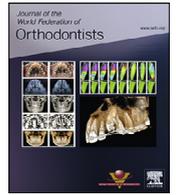




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Research Article

Applications and effectiveness of teledentistry in orthodontic practice during the COVID-19 restrictions

Emre Kayalar^{a,b,*}, Berkan Küçükkurt^c^a Lecturer, Discipline of Orthodontics and Paediatric Dentistry, School of Dentistry, The University of Sydney, Sydney, Australia^b Assistant Professor, Department of Orthodontics, Faculty of Dentistry, Istanbul Aydin University, Istanbul, Turkey^c PhD Candidate, Department of Orthodontics, Faculty of Dentistry, Istanbul Aydin University, Istanbul, Turkey

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ABSTRACT

Background: The aim of this study was to identify the areas of application for teledentistry and analyze its effectiveness in orthodontic practice during the COVID-19 pandemic.

Methods: A total of 233 patients (159 women, 74 men) receiving orthodontic treatment were included. During the COVID-19 restriction period, patients were given teledentistry appointments. During these video conferences, remote orthodontic checkups were performed by one orthodontist, who asked the patients for photos or videos. The applications carried out during the interviews were recorded, classified, and analyzed. In addition, clinical emergency patients were identified. After the teledentistry consultations, two different questionnaires were presented to the patients, depending on their attendance at teledentistry appointments, and the results were statistically evaluated.

Results: In all, 21.25% of the patients were identified as having clinical emergencies, including injury because of damage from brackets and wires; 10% of them reported bracket breakage; 17.5% were encouraged to use intermaxillary elastics; and 3.75% were in pain. However, 50% of them were found to be unproblematic. A total of 91% of the participants in the survey reported that online checkups were sufficient to understand and resolve their symptoms. However, 28% wanted to communicate with orthodontists by video call or with photos instead of meeting face to face (65.5%) when unexpected problems arose during the COVID-19 pandemic.

Conclusions: Teledentistry can be an effective method for motivating patients who are undergoing orthodontic treatments that require cooperation. It is also an effective way of understanding the patients' symptoms and reducing the risk of cross-infection by identifying patients who will require face-to-face emergency treatment during pandemics.

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1. Introduction

COVID-19 was first identified and isolated during an outbreak of pneumonia of unknown causes in Wuhan, China [1,2]. The transmission of COVID-19 has been rapid and it has led to severe health

emergencies worldwide. The World Health Organization declared the epidemic to be a pandemic [3].

The risk of infection in dental practices and clinics is very high for dentists because of close contact with patients, environmental material surface transmission, aerosol transmission, and nosocomial contamination [4]. For these reasons, some dental clinics and dental hospitals were temporarily closed during the pandemic restrictions. In addition, the high contagiousness of SARS-CoV-2 led to changes in treatment methods, including safe ways of providing dental care without compromising the patients' overall health during the pandemic period [5]. However, health-care professionals have still been looking for the safest methods of assisting patients and maintaining a healthy distance between patients and staff during treatment. At present, one of the measures that may assist patients is teledentistry [6].

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* Corresponding author: Discipline of Orthodontics and Paediatric Dentistry, School of Dentistry, The University of Sydney; Sydney Dental Hospital, 02 Chalmers Street, Surry Hills 2010, Australia, Istanbul Aydin University, Faculty of Dentistry, Department of Orthodontics Besyol mah, Inonu cad, Akasya sok, No:6, 34295 Kucukcekmece, Istanbul, Turkey

E-mail address: emrekayalar@aydin.edu.tr (E. Kayalar).

Teledentistry is a process of information-based remote communication between dentist and patient [7]. Teledentistry, a communication system involving audio and video feedback, collects clinical data from patients. It also involves the exchange of photographs or radiographs and clinical information of the patient [8,9].

Orthodontic treatments are usually long-term therapies that continue with routine checkups. During the COVID-19 restrictions, patients had a variety of issues with their treatment and consequently became concerned about longer treatment periods [10]. How to achieve social distancing—e.g., by reducing the numbers of patients and accompanying persons in clinics and practices—has been one of the areas of concern in orthodontic practice [11]. Whether it might be effective to carry out some types of orthodontic checkup remotely through teledentistry during the pandemic period as a way of reducing the risk of cross-infection and patients' levels of concern has become a focus of interest.

