ORTHODONTISTS' PERCEPTIONS OF TELEDENTISTRY AND REMOTE DENTAL

MONITORING IN ORTHODONTIC TREATMENT

A THESIS IN
Oral and Craniofacial Sciences

Presented to the Faculty of the University
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ABSTRACT

The purpose of this study was two-fold. First, to survey orthodontists to determine the clinician demographics and practice characteristics that may influence the utilization of teledentistry and/or remote dental monitoring. Second, to describe orthodontists' opinions and perceived barriers regarding teledentistry and remote dental monitoring. A 30-question survey, approved by the UMKC IRB, was distributed to 2,171 orthodontists by email through the American Association of Orthodontists Partners in Research program. The survey was used to determine the clinician and practice demographic factors that may influence the prevalence of orthodontists utilizing teledentistry and/or remote dental monitoring, orthodontists' opinions on teledentistry and remote dental monitoring, and perceived barriers of teledentistry and remote dental monitoring. The survey was divided into two domains: orthodontist demographics and orthodontic practice characteristics. Additional questions addressed opinion items such as concerns with teledentistry and remote dental monitoring, treatment that could be conducted using these modalities, and the effects the COVID 19 pandemic had on orthodontists' perceptions of teledentistry or remote dental monitoring. A significance level of 0.05 was used.

Overall, this study found there were no statistically significant associations between orthodontist demographics and their utilization of teledentistry or remote dental monitoring. Statistically significant associations were found between orthodontic practice technologies and utilization of teledentistry or remote dental monitoring. Orthodontists are more likely to use teledentistry or remote dental monitoring if they are using digital patient records, or if they have an intraoral scanner. No other statistically significant results were found, and no other factors showed a significant association with utilization of teledentistry or remote dental monitoring. Opinion questions revealed the three main concerns orthodontists have with teledentistry and remote dental monitoring are diagnostic accuracy, exam comprehension, and legal issues. It was also found that the majority of orthodontists' opinions of remote dental monitoring changed due to COVID-19 and majority of orthodontists think that utilization of teledentistry and remote dental monitoring will increase in the future.

APPROVAL PAGE

The faculty listed below, appointed by the Dean of the School of Dentistry have examined a thesis titled "Orthodontists' Perceptions of Teledentistry and Remote Dental Monitoring in Orthodontic Treatment" presented by Grant Severs, candidate for the Master of Science degree in Oral and Craniofacial Sciences, and hereby certify that in their opinion it is worthy of acceptance.

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CHAPTER 1

INTRODUCTION

History of Telehealth and Telemedicine

Telehealth is defined as the use of electronic information and telecommunication technologies to support long-distance clinical healthcare, patient and professional health related education, public health, and health administration (Health Resources & Services Administration 2019). Goals of telehealth consist of long-distance doctor-patient interactions that can include care, patient education, advice, and monitoring. The term telemedicine is sometimes used interchangeably with the term telehealth, but the term telehealth encompasses all aspects of healthcare, including but not limited to: telemedicine, teledentistry, telenutrition, teleaudiology, teleradiology, teleneurology, telerehabilitation, telecardiology, teledermatology, etc.

Telehealth has different modalities of interaction between the patient and the provider. The two more popular methods include store and forward, and remote monitoring. Store and forward, which was one of the original modalities of telehealth, occurs when records are collected at one location and sent to a specialist to view at a separate location. Remote monitoring, which is a more modern method, occurs when medical professionals can monitor a patient using different technologies (Kvedar et al. 2014).

Telehealth may seem relatively new because of the technological advancements available today, but it has been around for over a hundred years. Early cases of telemedicine were conducted using Alexander Graham Bell's telephone in 1876 and telegraphs were even used during the American Civil War to deliver proper medical care to soldiers. Telehealth played an important role when first sending astronauts into space by incorporating

apparatuses in spacesuits to monitor their health (Bashshur and Shannon 2009). Today's technologies like laptops and mobile phones when paired with the invention of high-speed internet has allowed telehealth to become more wide-spread and have an impact over many parts of the world.

History of Teledentistry

One of the first well-known teledentistry projects was designed in 1994 by the United States Army, known as the Total Dental Access (TDA) project (Chen et al. 2003). General dentists in the military could exchange information with specialists in the form of photographs or radiographs, with the goal being to expand the geographical area a specialist could treat. The store and forward method was the primary way information acquired from the general dentist was relayed to the specialist in the TDA project. Once the specialist viewed the information, they could formulate a diagnosis, make a treatment plan, and guide the general dentist through treatment while being in another location. The TDA project confirmed the notion that teledentistry could increase access of dental care to remote locations (Kravitz et al. 2016). The American Dental Association (ADA) first adopted a teledentistry policy in 2015, stating "teledentistry refers to the use of telehealth systems and methodologies in dentistry (American Dental Association 2020).

Teledentistry Effectiveness

Since teledentistry's introduction with the U.S. Army in 1994, it has continued to increase access to dental care for rural populations. Teledentistry has been shown to be just as effective as face-to-face dentistry in certain aspects. Discovery of intraoral pathology using teledentistry has been shown to be just as effective when compared to the gold standard clinical exam. The sensitivity for diagnosing oral pathology using teledentistry was reported

to be 93.8% and the specificity was 94.2%. The same study also found teledentistry assessments were faster than the standard clinical examination (12 minutes versus 20 minutes) (Queyroux et al. 2017). One review cited multiple studies that found intraoral images to be superior for detecting dental caries when compared with a clinical exam (Ines Meurer et al. 2015). Teledentistry's effectiveness has been proven many times, but it is important to mention that the main objective of teledentistry after its inception has been to assist in managing disease driven cases, and very little has been assessed about teledentistry being used in elective treatment, such as orthodontics.

Potential Orthodontic Teledentistry Models

The original orthodontic patient population stemmed strictly from general dentist referrals or patients that walked into orthodontic offices themselves, desiring straighter teeth. This is still in effect today, but more general dentists are treating orthodontic cases in their own offices without support from orthodontists. Nowadays aligners are even being offered directly to consumers without continuous monitoring by orthodontists or other trained dental providers. This has created discomfort among the orthodontic profession and some concerns that these types of treatment may not be meeting the standard of care conducted by orthodontic specialists. If more orthodontists introduce teledentistry into their practice, by a model of either classic store and forward method, or remote dental monitoring, it would allow more patients to be overseen by an orthodontist, ensuring proper care is provided. This will allow the convenience of direct-to-consumer treatment with proper orthodontic specialist supervision.

