings also showed that the ICON score and the treatment difficulty score were both significantly lower among the patients during than before the COVID-19 pandemic (Table 6 and 7). Among the variables included in the ICON assessment, the crossbite and the buccal segment anteroposterior were the contributing variables for this difference. According to Daniels et al[14], the patients before the pandemic (63.9±14.0) were classified as having a difficult (64–77) complexity grade, whereas patients during the pandemic (58.3±15.3) as moderate (51–63). In addition to the treatment need, the difficulty of treatment also decreased in the patients during the pandemic. The difference in the total scores of treatment difficulty between the groups were particularly noticeable in the skeletal and facial scores (Table 7). With a stronger focus on the determining component, the assessments primarily revolved around the sagittal dimension encompassing skeletal, dental, and soft-tissue categories.

These observed results were consistent throughout our study that patients with more problematic dental malocclusion types, greater treatment needs, and higher treatment difficulty, especially those associated with sagittal problems, decreased in the amount of patients having orthodontic treatment during the coronavirus outbreak. One possible explanation was that wearing masks on a daily basis temporarily resolved esthetic problems. The lips and chin are the most important facial features influencing the perception of facial esthetics and both can be covered by facemasks.[26] Facemasks may have concealed the problems in the sagittal plane in skeletal, dental, and soft tissue aspects during the pandemic. In Taiwan, wearing masks to reduce the transmission of COVID-19 was mandatory in all public areas during the pandemic.[27] A recent study examined the effect of facemasks on the perception of attractiveness during the COVID-19 pandemic.[28] The results

showed that wearing facemasks increases the perceived attractiveness of less attractive faces in both young and old people, while highly attractive faces are not affected. Therefore, in less attractive faces, one of the main motivations for seeking orthodontic treatment was lost. However, for patients with more attractive faces, they do not benefit from the masks. These outcomes revealed that even among patients with lower levels of malocclusion and aesthetic issues, those with high aesthetic demands still expressed a strong intention to pursue orthodontic treatment during the pandemic. Furthermore, there was also an increase in the number of patients opting for clear aligners and porcelain brackets even though the use of facemasks diminished the visibility and the aesthetic privilege of these orthodontic appliance.

The results of our study are valuable and surprising. Initially, we expected a decrease in the number of orthodontic patients seeking treatment during the COVID-19 pandemic, with only those who had severe orthodontic and functional issues seeking care. However, our findings revealed that patients with fewer malocclusion problems, steady financial support, and a greater focus on aesthetics and convenience were the primary customers at our orthodontic clinic during the pandemic. This research demonstrated a significant impact of the pandemic and provided valuable insights into the evolving needs and priorities of orthodontic patients. To the best of our knowledge, there have been few studies reported on this similar topic. More studies are needed for orthodontic practitioners to develop protocols for optimal patient care and minimize the likelihood of orthodontic emergencies in future practice. It is essential to be proactive and innovative in promoting patient health and well-being, enhancing the quality of medical care, and fostering strong doctor–patient relationships. Leveraging the global knowledge and experience gained from dealing with the pandemic allows for the implementation of measures that meet patient expectations and ensure their safety. The collective scientific effort, including studies like ours, instills confidence in modern medical care and its ability to navigate challenges posed by the pandemic.

The main limitation of our study was the sample recruited solely from Chang Gung Memorial Hospital, which may not adequately represent the general population in Taiwan and other countries. The assessment of the treatment difficulty could be very complex. Some used the American Board of Orthodontics discrepancy index, while we chose the one developed by the Taiwan Association of Orthodontists because it better suits the Asian population. However, further research is needed for validation. To gain a better understanding of the impact of the COVID-19 pandemic on orthodontic patients, studies with more diverse samples are recommended. Additionally, in order to obtain more comprehensive knowledge, it would be beneficial to gather data of overall well-being, psychological state, frequency of dental visits, and other relevant information.

Conclusion

The COVID-19 pandemic influenced the characteristics and decisions of orthodontic patients. Those who still came to the orthodontic clinic despite the COVID-19 outbreak may have been those with less malocclusion severity and treatment difficulty. Besides, during the time of covid-19 pandemic, more patients chose ceramic bracket and Invisalign as their orthodontic treatment device rather than conventional or self-ligating metal brackets. Understanding these changes can help in implementing measures to ensure the safety of patients and meet their expectations in future orthodontic practice.

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Disclosure

The authors report no conflicts of interest in this work.

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