Brecher et al. [12] tested teledentistry applications in pedodontic patients. Estai et al. [13] reviewed the diagnostic accuracy of teledentistry applications for detecting dental caries. Mandall et al. [14] concluded that teledentistry is a valid and time-saving clinical screening method for identifying patients who should be referred to an orthodontics specialist. Borujeni et al. [15] suggested that teledentistry is an effective way of motivating patients to improve oral hygiene while undergoing fixed orthodontic treatment. However, there has been a lack of reports examining the effectiveness of teledentistry in an orthodontic clinic during the restrictions and lockdowns caused by COVID-19.

The aim of the present study was to examine the areas in which teledentistry is used in orthodontic practices and its effects on patients' levels of concern during the COVID-19 restrictions by offering remote dental checkup appointments to patients who were receiving treatment in an orthodontic clinic within a specific period.

2. Methods and materials

This prospective study included 233 patients (74 male, 159 female) aged 8–40 years who were undergoing orthodontic treatment in a private clinic during the COVID-19 pandemic restrictions between May 18, 2020 and August 18, 2020. A curfew was imposed during the period in which the study was conducted. The government has urged the public to stay at home and not to visit hospitals or clinics, except in emergencies. Ethics approval was obtained from the Non-Interventional Clinical Research Ethics Committee of Istanbul Aydin University (protocol number: 2021/424). The purpose of the study was explained, and detailed written informed consent forms were obtained from all of the patients. Text messages for Zoom appointments (Zoom Video Communications, Inc., San Jose, CA) were sent to the patients through the DentalBulut online patient appointment system (Istanbul, Turkey). The inclusion criteria consisted of ongoing fixed or removable orthodontic treatments, being treated by the same orthodontist (E. K.), availability of sufficient contact information, and technical facilities for the remote online consultation. Attending the teledentistry appointments and completing further questionnaires were voluntary.

The procedures performed during the teledentistry appointment were documented, and patients who required a clinical appointment because of a need for emergency procedures during lockdowns were identified. The same researcher (E. K.) identified and classified the patients according to sex, age, and clinical symptoms during the video conference appointments.

After the teledentistry appointments, a second text message for a postconsultation questionnaire was sent to all patients. The patients were asked to fill the postconsultation questionnaires electronically (using Google Forms; Google LLC, Mountain View, CA).

The questions were chosen according to previous studies assessing the feasibility of using teledentistry [16] and the challenges faced by patients receiving orthodontic treatment and their preferred solutions to overcoming these challenges during the pandemic [17]. Two different questionnaires were presented to the patients, depending on their attendance at the appointments. In both the first and second questionnaires, the participants were asked questions to assess their age, sex, whether the duration of treatment could be prolonged during the pandemic period, their level of concern about their orthodontic treatment in general, and how they would proceed when faced with an orthodontic emergency (broken brackets, pain, etc.). They were also asked in both questionnaires how they felt about the pandemic and how worried they were about the course of their orthodontic treatment in both questionnaires. The difference between the two questionnaires consisted of a few additional questions for nonparticipants examining the reason for not participating in their teledentistry appointments. Thus, the second questionnaire additionally included some questions about the reasons for not attending their appointments for the nonparticipants, such as technical problems, lack of complaints, internet connection problems, or missed appointments. The participants were given sufficient time to complete the questionnaire. The confidentiality of each participant was protected (Fig. 1). The results were evaluated statistically.

2.1. Statistical analysis

The statistics program IBM SPSS Statistics for Windows, version 25.0 (IBM Corporation, Armonk, NY) was used to analyze the data obtained in the study. In view of the non-normal distribution of the data, the relationship between the categorical data was examined using the chi-square test. Significance was set at $P < 0.05$.

3. Results

On a voluntary basis, 233 patients (74 male, 159 female) received an online questionnaire. Examination of the responses to the questionnaires relative to completion or noncompletion showed that 15 questionnaires were not completed, and 18 questionnaires were partly completed. These 33 questionnaires were therefore excluded from the study, and a total of 200 fully completed questionnaires by 102 patients who attended teledentistry appointments and 98 who did not attend their appointments were included in the study. To investigate the effects of teledentistry during the period of restrictions, the results of the questionnaires in the patients who were treated and in those who did not attend were compared (Fig. 2).

3.1. Attendance at teledentistry appointments relative to age and educational status

There were significant relationships between attendance at teledentistry appointments and age groups and educational status ($P < 0.05$). The attendance rate of those in the 8–14-year-old age group was higher (23.5%), and 49% of the participants had university-level educational qualifications (Table 1).