Model 1: Classic Teledentistry (TD)

There are two main teledentistry models available. The first one is the classic model, originally known as store and forward, which will be referred to as teledentistry (TD) from here on. In this model, a general dentist sends patient information to an orthodontist for a consultation. The orthodontist can then provide a simple opinion or more complex treatment guidance for the general dentist to provide patient care. This relationship is demonstrated below in figure 1.
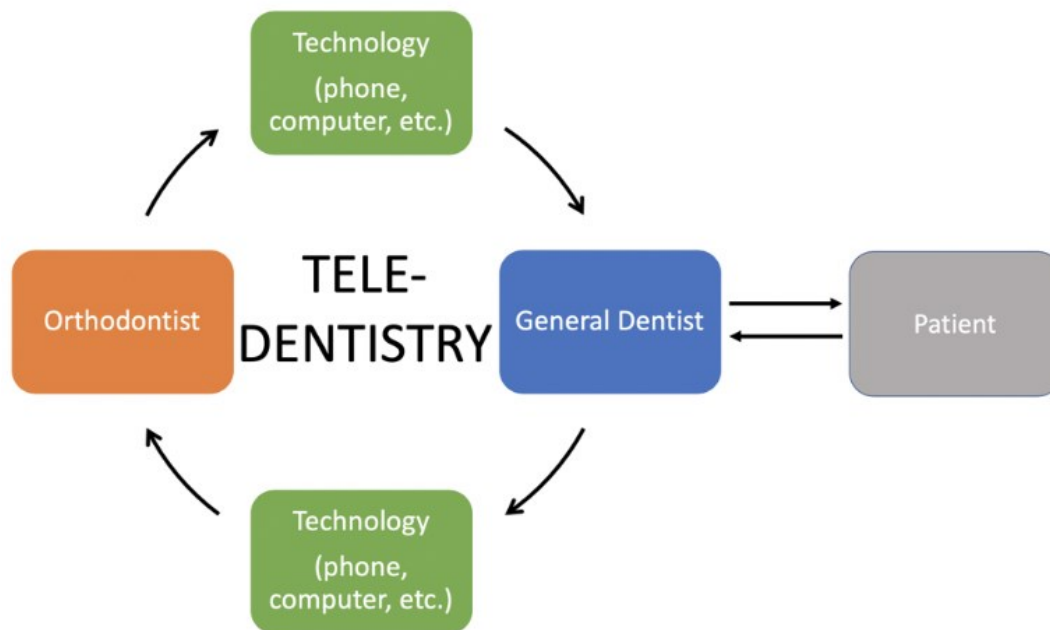
Figure 1. Teledentistry flowchart. Demonstration of relationship between orthodontist and patient.

Model 2: Remote Dental Monitoring (RDM)

The second model is remote dental monitoring (RDM). This occurs when an orthodontist directly treats a patient utilizing remote technology and may only meet with the patient when deemed necessary. This can be seen in figure 2 below.
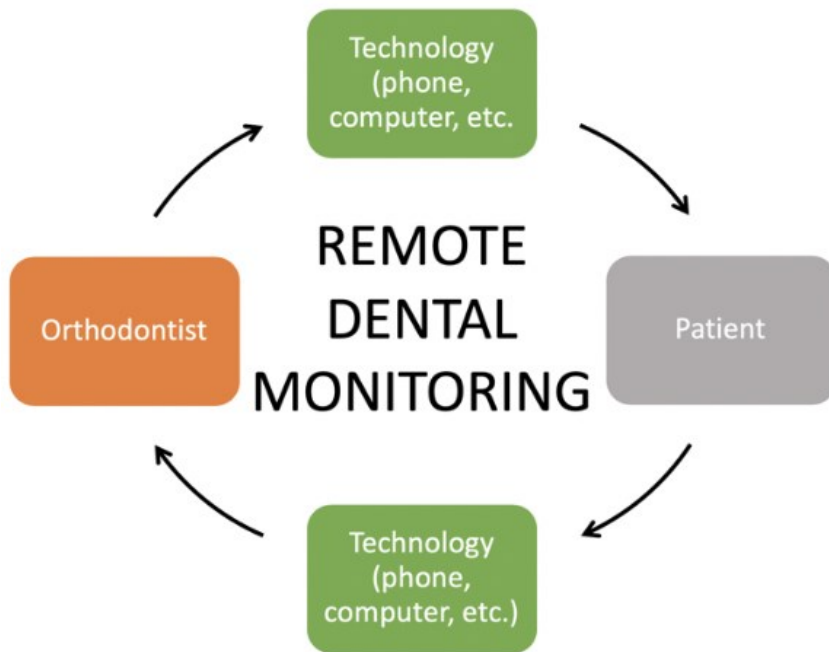
Figure 2. Remote dental monitoring flowchart. Demonstration of relationship between orthodontist and patient.

Feasibility Studies of Orthodontic Teledentistry Models

As the U.S. Army showed decades ago, teledentistry can allow more people access to all dental specialties. A randomized control trial found teledentistry to be an accurate and effective system for recognizing suitable orthodontic referrals and could be an efficient way to reduce inappropriate referrals, saving both the patient and orthodontic practitioner time and money (Mandall et al. 2005).

In orthodontics, remote dental monitoring has been shown to help with minor emergencies including irritation of the lip or cheek, and displacement of elastic ligatures. It has also been shown to make patients feel more comfortable with their treatment (Favero et al. 2009). Studies have also shown that practitioners that have access to remote dental

monitoring technologies reported patients and parents were impressed with the "high tech" aspect of treatment (Cook et al. 2001).

New technologies allow orthodontists to monitor treatment remotely, with the creation of a treatment-monitoring applications for smartphones. There are different platforms available today marketed towards orthodontists so they can efficiently monitor their patients. Moylan et al. explored one of these applications and found that there was no clinically significant difference between measurements computed on the application when compared to Boley-gauge measurements taken by calibrated practitioners on plaster models (2019). They also found a non-significant difference in image quality between the intraoral scans taken on the application by the dental provider when compared to scans taken on the smart phone application by the patient. The study also concluded the use of the monitoring software can be accurate enough to make clinical decisions (2019). Another recent study evaluating remote dental monitoring with self-ligating brackets found a reduction in chair time, material costs, and number of visits. This same study also found an increase in frequency of patient monitoring, resulting in a more precise evaluation of treatment, benefitting both the patient and the orthodontist (Impellizzeri et al. 2020).

Orthodontic practitioners could also be interested in a teledentistry or a remote dental monitoring model to retrieve some of the market share they are currently missing out on due to geographical matters and/or direct-to-consumer aligners. Not only will these treatment models incentivize patients to see a trained specialist as opposed to opting for direct-to-consumer aligners, but orthodontists can also ensure the highest standard of care is being achieved. With new technology available every day, it seems it is only a matter of time before teledentistry and remote dental monitoring become widespread in the field of

orthodontics. If current specialists are not open-minded to solutions for efficiently and

effectively treating patients through technological means such as smart phone applications

and video conferencing, then they may not be offering their patients the best possible care.

Complications and Concerns Related to Orthodontic
Teledentistry Models and Telehealth

Teledentistry and remote dental monitoring have their own set of barriers. Because

teledentistry and remote dental monitoring allow orthodontists to treat patients in a different

geographical location, this means they could be in a different state than the patient. This

raises questions on state licensing. As the system is today, if an orthodontist is only licensed

in one state, they cannot provide teledentistry or remote dental monitoring services to a

patient in a state where they are not licensed (American Dental Association 2020). In a 2016

paper, Kravitz et al. states Congress founded a "Joint Working Group on Telemedicine" to

meet with licensing boards with an objective to come to an agreement to overcome this

barrier. Kravitz et al. also stated the Federation of State Medical Boards has proposed a

"consultation exception" that allows a doctor to deliver diagnostic services in a state they are

not licensed in an effort to promote telemedicine and grant people in remote areas access to

care (Kravitz et al. 2016). Laws and regulations are continuing to be modified to promote

telehealth and remote monitoring, but the ADA states they oppose a federalized system of

dental licensure for the purposes of teledentistry (American Dental Association (2020a).

Liability is another hurdle for telehealth. In the classical teledentistry model, where a

general practitioner is treating a patient while also communicating with a specialist, it is

uncertain which doctor is liable if something goes wrong. There are many legality issues that

are not clearly defined. Some malpractice insurance will not cover doctors across state lines.

There is also uncertainty in which types of telehealth services constitute a legally binding relationship.

Another large concern with telehealth is confidentiality and private health information being stored or transferred via internet. Teledentistry and remote dental monitoring records must be saved and stored securely just like physical papers and plaster models. If secure web pages or smart-phone applications are breached with patient records and personal health information, then doctors would be in violation of HIPPA (Health Insurance Privacy and Portability Act).

An additional worry with regards to the teledentistry and remote dental monitoring models is that the standard of care will not be met when treating or managing a patient from another location. It is the duty and responsibility of the medical providers to deliver optimal care. If a provider feels they cannot deliver the standard of care because of case complexity or geographical distances, then it is up to the doctor to refer them to someone who can treat the patient appropriately.

Patient connection seems to be another concern while treating using telehealth models. Doctor-patient relationships are very important and may not be as strong when relying on technology versus traditional appointments and consultations. Positive doctor – patient relationships could result in higher patient satisfaction, less malpractice claims, and less doctor burnout (Lipp et al. 2016) . Multiple studies have found significance of face-to-face rapport, and a prior study found preference of in-person consultation over the exclusive use of technology (Dunbar et al. 2014).

Combi et al. studied, reviewed, and evaluated multiple telemedicine projects and created important feedback on what to consider when designing and implementing a

telehealth plan. Some of the more prominent challenges included initial expense, resistance to change, unavailable infrastructure, lack of standards, lack of a business model, and accreditation issues of health care providers. Combi et al. also came up with a list of recommendations on how to plan, manage and operate future telehealth projects. A few of these recommendations include setting clear goals for the project, adopting user-friendly interfaces, training personnel, increasing accessibility via internet connectivity, motivating users, implementing standards and protocols, starting small, and measuring user satisfaction (Combi et al. 2016).

Orthodontic Teledentistry Models: Interest and Implementation Concerns in Practice

Even though teledentistry has been around for 25 years there still seems to be a lack of knowledge and willingness to incorporate it by dental practitioners (Boringi et al. 2015). Technology is developing rapidly with new equipment and software created daily, yet people still have concerns about teledentistry and its capabilities (Pradhan et al. 2019).

With the proven efficacy shown regarding teledentistry and remote dental monitoring from the aforementioned studies, it is difficult to understand why more practitioners are not implementing these models in their practices. The recent interruption of care due to COVID-19 shows how useful these models could be. A prior study evaluated orthodontists' and general dentists' opinions on "telemonitoring" but merged all of the data from both types of practitioners into one sample, and did not solely evaluate orthodontic specialists (Dalessandri et al. 2021). Research needs to be conducted, and orthodontists need to be asked about their current utilization and opinions on teledentistry and remote dental monitoring. This would

provide better insight on their viewpoints and determine why it is not more prevalent in the field of orthodontics.

Problem Statement

To date, there has been no study to solely evaluate orthodontists' utilization of, and opinions on, teledentistry or remote dental monitoring. Previous studies looked at opinions of orthodontists, general dentists, and dental students related to teledentistry, but this subject has not been evaluated solely from the perspective of orthodontists. The purpose of this study is two-fold. First, to survey orthodontists to determine the clinician demographics and practice characteristics that may influence the utilization of teledentistry and/or remote dental monitoring. Second, to describe orthodontists' opinions and perceived barriers regarding teledentistry and remote dental monitoring.

Hypotheses

1. The demographics of the orthodontist, such as age, gender, residency graduation year, U.S. residency region, and working status will influence utilization of teledentistry and remote dental monitoring.

2. Practice characteristics such as number of office locations, U.S. region, population density (rural suburban, urban), number of orthodontists, and technologies in the practice will influence utilization of teledentistry and remote dental monitoring.

CHAPTER 2

METHODS

Survey Development and Description

A survey was created to gather current orthodontists' utilization and perceptions of teledentistry and remote dental monitoring. The questions collected information regarding orthodontists' opinions and concerns with teledentistry and remote dental monitoring, as well as their potential uses in the field of orthodontics.

The 30-question survey focused on two domains: (1) the orthodontist demographics, and (2) the orthodontic practice characteristics. The first domain, orthodontist demographics, collected: working status, age, gender, year of residency graduation, US region of residency program, and current status as a practitioner.

The second domain, orthodontic practice characteristics, focused mainly on the practice demographics where the orthodontist spends the majority of his or her time. These questions solicited information regarding number of office locations, population density surrounding the office (rural/suburban/urban), US region office location, technologies in the office, and number of orthodontists working in the practice.

These two domains determined whether they play a role in the utilization of teledentistry and remote dental monitoring, opinions of the practitioner with regards to teledentistry and/or remote dental monitoring, as well as the barriers thought to be associated with these models. The survey also provided information regarding whether orthodontists think positively or negatively about teledentistry and remote dental monitoring. Additional questions addressed orthodontists' opinions regarding advantages and disadvantages, future implications, and the impact of COVID-19 on teledentistry and remote dental monitoring.

Before finalizing the survey, a focus group of part-time orthodontic faculty in the UMKC Advanced Orthodontic Clinic evaluated the survey for clarity and content. The focus group was given an evaluation form (Appendix A) as well as a copy of the survey. Feedback from the focus group was used to update the survey prior to distribution.

The final version of the survey was in an electronic format and designed using Research Electronic Data Capture (REDCap) (Harris et al. 2009). A copy of the final version of the survey is located in Appendix B. The Center for Health Insights of UMKC hosts REDCap and allows data entry though electronic forms which are then stored securely.

Survey Distribution and Data Collection

The survey was distributed to orthodontists who were active members in the American Association of Orthodontists (AAO). The survey was distributed electronically through AAO Foundation Partners in Research program for a fee of 275 dollars. As of January 2020, the AAO consisted of approximately 9,222 practicing members in the United States. The Partners in Research program distributed the survey electronically via email to 2,171 randomly selected members. A copy of that email is located in Appendix C. One additional identical email was sent to the same randomly selected members 3 weeks after the initial email to remind them about taking the survey. No additional communication occurred with possible survey participants.

Prior to distribution, the survey and proposed distribution protocol were reviewed by the University of Missouri-Kansas City (UMKC) Institutional Review Board (IRB). An approval letter from the IRB can be found in Appendix D.

Experimental Design

As previously discussed, the survey was distributed electronically via email to orthodontists who are active members of the AAO. This study used a non-experimental design with two factors. The two independent variables were the orthodontist demographics and the orthodontic practice characteristics. These two independent variables were then broken into more specific details that could influence the use of teledentistry and remote dental monitoring. The dependent variables assessed by this study included utilization, opinions, and barriers of teledentistry and remote dental monitoring. The overall design of the study is shown in table 1.