3.2. Application areas for teledentistry in orthodontic practice

During the teledentistry video conference, 50% of the patients stated that they had no problems with their orthodontic treatment. Advice on how to use intermaxillary elastics and encouragement to do so were given to 17.5% of the patients, 10% of whom reported broken brackets and 3.75% of whom were experiencing

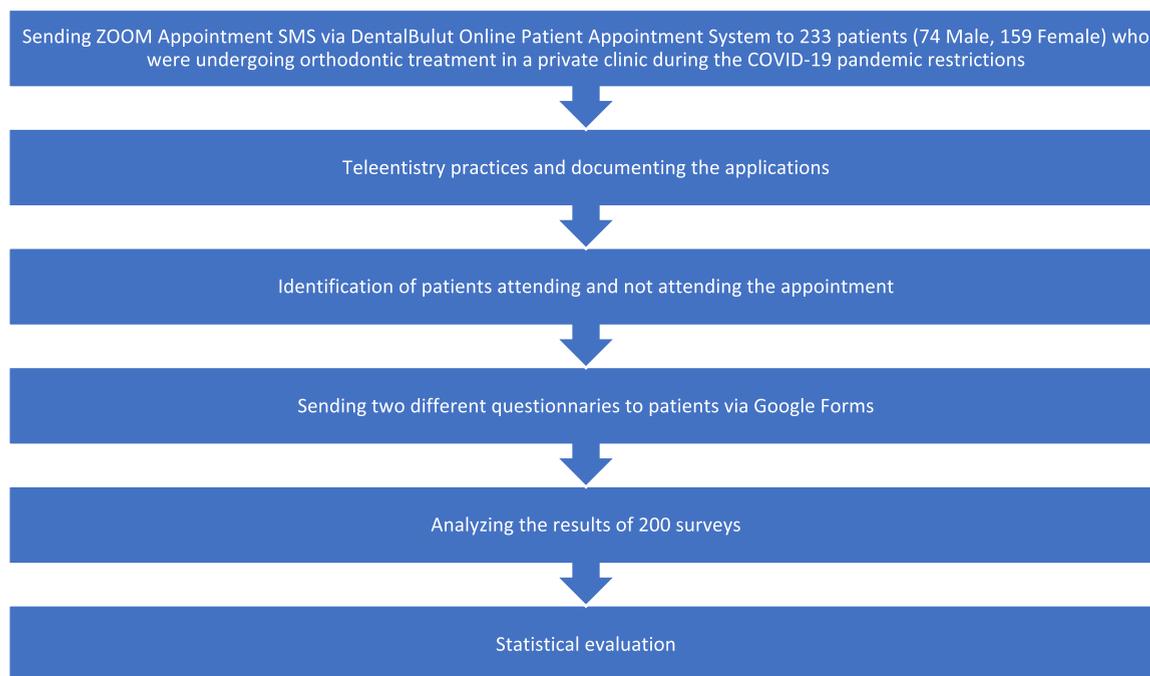


Fig. 1. Methodology of the study.