TABLE 1

EXPERIMENTAL DESIGN: INDEPENDENT AND DEPENDENT VARIABLES

Specific details	Independent variables	Dependent variables
Working status		
Age		
Year of graduation from residency	Orthodontist demographics	1. Utilization of teledentistry and remote dental monitoring
Gender		
Region orthodontic residency is located		2. Opinions on teledentistry and remote dental monitoring
Number of offices		
Population density surrounding the office		
Region of orthodontic practices	Orthodontic practice characteristics	3. Barriers regarding teledentistry and remove dental monitoring
Number of orthodontists in practice		
Technologies in practice		
Sample size (n) = 65 orthodontists (out of 2171) responding to survey		

Data Analysis

Data was analyzed to look at the effect of orthodontist demographics and orthodontic practice characteristics on utilization of teledentistry and remote dental monitoring, as well as orthodontists' opinions and barriers regarding both teledentistry and remote dental monitoring. Data collected from the responses to the survey was coded and input into a statistic software program[1].

Descriptive statistics were calculated for all variables (counts and percentages). Associations between all variables and utilization of teledentistry and remote dental monitoring (RDM) (yes/no) were tested with Chi-square or Fisher's Exact tests. A significance level of 0.05 was used for all statistical tests.

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[1] IBM SPSS Statistics for Windows, Version 26.0. IBM Corp, Armonk, NY 10504

CHAPTER 3

RESULTS

A survey was distributed to 2,171 orthodontists, of which 81 orthodontists initiated

the survey, and 65 orthodontists completed the survey. This leads to a total response rate of

3.0%.

Orthodontist Demographics

Table 2 summarizes the sample of orthodontists that responded to the survey, as well

as their utilization of teledentistry and remote dental monitoring. Most of the respondents

were 50-59 years of age (43.1%), male (76.4%), graduated residency between 1990-2004

(48.6%), graduated from a residency located in the Midwest (35.2%), and are owners of an

orthodontic practice (84.7%). Of the orthodontists that completed the survey, only 31.9%

currently utilize teledentistry, while 56.9% of them utilize remote dental monitoring. No

significant association was found between orthodontic demographics and utilization of

teledentistry or remote dental monitoring.

TABLE 2

ORTHODONTIST DEMOGRAPHICS AND ASSOCIATIONS WITH TELEDENTISTRY
AND REMOTE DENTAL MONITORING UTILIZATION

		Teledentistry Utilization			Remote Dental Monitoring Utilization		
	Sample (N = 72)	Yes (N = 23)	No (N = 49)		Yes (N = 41)	No (N = 31)	
	N (%)	N (%)	N (%)	p-value	N (%)	N (%)	p-value
Age				0.81			0.76
30-39	8 (11.1%)	3 (37.5%)	5 (62.5%)		6 (75.0%)	2 (25.0%)	
40-49	19 (26.4%)	7 (36.8%)	12 (63.2%)		11 (57.9%)	8 (42.1%)	
50-59	31 (43.1%)	10 (32.3%)	21 (67.7%)		16 (51.6%)	15 (48.4)	
60-69	14 (19.4%)	3 (21.4%)	11 (78.6%)		8 (57.1%)	6 (42.9%)	
Gender				0.74			0.46
Male	55 (76.4%)	17 (30.9%)	38 (69.1%)		30 (54.5%)	25 (45.5%)	
Female	17 (23.6%)	6 (35.3%)	11 (64.7%)		11 (64.7%)	6 (35.3%)	
Residency Graduation				0.62			0.29
1975-1989	12 (16.7%)	3 (25.0%)	9 (75.0%)		5 (41.7%)	7 (58.3%)	
1990-2004	35 (48.6%)	10 (28.6%)	25 (71.4%)		19 (54.3%)	16 (45.7%)	
2005-2020	25 (34.7%)	10 (40.0%)	15 (60.0%)		17 (68.0%)	8 (32.0%)	
Residency Region				0.76			0.44
Pacific	9 (12.7%)	3 (33.3%)	6 (66.6%)		6 (66.7%)	3 (33.3%)	
Rocky Mountains	5 (7.0%)	2 (40.0%)	3 (60.0%)		3 (60.0%)	2 (40.0%)	
Southwest	7 (9.9%)	3 (42.9%)	4 (57.1%)		5 (71.4%)	2 (28.6%)	
Midwest	25 (35.2%)	6 (24.0%)	19 (76.0%)		10 (40.0%)	15 (60.0%)	
Southeast	14 (19.7%)	4 (28.6%)	10 (71.4%)		10 (71.4%)	4 (28.6%)	
Northeast	10 (14.1%)	3 (30.0%)	7 (70.0%)		5 (50.0%)	5 (50.0%)	
Noncontiguous	1 (1.4%)	1 (100%)	0 (0.0%)		1 (100%)	0 (0.0%)	
Orthodontic Practitioner				0.72			0.72
Owner	61 (84.7%)	21 (34.4%)	40 (65.6%)		36 (59.0%)	25 (41.0%)	
Associate	1 (1.4%)	0 (0.0%)	1 (100.0%)		0 (0.0%)	1 (100.0%)	
Employee	4 (5.6%)	0 (0.0%)	4 (100.0%)		2 (50.0%)	2 (50.0%)	
Independent Contractor	1 (1.4%)	0 (0.0%)	1 (100.0%)		0 (0.0%)	1 (100.0%)	
Dental School Faculty	5 (6.9%)	2(31.9%)	3 (68.1%)		3 (60.0%)	2 (40.0%)	

Orthodontic Practice Characteristics

Tables 3 and 4 summarize the orthodontic practice characteristics of the orthodontists that responded to the survey. Table 3 summarizes specifics regarding the location of the practice, as well as the number of doctors present, while table 4 summarizes the technologies within the practice.

Table 3 demonstrates most of the respondents had one office location (34.3%), practice in suburban areas (59.2%), have less than 25% rural patients (52.1%), practice in the Midwest (32.4%), and have one orthodontist in the practice (60.6%). Table 3 also summarizes the relationship between orthodontic practice locations, as well as the number of doctors, and utilization of teledentistry and remote dental monitoring. No significant associations were found in table 3.

TABLE 3

ORTHODONTIC PRACTICE CHARACTERISTICS AND ASSOCIATIONS WITH
TELEDENTISTRY AND REMOTE DENTAL MONITORING UTILIZATION

		Teledentistry Utilization			Remote Dental Monitoring Utilization		
	Sample (N =70) N (%)	Yes (N=23) N (%)	No (N=47) N (%)	p-value	Yes (N=40) N (%)	No (N=30) N (%)	p-value
Number of office locations				0.17			0.37
1	24 (34.3%)	12 (50.0%)	12 (50.0%)		17 (70.8%)	7 (29.2%)	
2	22 (31.4%)	7 (31.8%)	15 (68.2%)		11 (50.0%)	11 (50.0%)	
3	14 (20.0%)	2 (14.3%)	12 (85.7%)		6 (42.9%)	8 (57.1%)	
4	9 (12.9%)	2 (22.2%)	7 (77.8%)		5 (55.6%)	4 (44.4%)	
5	1 (1.4%)	0 (0.0%)	1 (100.0%)		1 (100.0%)	0 (0.0%)	