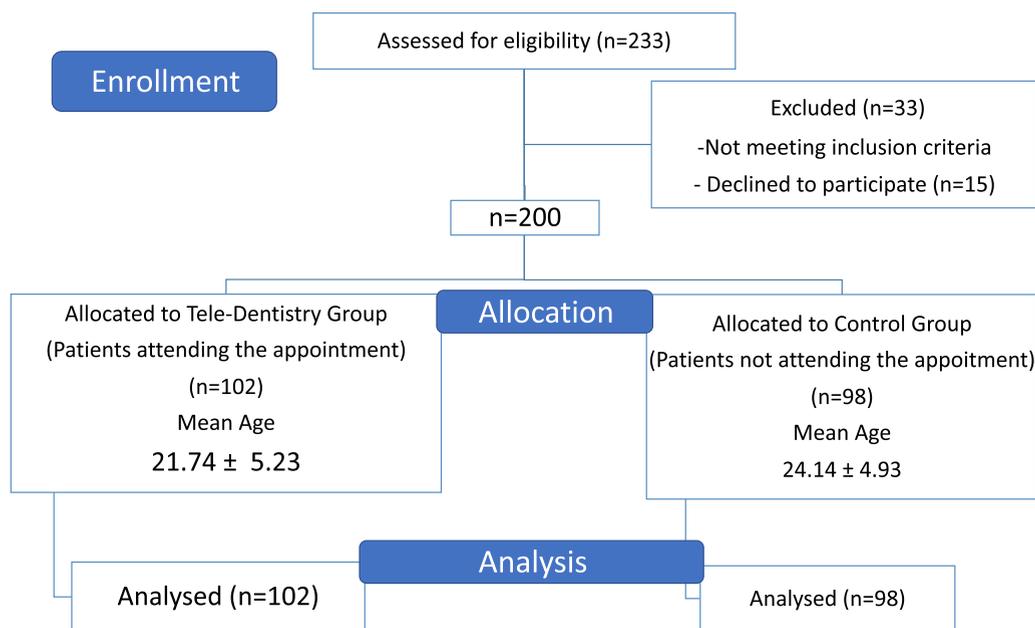


Fig. 2. Flow chart for the patients from enrollment to analysis.

pain. In all, 21.25% of the patients were referred to the clinic for urgent reasons, such as broken brackets and wires. In the remaining 78.25% of the patients, emergency checkup appointments were not required.

3.3. Effect of teledentistry on patients' levels of concern

A total of 67% of the respondents stated that online teledentistry appointments conducted through Zoom during the COVID-19 pandemic relieved their worries about the course of the treatment; 8% indicated that the appointments did not provide a sense of relief. A total of 95% of the participants answered “yes” to the

question “Was it easy for you to explain your symptoms and complaints to the doctor during the online checkup appointment made via Zoom?”. A total of 91% of the participants reported that online teledentistry appointments were sufficient for them to understand and resolve their symptoms and complaints (Table 2). The participants evaluated their satisfaction levels with online checkups during the pandemic period as good in 76.3% of cases, normal in 19.8%, and poor in 4%.

Among the 60.2% of nonrespondents who did not take part in the teledentistry appointment or missed their appointments for various reasons, 25.5% did not attend because everything was fine with their treatment, 10.2% were not able to connect to the online

Table 1
Attendance at appointments relative to age and educational status.

	Teledentistry group		Control group		Total		χ^2	P
	n	%	n	%	n	%		
Age, y								
8–14	24	23.5	7	7.1	31	15.5	14.173*	0.007
15–19	21	20.6	32	32.7	53	26.5		
20–29	43	42.2	38	38.8	81	40.5		
30–39	12	11.8	15	15.3	27	13.5		
≥40	2	2.0	6	6.1	8	4.0		
Total	102	100.0	98	100.0	200	100.0		
Educational status								
Elementary	20	19.6	13	13.3	33	16.5	9.653†	0.022
High school	27	26.5	44	44.9	71	35.5		
University	50	49.0	33	33.7	83	41.5		
Postgraduate	5	4.9	8	8.2	13	6.5		
Total	102	100.0	98	100.0	200	100.0		

Notes. χ^2 Pearson chi-square analysis; significance was set at $P < 0.05$.

*2 cells (20.0%) have expected count less than 5. The minimum expected count is 3.92.

†0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.37.

Chi-square tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	14.173*	4	0.007
Likelihood ratio	14.813	4	0.005
Linear-by-linear association	5.023	1	0.025
N of Valid Cases	200		

Notes. Table 1 is an RxC level table. In a table with $5 \times 2 = 10$ compartments (RxC), the expected values falling on the wells are expected to be greater than 5. Pearson chi-square analysis is used if up to 20% of the cells (2 cells in Table 1) have an expected value of <5 . In this table, as a result of chi-square analysis (χ^2 -Square = 14.173; $P = 0.007$; $P < 0.05$), it is said that there is a dependency between age and groups. The participation rate (77.4%) in the 8 to 14 age group is significantly higher than in other age groups.

Asymp. Sig., asymptotic significance.

*2 cells (20.0%) have expected count <5 . The minimum expected count is 3.92.

Chi-square tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.653*	3	0.022
Likelihood ratio	9.732	3	0.021
Linear-by-linear association	0.044	1	0.834
N of Valid Cases	200		

Asymp. Sig., asymptotic significance.

* 0 cells (0.0%) have expected count <5 . The minimum expected count is 6.37.

Table 2
Effect of teledentistry on the patients' levels of concern.