Table 3 Continued

	Sample (N =70) N (%)	Teledentistry Utilization Yes (N=23) N (%)	No (N=47) N (%)	p-value	Remote Dental Monitoring Utilization Yes (N=40) N (%)	No (N=30) N (%)	p-value
Practice Region				0.15			0.09
Rural	11 (15.5%)	2 (18.2%)	9 (81.8%)		9(81.8%)	2 (18.2%)	
Suburban	42 (59.2%)	12 (28.6%)	30 (71.4%)		18 (42.9%)	24 (57.1%)	
Urban	18 (25.4%)	9 (50.0%)	9 (50.0%)		14 (71.4%)	4 (22.2%)	
	N=71	N=23	N=48		N=41	N=30	
Percent of Patients from Rural Area				0.20			0.67
< 25%	37 (52.1%)	16(43.2%)	21 (56.8%)		22(59.5%)	15 (40.5%)	
25%-49%	15 (21.1%)	3 (20.0%)	12 (80.0%)		7 (46.7%)	8 (53.3%)	
50%-74%	6 (8.5%)	2 (33.3%)	4 (66.7%)		3 (50.0%)	3 (50.0%)	
> 75%	13 (18.3%)	2 (15.4%)	11 (84.6%)		9 (69.2%)	4 (30.8%)	
Practice Location				0.80			0.43
Pacific	13 (18.3%)	4 (30.8%)	9 (69.2%)		8 (61.5%)	5 (38.5%)	
Rocky Mountains	5 (7.0%)	2 (40.0%)	3 (60.0%)		3 (60.0%)	2 (40.0%)	
Southwest	8 (11.3%)	3 (37.5%)	5 (62.5%)		5 (62.5%)	3 (37.5%)	
Midwest	23 (32.4%)	7 (30.4%)	16 (69.6%)		10 (43.5%)	13 (56.5%)	
Southeast	14 (19.7%)	5 (35.7%)	9 (64.3%)		11(78.6%)	3 (21.4%)	
Northeast	7 (9.9%)	1 (14.3%)	6 (85.7%)		3(42.9%)	4 (57.1%)	
Noncontiguous	1 (1.4%)	1 (100%)	0 (0.0%)		1 (100%)	0 (0.0%)	
Number of Orthodontists in Primary Practice				0.29			0.94
0	1 (1.4%)	1 (100.0%)	0 (0.0%)		1 (100.0%)	0 (0.0%)	
1	43 (60.6%)	13 (30.2%)	30 (69.8%)		23 (53.5%)	20 (46.5%)	
2	17 (23.9%)	4 (23.5%)	13 (76.5%)		10 (58.7%)	7 (41.2%)	
3	7 (9.9%)	3 (42.9%)	4 (57.1%)		5 (71.4%)	2 (28.6%)	
4	2 (2.8%)	1 (50.0%)	1 (50.0%)		1 (50.0%)	1 (50.0%)	
5	1 (1.4%)	1 (100.0%)	0 (0.0%)		1 (100.0%)	0 (0.0%)	

Table 4 summarizes orthodontic practice technologies used in the offices of the orthodontists that responded to the survey. The majority have digital x-rays (91.7%), digital patient records (88.9%), and intraoral scanners (88.9%). The survey also found the majority do not have cone beam computed tomography (CBCT) machines (54.2%) or 3D printers (56.9%).

Table 4 also summarizes the relationship between orthodontic practice technologies and utilization of teledentistry and remote dental monitoring. Associations were found between some orthodontic practice technologies and utilization of teledentistry or remote dental monitoring. Orthodontists are more likely to use teledentistry if they are using digital patient records than not using digital patient records (36% vs 0%, p=0.05), or if they have an intraoral scanner versus those that do not have an intraoral scanner (36% vs 0%, p=0.05) . Orthodontists are also more likely to use remote dental monitoring if they are using digital patient records than not using digital patient records (62% vs 13%, p=0.02) or if they have an intraoral scanner versus those that do not have an intraoral scanner (62% vs 13%, p=0.02).

TABLE 4

TECHNOLOGY WITHIN AN ORTHODONTIC PRACTICE AND ASSOCATIONS WITH
TELEDENTISTRY AND REMOTE DENTAL MONITORING UTILIZATION

| | Teledentistry Utilization | | | | Remote Dental Monitoring Utilization | | |
	Sample (N = 72) N (%)	Yes (N = 23) N (%)	No (N = 49) N (%)	p - value	Yes (N = 41) N (%)	No (N = 31) N (%)	p-value
Digital X Rays				0.99			0.69
Yes	66 (91.7%)	21 (31.8%)	45 (68.2%)		37 (56.1%)	29 (43.9%)	
No	6 (8.3%)	2 (33.3%)	4 (66.7%)		4 (66.7%)	2 (33.3%)	
Digital Patient Records				0.05*			0.02*
Yes	64 (88.9%)	23 (35.9%)	41 (64.1%)		40 (62.5%)	24 (37.5%)	
No	8 (11.1%)	0 (0.0%)	8 (100.0%)		1 (12.5%)	7 (87.5%)	
Intraoral Scanner				0.05*			0.02*
Yes	64 (88.9%)	23 (35.9%)	41 (64.1%)		40 (62.5%)	24 (37.5%)	
No	8 (11.1%)	0 (0.0%)	8 (100.0%)		1 (12.5%)	7 (87.5%)	
CBCT				0.21			0.13
Yes	33 (45.8%)	13 (39.4%)	20 (60.6%)		22 (66.7%)	11 (33.3%)	
No	39 (54.2%)	10 (25.6%)	29 (74.4%)		19 (48.7%)	20 (51.3%)	
3D Printer				0.11			0.26
Yes	31 (43.1%)	13 (41.9%)	18 (58.1%)		20 (64.5%)	11 (35.5%)	
No	41 (56.9%)	10 (24.4%)	31 (75.6%)		21 (51.2%)	20 (48.8%)	

*Statistically Significant

Opinion Data

Table 5 shows the concerns of those that do and do not practice teledentistry and remote dental monitoring. When looking at orthodontists' concerns with teledentistry and remote dental monitoring, the three main concerns are diagnostic accuracy, exam comprehension, and legal issues. When comparing those that do currently practice teledentistry with those that do not practice teledentistry, the numbers are very similar: diagnostic accuracy (65.2% vs. 65.3%), exam comprehension (43.5% vs. 55.1%), and legal issues (65.2% vs. 59.2%).

When comparing those that do currently practice remote dental monitoring with those that do not practice remote dental monitoring, the orthodontists that do practice remote dental monitoring are not as concerned as those that do not utilize remote dental monitoring. For example: diagnostic accuracy (53.7% vs. 80.1%), exam comprehension (48.8% vs. 64.5%), legal issues (48.8% vs. 54.8%).

Concerns were much less with regards to technology, expense, insurance/Medicaid reimbursement, and initial time investment. It is worth noting that those who practice remote dental monitoring had the highest percentages of concern in technology (41.5%), expense (34.1%), and initial time investment (41.5%).

TABLE 5

CONCERNS OF ORTHODONTISTS THAT DO AND DO NOT PRACTICE REMOTE DENTAL MONITORING AND/OR TELEDENTISTRY

	Practice Teledentistry N =23	Do Not Practice Teledentistry N = 49	Practice RDM N = 41	Do Not Practice RDM N = 31
Concerns Regarding TD & RDM				
Diagnostic Accuracy				
Yes	15 (65.2%)	32 (65.3%)	22 (53.7%)	25 (80.1%)
No	8 (34.8%)	17(34.7%)	19 (46.3%)	6 (19.9%)
Exam Comprehension				
Yes	10 (43.5%)	27 (55.1%)	20 (48.8%)	20 (64.5%)
No	13 (56.5%)	22 (44.9%)	21 (51.2%)	11 (35.5%)
Legal Issues				
Yes	15 (65.2%)	29 (59.2%)	21 (48.8%)	17 (54.8%)
No	8 (34.8%)	20 (44.8%)	20 (51.2%)	14 (45.2%)
Technology				
Yes	8 (34.8%)	9 (18.4%)	17 (41.5%)	9 (29.0%)
No	15 (65.2%)	40 (81.6%)	24 (58.5%)	22 (71.0%)
Expense				
Yes	3 (13.0%)	4 (8.2%)	14 (34.1%)	6 (19.9%)
No	20 (87.0%)	45 (91.8%)	27 (65.9%)	25 (80.1%)
Insurance / Medicaid reimbursement				
Yes	3 (13.0%)	8 (16.3%)	6 (14.6%)	7 (22.6%)
No	20 (87.0%)	41 (83.7%)	35 (85.4%)	24 (77.4%)
Initial Time Investment				
Yes	7 (30.4%)	6 (12.2%)	17 (41.5%)	6 (19.9%)
No	16 (69.6%)	43 (87.8%)	24 (58.5%)	25 (80.1%)

Table 6 demonstrates orthodontists' perceptions of what they believe could be treated using teledentistry and remote dental monitoring. When using teledentistry, over half of the respondents thought it was appropriate to monitor oral hygiene (58.5%), conduct screenings (64.6%), and manage orthodontic emergencies (55.4%). Conversely, few orthodontists thought it would be appropriate to monitor elastic wear (38.5%), conduct expander checks (36.9%), evaluate midline discrepancies (33.8%), treat clear aligners (36.9%), or conduct retainer checks (47.7%) using teledentistry.

When respondents were asked what they felt they could effectively treat using remote dental monitoring, the majority felt they could monitor elastic wear (81.5%), conduct expander checks (76.9%), evaluate midline discrepancies (67.7.%), evaluate clear aligner cases (73.8%), monitor oral hygiene (81.5%), conduct screenings (60.0%), check retainers (72.3%) and manage orthodontic emergencies (76.9%).

TABLE 6

PERCEPTIONS OF WHAT COULD BE TREATED USING TELEDENTISTRY AND/OR
REMOTE DENTAL MONITORING

Treatment that could be conducted with TD / RDM		Perceptions of Treatment with Teledentistry (N = 65)	Perceptions of Treatment with Remote Dental Monitoring (N = 65)
Elastic wear		N (%)	N (%)
	Yes	25 (38.5%)	53 (81.5%)
	No	40(61.5%)	12(18.5%)
Expander checks			
	Yes	24 (36.9%)	50 (76.9%)
	No	41(63.1%)	15 (23.1%)
Midline discrepancy			
	Yes	22 (33.8%)	44 (67.7%)
	No	43(66.2%)	21(32.3%)
Progress using clear aligners			
	Yes	24 (36.9%)	48 (73.8%)
	No	41(63.1%)	17(26.2%)
Oral hygiene			
	Yes	38 (58.5%)	53 (81.5%)
	No	27 (41.5%)	12(18.5%)
Screenings			
	Yes	42 (64.6%)	39 (60.0%)
	No	23 (35.4%)	26(40.0%)
Evaluation for relapse / Retainer checks			
	Yes	31 (47.7%)	47 (72.3%)
	No	34 (52.3%)	18(27.7%)
Management of orthodontic emergencies			
	Yes	36 (55.4%)	50 (76.9%)
	No	29 (44.6%)	15(23.1%)

Table 7 shows the current perceptions of the orthodontists who responded to this study with regards to teledentistry and remote dental monitoring. When orthodontists were asked their overall opinions, the most common response was "neutral" (35.4%) to teledentistry and "positive" (38.5%) to remote dental monitoring. While most orthodontists (64.6%) state that their opinion of teledentistry did not change due to the COVID-19 pandemic, the majority of orthodontists (61.5%) said that their opinion of remote dental monitoring did change due to COVID-19. Most orthodontists (69.2%) think that utilization of teledentistry will increase in the future, while 90.8% think that remote dental monitoring utilization will increase in the future. The majority (58.5%) of orthodontists think that COVID-19 has changed the number of orthodontists that will use teledentistry in the future, while even more (78.5%) think that COVID-19 has changed the number of orthodontists that will use remote dental monitoring in the future. Finally, only 20.0% of orthodontists said they would consider practicing teledentistry after the survey, while 57.1% of orthodontists said they would consider practicing remote dental monitoring after the survey.

TABLE 7

CURRENT OVERALL PERCEPTIONS ON TELEDENTISTRY AND REMOTE DENTAL
MONITORING, INCLUDING THE COVID-19 PANDEMIC

	Perceptions of Teledentistry	Perceptions of Remote Dental Monitoring
What are your overall opinions of TD / RDM in orthodontics	N = 65	N = 65
Strongly Positive	4 (6.2%)	12 (18.5%)
Positive	14 (21.5%)	25 (38.5%)
Neutral	23 (35.4%)	17 (26.2%)
Negative	17 (26.2%)	9 (13.8%)
Strongly Negative	7 (10.8%)	2 (3.1%)
Have your overall opinions changed due to COVID-19?	N = 65	N = 65
Yes	21 (32.3%)	40 (61.5%)
No	42 (64.6%)	25 (38.5%)
I Do Not Know	2(3.1%)	0 (0.0%)
Do you think Orthodontists using TD/ RDM will increase in the future?	N = 65	N = 65
Yes	45 (69.2%)	59 (90.8%)
No	8 (12.3%)	1 1.5%)
I Do Not Know	12(18.5%)	5 (6.2%)
Do you think COVID-19 has changed the number of orthodontists that will use TD/RDM in the future?	N = 65	N = 65
Yes	38 (58.5%)	51 (78.5%)
No	16 (24.6%)	9 (13.8%)
I Do Not Know	11 (16.9%)	5 (6.2%)
After the survey, would you consider practicing TD or RDM?	N = 45	N = 28
Yes	9 (20.0%)	16 (57.1%)
No	21 (46.7%)	6 (21.4%)
I Do Not Know	15 (33.3%)	6 21.4%)

CHAPTER 4

DISCUSSION

The purpose of this study was two-fold. First, to survey orthodontists to determine the clinician demographics and practice characteristics that may influence the utilization of teledentistry and/or remote dental monitoring. Second, to describe orthodontists' opinions and perceived barriers regarding teledentistry and remote dental monitoring. Prior to this study, no studies had solely evaluated orthodontists' utilization of, or opinions on, teledentistry and remote dental monitoring. Since the current study began, another study (Dalessandri et al. 2021) was published that evaluated the attitudes of orthodontists and general dentists with regards to "telemonitoring" in orthodontic treatment. The Dalessandri et al. study combined orthodontists' and general dentists' attitudes together and did not solely evaluate orthodontic specialists. Dalessandri et al. was also distributed prior to the COVID-19 pandemic. Multiple previous studies have looked at opinions of general dentists and dental students related to teledentistry, but did not extend into the field of orthodontics (Ramesh et al. 2013; Boringi et al. 2015; Pradhan et al. 2019).