	Patients	
	n	%
During the coronavirus (COVID-19) epidemic, did the online checkup via Zoom relieved your concern in relation to your treatment?		
Yes	67	67.0
No	8	8.0
Unstable	25	25.0
Total	100	100.0
Were you able to easily convey your symptoms and complaints to your orthodontist during the online checkup via Zoom?		
Yes	95	95.0
No	5	5.0
Total	100	100.0
No	85	85.0
Total	100	100.0
How effective do you think this type of online checkup was for explaining and resolving symptoms and complaints?		
Inadequate	9	9.0
Partly adequate	56	56.0
Adequate	31	31.0
Quite adequate	4	4.0
Total	100	100.0

meeting, and 4.1% did not attend because of insufficient technical facilities.

A total of 28% of the participants preferred to communicate with the orthodontists through video calls or photos instead of meeting with them face-to-face (which was the preference for

65.5%) regarding unexpected problems during the COVID-19 pandemic. A total of 68 of the participants thought that thanks to technological developments in recent years, online appointments might be able to replace some face-to-face appointments with orthodontists in the future (Table 3).

Table 3
Patients' preferences in relation to teledentistry.

	Teledentistry group		Control group		Total		χ^2	P
	n	%	n	%	n	%		
During the coronavirus (COVID-19) pandemic, how would you prefer to deal with unexpected problems (breakage of brackets, irritating of ligature wire, breakage of removable appliance)?								
I would like to meet the doctor face to face	64	62.7	67	68.4	131	65.5	*	0.38
I would like to communicate with the doctor via video call or photos	33	32.4	23	23.5	56	28.0		
I wouldn't follow any plan	3	2.9	3	3.1	6	3.0		
I would try to solve the problem at home myself	2	2.0	5	5.1	7	3.5		
Total	102	100.0	98	100.0	200	100.0		
Did you ever worry about the wire breaking and irritating during the pandemic?								
I was never worried	51	51.0	42	43.3	93	47.2	4.607	0.1
I was sometimes worried	46	46.0	45	46.4	91	46.2		
I was always worried	3	3.0	10	10.3	13	6.6		
Total	100	100.0	97	100.0	197	100.0		
During the pandemic, did you ever worry that the aligners might break and you would have difficulty using them?								
I was never worried	73	89.0	76	87.4	149	88.2	*	1
I was sometimes worried	7	8.5	8	9.2	15	8.9		
I was always worried	2	2.4	3	3.4	5	3.0		
Total	82	100.0	87	100.0	169	100.0		
During the pandemic, did you experience pain related to your orthodontic treatment and feared you would not be able to reach your doctor?								
I was never worried	66	64.7	63	64.9	129	64.8	*	0.658
I was sometimes worried	34	33.3	30	30.9	64	32.2		
I was always worried	2	2.0	4	4.1	6	3.0		
Total	102	100.0	97	100.0	199	100.0		
Do you think online appointments in health care will be able to replace some face-to-face appointments with a doctor in the future, thanks to technological developments?								
Definitely not	22	21.6	24	24.5	46	23.0	4.504	0.342
No	33	32.4	20	20.4	53	26.5		
Undecided	13	12.7	18	18.4	31	15.5		
Maybe partly	31	30.4	31	31.6	62	31.0		
Definitely	3	2.9	5	5.1	8	4.0		
Total	102	100.0	98	100.0	200	100.0		

Notes. χ^2 Pearson chi-square analysis.

*With the help of Montecarlo-simulation technique; Significance was set at $P < 0.05$.

Chi-square tests

	Value	df	Asymp. Sig. (2-sided)	Monte Carlo Sig. (2-sided)	Monte Carlo Sig. (1-sided)	99% Confidence Interval	Sig.	99% Confidence Interval	Lower Bound	Upper Bound
Pearson chi-square	3.061*	3	0.382	0.399†	0.386	0.412				
Likelihood ratio	3.112	3	0.375	0.408†	0.396	0.421				
Fisher's exact test	3.064			0.380†	0.368	0.393				
Linear-by-linear Association	0.006‡	1	0.939	1.000†	1.000	1.000	0.506†	0.493	0.519	
N of valid cases	200									

Notes. Since the expected value is <5 in 4 cells in the table above, chi-square analysis was performed with the help of Montecarlo-simulation technique. It is a method used when the number of subjects falling into the eyes is low. It is seen that there is no significant dependency/relation between the answers given and the groups ($P > 0.05$).