Demographic Factors

This study found that there were no significant associations between orthodontist demographics and utilization of teledentistry or remote dental monitoring. Even though there were no significant orthodontist characteristics, several trends were found. For example, younger and female practitioners were more likely to use teledentistry and remote dental monitoring. Furthermore, practitioners who graduated more recently from residency were more likely to utilize teledentistry and remote dental monitoring. The trend of age and residency graduation year could be due to younger individuals being more comfortable with

technology and they could have also been exposed to these treatment modalities during residency. There is little explanation as to why females tend to utilize teledentistry and remote dental monitoring more than males. At first it was assumed that the females who responded to the survey were younger than the males that responded to the survey, which was true, but not significant. Nearly 42% of the female respondents and 37% of the male respondents were 49 years old or younger.

There were four significant associations found between orthodontic practice characteristics and the utilization of teledentistry or remote dental monitoring, with regards to technologies in the practice. Orthodontists are more likely to use teledentistry if they have digital patient records or an intraoral scanner. The same is true for remote dental monitoring. Orthodontists are more likely to use remote dental monitoring if they have digital patient records or an intraoral scanner. One could assume that if a practice has digital patient records or an intraoral scanner, then the practitioner would be more proficient with technology. Therefore, the practitioner could be more comfortable with similar technology used in teledentistry and remote dental monitoring. However, those that had even more advanced equipment like 3D-printers or CBCT machines were not found to be more likely to utilize teledentistry or remote dental monitoring. On the other hand, even though CBCT machines and 3D printers are more high-tech, a doctor with digital patient records or an intraoral scanner may be better set up to utilize teledentistry and remote dental monitoring, than those without these technologies.

Though it was not significant, the survey showed that practices in urban locations were more likely to use teledentistry. This trend could be due to the saturation of urban orthodontic markets to the point that orthodontists need to branch out and treat patients in

rural areas to increase production. It could also be due to orthodontic specialists feeling they are able to offer better and more efficient patient care by utilizing teledentistry.

Opinion Responses

The current study revealed concerns and perceived barriers orthodontists have with teledentistry and remote dental monitoring. The top three concerns orthodontists have with both teledentistry and remote dental monitoring, whether they utilize these treatment modalities or not, are diagnostic accuracy, exam comprehension, and legal issues. These findings agree with multiple studies (Combi et al. 2016; Kravitz et al. 2016; Lipp et al. 2016; Pradhan et al. 2019). This could show that orthodontists feel they gather more accurate diagnostic information and conduct more thorough exams while being face-to-face with the patient. The concerns of diagnostic accuracy and exam comprehension lead into the third concern, legal issues. Orthodontists could be concerned with legal issues because they fear they are not getting proper diagnostic information or thorough comprehensive exams with teledentistry or remote dental monitoring. The concerns found in this study were different than in the most recent comparable study. The most recent study found a main concern to be the additional time it takes doctors to view the remote monitoring pictures. This concern was not specifically addressed in this survey because it was not mentioned in the literature prior to survey distribution. Another concern found in the previous study was not being able to relate with patients as well as when treating in them in person (Dalessandri et al. 2021), potentially leading to potential lawsuits (Lipp et al. 2016).

An additional problem with teledentistry and remote dental monitoring in orthodontics is that there have never been official standards of what can be treated through these different modalities. The ADA states it "can be an effective way to extend the reach of

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dental professionals" but does not give treatment specifics. The policy was updated November of 2020, during the pandemic, stating services delivered remotely must be consistent with how they would be delivered in-person. The update also addressed the fact that insurances should cover services provided remotely as if they were provided in the office. It also stated that the practitioner should be licensed in the state the patient is receiving treatment (American Dental Association 2020). This most recent update responds to the concerns in this survey about insurance reimbursement and answers the question about state licensing as well. The American Association of Orthodontists (AAO) does not currently have a policy on teledentistry or remote dental monitoring and the ADA's policy could be an excellent template for the AAO to use.

When comparing what orthodontists thought could be treated with remote dental monitoring versus teledentistry, practitioners felt remote dental monitoring was better suited for every treatment choice, except screenings (60.0% vs. 64.6%). These results suggest orthodontists are much more trustworthy of technology and utilizing monitoring software, than treating alongside a general practitioner. This could be due to the high-quality videos and photos available now on applications and mobile devices, or because they would rather work independently than be held liable for the treatment of another practitioner. Multiple respondents also added that treating through teledentistry and teaching general practitioners how to do orthodontics is asking for them to treat patients, instead of referring them. A solution needs to be created so the relationship between the general dentist and the orthodontist is mutually beneficial, leading to the highest quality of care and treatment provided to the patient.

As far as overall opinions on these two treatment modalities, the most common response was "neutral" (35.4%) to teledentistry and "positive" (38.5%) to remote dental monitoring. These results differ drastically to a prior study that found 100% of doctors judged "telemonitoring" positively (Dalessandri et al. 2021). This could be due to the sample of 40 orthodontists and 40 general practitioners being surveyed and combined into the same group for data analysis.

Teledentistry and remote dental monitoring are more relevant now than ever with the COVID-19 pandemic. Many orthodontists were forced to close their offices and see emergency patients only. In this study, over 78% of orthodontists thought COVID-19 will change the number of orthodontists that utilize remote dental monitoring in the future and approximately 62% of orthodontists report that COVID-19 has changed their opinion on remote dental monitoring. A recent survey on perceived impacts of COVID-19 completed by orthodontists and orthodontic resident showed approximately 80% of respondents permanently changed the way they practice orthodontics due to the pandemic. The same study also discussed the increased use of teledentistry and remote dental monitoring (Isiekwe et al. 2020). These results agree with the results gathered in this study.

Clinical Implications

With technology always evolving and the recent COVID-19 pandemic, over 90% of respondents believe the number of orthodontists utilizing remote dental monitoring in the future will increase. The ability to treat patients with remote dental monitoring or teledentistry will continue to rise and practitioners will continue to become more comfortable with the technology. Nearly all patients have a cell phone with a high-quality camera and connection platforms, making remote dental monitoring extremely efficient and convenient.

Utilization of remote dental monitoring could lead to less in-office appointments, resulting in less school or work missed for the patient, but more frequent check-ins with the doctor. This could allow patients to feel more comfortable and confident during their treatment, without the hassle of coming to the office. These treatment modalities also allow orthodontists to more frequently monitor compliance with oral hygiene, clear aligners, or elastics. Remote dental monitoring and teledentistry could also catch problems between the standard four to six-week intervals between appointments, preventing lost treatment time due to broken brackets or appliances.

The COVID-19 pandemic showed the profession just how beneficial remote dental monitoring could be when practitioners were forced to close their offices and could not see their patients for an in-person exam, unless there were emergent circumstances. This led many providers wanting to help and treat their patients, but not having the avenue to do so. After COVID-19, one respondent from this survey stated, "I now view having these options available as a necessity, rather than a nice convenience" and "the pandemic simply sped the process of adoption" (Appendix E).

Based on the survey results, orthodontists do feel there is a place for teledentistry and remote dental monitoring in the profession, but they do not feel either modality is a complete substitution for hands-on care. Many respondents are hesitant due to diagnostic accuracy and legal issues. There are two things that could help change negative opinions on utilization of remote dental monitoring and teledentistry. First, if the American Association of Orthodontists would create guidelines of what is, and what is not, appropriate to treat remotely then practitioners would have a standard to follow. Second, if orthodontic residents were exposed to these modalities during their orthodontic residency programs, it would allow

them to become familiar with the technologies and benefit patient care. This would enable them to form their own opinions on teledentistry and remote dental monitoring after having experience with them, very similar to experimenting with different brackets and clear aligner therapy during residency.