Asymp. Sig., asymptotic significance; N, number.

* 4 cells (50,0%) have expected count <5. The minimum expected count is 2.94.

† Based on 10,000 sampled tables with starting seed 2,000,000.

‡ The standardized statistic is 0.077.

4. Discussion

The risk of transmission of COVID-19 through cross-infection is high because it spreads by face-to-face contact and droplet transmission. Applications that provide remote access to patients for various purposes, such as prevention, monitoring, treatment, and diagnosis of dental diseases, are known as teledentistry. During the pandemic and strict quarantines, emergency dental care treatments were given priority over normal dental care. Teledentistry gained popularity worldwide during the lockdowns [18]. This

study examined the effectiveness of teledentistry in orthodontic clinical practice during the extraordinary situation resulting from the COVID-19 pandemic and aimed to evaluate the effects of online teledentistry sessions on the patients' levels of concern.

A review of the literature shows that several studies on orthodontic treatment during the COVID-19 restriction periods and on the way in which teledentistry is perceived have already appeared [7,19,20]. However, there have been only few studies examining the effectiveness of teledentistry in an orthodontic clinic during COVID-19 restrictions.

The COVID-19 pandemic has made it difficult to maintain health services; moreover, dentistry is reported to be one of the highest-risk occupational fields. In addition, aerosols and droplets from infected individuals increase the likelihood of infection for clinicians. During the pandemic period, clinicians sought different solutions to prevent disruptions to dentistry and health services [4]. Teledentistry appeared to provide the solution because it satisfies the requirement for social distancing by providing remote dental health care and guidance through video conferences and video calls, thanks to technological developments. These advantages ensured that it has become one of the methods advocated by health authorities around the world. It enables clinicians to safely provide services to patients through technology for managing and resolving some potential dental problems [6].

An earlier review of teledentistry recommended that one of its uses could be to identify emergency patients [8]. In the present study, providing emergency checkup appointments to 21.25% of the patients after teledentistry consultations and determining that the remaining patients did not need checkups in the clinical setting reduced the risk of cross-infection as much as possible during the COVID-19 pandemic period. The teledentistry consultations provided adequate information and ensured that patients were only referred to in-person/face-to-face clinics for emergency or urgent reasons, such as injuries because of dislocation of brackets and wires.

Accordingly, the findings of this study support the view that remote orthodontic checkups, such as recommendations to use intermaxillary elastics in fixed treatments or offering encouragement to patients in treatments with removable appliances, with the help of photographs and videos, can reduce the clinical workload. Some national health authority guidelines also indicate a consensus that teledentistry is an effective alternative to face-to-face clinical treatment, especially for nonemergency patients [21]. A study conducted at a Swiss university dentistry center also showed that the COVID-19 quarantine significantly affected the dental emergency department in relation to the patients' diagnoses, treatment needs, and the characteristics of the emergency care provided [22].

Orthodontic treatments have been significantly impacted by the COVID-19 epidemic. Most patients had to stop going to appointments in orthodontic clinics, putting them in a difficult situation and at risk of treatment delays. Patients who were treated in public clinics and those with fixed orthodontic appliances had more problems. The use of teledentistry in orthodontic clinics should be considered with a stronger emphasis because it will enable patients to deal with some of the challenges associated with their appliances whenever possible [17]. In a study of pedodontic patients, Mariño et al. [16] reported that teledentistry was successful in enabling physicians to understand the patients' problems and alleviate their concerns (82%), a rate similar to that in the present study (85.5%). This study evaluated the effectiveness of teledentistry during COVID-19 pandemic restrictions and its effects on the patients' levels of concern. The fact that three-quarters of the participants were female and more than 48% of the patients were university graduates suggests that the participation rate may be related to levels of awareness.

The participants stated that online checkup appointments made during the COVID-19 epidemic period provided relief about concerns regarding the course of their treatment in 67% of cases. This result suggests that teledentistry can be effective in relieving the concerns of patients about their treatment. In addition, 91% of the participants reported that the online checkups were sufficient for them to understand and resolve their symptoms and complaints. Based on this result, teledentistry can be regarded as a reliable

method that can be used to prevent the interruption of treatment services during extraordinary conditions, such as the COVID-19 pandemic.

In this study, significant differences between the case and control groups were found in terms of age and educational level. The attendance rate of those in the 8–14-year-old age group was higher than in older age groups. The reason for children between the ages of 8 and 14 participating in teledentistry practices may be because of their families' control and they ensure that it happens. Furthermore, children who had switched to online schooling might be more open and technically more accessible to things done online. Moreover, half of the participants had university-level educational qualifications. As the educational level increases, receptiveness to and knowledge about the methods used for distance communication may increase.

The participants in the study expressed a high level of satisfaction (at 76%) with their online teledentistry appointments. Accordingly, it can be concluded that wider adaptation of teledentistry practices may prevent overcrowding in emergency departments and reduce the risk of disease transmission, preventing conditions in the health-care system from becoming more difficult. The American Dental Association has also broadly supported the use of teledentistry during the COVID-19 pandemic [15]. A recent study suggested that despite some skepticism, teledentistry can offer clinical orthodontics a number of benefits, allowing remote management of orthodontic treatment [23].

Where close personal contact is not desired, teledentistry offers valuable assistance for orthodontists and patients facing orthodontic emergencies [24]. Previous studies have suggested that teledentistry could be comparable to face-to-face visits, particularly in areas in which access to oral health care is limited [18]. However, 65% of patients in the present study still wanted to meet with the doctor face-to-face if they had unexpected problems (e.g., breakage of brackets, irritation from ligature wires, breakage of removable appliances). A recent systematic review suggested that teledentistry was a beneficial method for initial patient examinations but was not a reliable substitute for face-to-face orthodontic appointments in an office setting [25]. However, according to Berndt et al. [26] teledentistry can be a useful method for patients to facilitate access to preventive orthodontic services provided by orthodontists when access to orthodontists is difficult and the only viable solution is to afford treatment by untrained general practitioners. By sharing orthodontics-based patient records with practitioners of oral health care, teledentistry enhances treatment planning and monitoring; nonetheless, the importance of direct patient supervision and routine follow-ups throughout orthodontic therapy cannot be disregarded. In this developing sector, more research is needed to establish ethical norms and a standard of care [27]. Therefore, it is important to mention in the written informed consent form that there is a risk of a breach of confidentiality when the patients' photos, radiographs, and other health care-related information are shared using teledentistry.

Among the nonresponders who did not take part in the teledentistry appointment or missed their appointments for various reasons, it was found in this study that some patients did not attend their appointments because everything was fine with their treatments. Orthodontic treatments usually do not require urgent appointment if the patient does not have any complaints (irritation, breaking, rupture, etc.).

A total of 4.1% of the patients did not attend their appointments because of inadequate technical facilities. The inadequate technical facilities may be related to the fact that internet connections were affected during the pandemic period. Internet connections slowed down because the remote online education that started in schools.

Furthermore, because of strict restrictions during the pandemic period, large numbers of people were connecting with each other through video calls. This overload led to slow internet speeds and connection problems.

During the COVID-19 pandemic, orthodontists only showed moderate understanding and practice of teledentistry, despite high levels of awareness and a positive attitude. More research on the many options for improving orthodontists' knowledge about and practice of teledentistry interventions is needed [28]. It would also be useful to compare the experience of orthodontists in other countries to develop an optimized teledentistry model in future studies. Although further research is required to objectively assess the efficacy, cost-effectiveness, and long-term consequences of these preliminary findings, we are convinced that teledentistry will play a significant role in orthodontics in the near future [29].

One limitation of the present study is that it does not differentiate between the types of appliances used to treat the malocclusion. The main aim of this cross-sectional study was to examine the areas in which teledentistry is used in orthodontic practices and its effects on patients' levels of concern during the COVID-19 restrictions by offering remote dental checkup appointments to patients who were receiving treatment in an orthodontic clinic within a specific period. Therefore, we did not make any distinctions relative to methods of treating malocclusions. The relationship between teledentistry and cooperation in different appliances used to treat different malocclusions should be examined in the future clinical trials.

5. Conclusions

Teledentistry can be an effective method of encouraging patients undergoing orthodontic treatment to adhere to orthodontists' instructions. It is also an effective way for orthodontists to understand the patients' symptoms, eliminate their concerns, and reduce the risks of cross-infection by referring patients who require emergency treatment for face-to-face care during pandemic periods. The attendance rate of those in the 8–14-year-old age group was higher (23.5%), and 49% of the participants had university-level educational qualifications.

Informed consent

Written informed consent was obtained from the patients who agreed to take part in the study.

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