Study Limitations

The main limitation of this study was the small sample size. The survey was distributed to 2,171 orthodontists, of which 81 orthodontists initiated the survey, and 65 orthodontists completed the survey. This leads to a total response rate of 3.0 percent. The low response rate was likely due to the generic email sent out from the AAO Foundation. A better approach could have been to reach out to orthodontists with a more personal message, being sure to not add any bias to the study. The response rate may have been higher if the survey was incentivized upon completion.

Additionally, the survey was sent out in November of 2020, during the COVID-19 pandemic. Orthodontic practitioners were likely very anxious about their own patients and managing their practices during such unforeseen times, they were likely too busy to complete a survey from an orthodontic resident.

Additional responses received from the survey were from practitioners that lived in areas were these modalities are not legal, or in different countries that were not included in the choices of some of the questions. It is important when developing survey questions to make them suitable for all responses, and that could have been executed better in this survey.

Future Studies

Opinions of teledentistry and remote dental monitoring appear to be improving in the orthodontic community. While many practitioners are already utilizing these modalities,

others reported they plan to utilize them in the future. Future studies should focus more on what practitioners think would be appropriate standards when using teledentistry or remote dental monitoring. The answers to these questions could help the AAO more clearly address this issue.

Another survey could also go deeper into the concerns with these modalities and ask what is not accurate enough for diagnostics, or which part of the exam is not comprehensive enough. This would enable companies to address these problems with software upgrades to make the practitioner much more comfortable with the technology. It would also be interesting to see the exact same survey distributed well after the pandemic to compare the results.

CHAPTER 5

CONCLUSIONS

1) There were no statistically significant associations between orthodontist

    demographics and their utilization of teledentistry or remote dental monitoring.

2) Statistically significant associations were found between orthodontic practice

    technologies and utilization of teledentistry and remote dental monitoring.

    Orthodontists are more likely to utilize teledentistry, as well as remote dental

    monitoring, if they are using digital patient records, or if they have an intraoral

    scanner.

3) Opinion questions revealed:

    a. The three main concerns orthodontists have with teledentistry and remote

        dental monitoring are diagnostic accuracy, exam comprehension, and legal

        issues.

    b. Over half of the respondents agreed it was appropriate to monitor oral

        hygiene, conduct screenings, and manage orthodontic emergencies utilizing

        either teledentistry or remote dental monitoring.

    c. The majority of orthodontists' opinions of remote dental monitoring changed

        due to COVID-19

    d. The majority of orthodontists think that utilization of teledentistry and remote

        dental monitoring utilization will increase in the future.

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APPENDIX A

FOCUS GROUP SURVEY EVALUATION FORM

Dear Dr. XXX,

The research I am working on at UMKC investigates orthodontists' perceptions of teledentistry and remote dental monitoring. The attached survey will eventually be sent to members of the American Association of Orthodontists in hopes of better understanding current perceptions on teledentistry and remote dental monitoring. No personal identification information will be gathered from this survey. The final survey will be distributed in electronic form and will automatically end the survey or give additional questions depending on user responses. Please take the time to evaluate the attached survey for clarity and content. You are not expected to complete the survey, but rather to examine it with a critical eye. Please feel free to write comments on the attached survey if necessary.

Please fill out and return this page once you have completed your evaluation of the survey. A prepaid envelope is attached to this evaluation for easy return. Please mail the completed evaluation back to me within 1-2 weeks of receiving it. Your comments will help improve the survey prior to distribution to orthodontists throughout the country. If you receive this survey through the American Association of Orthodontists in the future, then please do NOT complete the survey. Thank you so much for your time in evaluating this survey. I could not succeed in this program without you.

Gratefully,
Grant Severs

Evaluation of Survey

Are there any questions within the survey that are unclear or could be worded differently to improve the survey? If so, please explain.

Are there any errors present in the survey such as grammatical errors? If so, please explain.

Are there any questions that could be omitted from the survey? If so, please explain.

Please give any other suggestions you might have to improve the survey.

APPENDIX B

SURVEY

Teledentistry and Remote Dental Monitoring Survey

| **Orthodontist Characteristics** |

1. Are you currently practicing orthodontics?

   ○ Yes   ○ No

2. What age range do you fall in?

   ○ Younger than 30   ○ 30-39   ○ 40-49   ○ 50-59   ○ 60-69   ○ 70 or older

3. What year did you graduate from your orthodontic residency?

   ○ Prior to 1960   ○ 1960-1974   ○ 1975-1989   ○ 1990-2004   ○ 2005-2020

4. What is your gender?

   ○ Male   ○ Female   ○ Do not wish to answer   ○ Other/Prefer to self-describe

4a. You selected 'Other/Prefer to self-describe' for gender. Please write in your preference.

   _____

5. In which region is the orthodontic program from which you graduated?

   PLEASE REFER TO THE MAP BELOW

   ○ A. Pacific
   ○ B. Rocky Mountains
   ○ C. Southwest
   ○ D. Midwest
   ○ E. Southeast
   ○ F. Northeast
   ○ G. Noncontiguous

U.S. Map Regions

6. What is your primary status as an orthodontic practitioner?

○ Owner
○ Associate
○ Employee
○ Independent Contractor
○ Dental school faculty
○ Retired

Orthodontic Practice Characteristics

7. How many orthodontic office locations do you currently work in?

   _____

8. Which of the following would you consider your primary practice location?

   ○ Rural   ○ Suburban   ○ Urban/Metro

9. What percent of your patients would you consider to live in a rural community?

   _____

10. In which region is your primary orthodontic practice located?

    PLEASE REFER TO THE MAP BELOW

    ○ A. Pacific
    ○ B. Rocky Mountains
    ○ C. Southwest
    ○ D. Midwest
    ○ E. Southeast
    ○ F. Northeast
    ○ G. Noncontiguous

11. How many orthodontists, including yourself, work in the practice where you spend the majority of your time?

    _____

12. Which of the following technologies do you have in your practice where you spend the majority of your time? Select all that apply.

☐ Digital Radiographs   ☐ Digital patient records   ☐ Intraoral scanner   ☐ CBCT   ☐ 3D Printer

13. What do you think teledentistry and remote dental monitoring encompass?

Check all that you agree with.

	Teledentistry	Remote Dental Monitoring
Provide long distance clinical healthcare	☐	☐
Provide care to remote and/or rural locations	☐	☐
Support health related patient education and advice	☐	☐
Support long distance patient/doctor relationships	☐	☐
Support patient monitoring	☐	☐
I do not know	☐	☐
Other	☐	☐

13g1You selected "Other" for what teledentistry encompasses. Please elaborate here:

_____

13g2You selected "Other" for what remote dental monitoring encompasses. Please elaborate here:

_____

PLEASE USE THE FOLLOWING DEFINITIONS TO COMPLETE THE REST OF THE SURVEY. The images will continue to appear throughout the rest of the survey for your reference.

Teledentistry: A general dentist sends patient information to an orthdontist for consultation. The orthodontist can then provide a simple opinion or more complex treatment guidance for the general dentist to treat the patient.
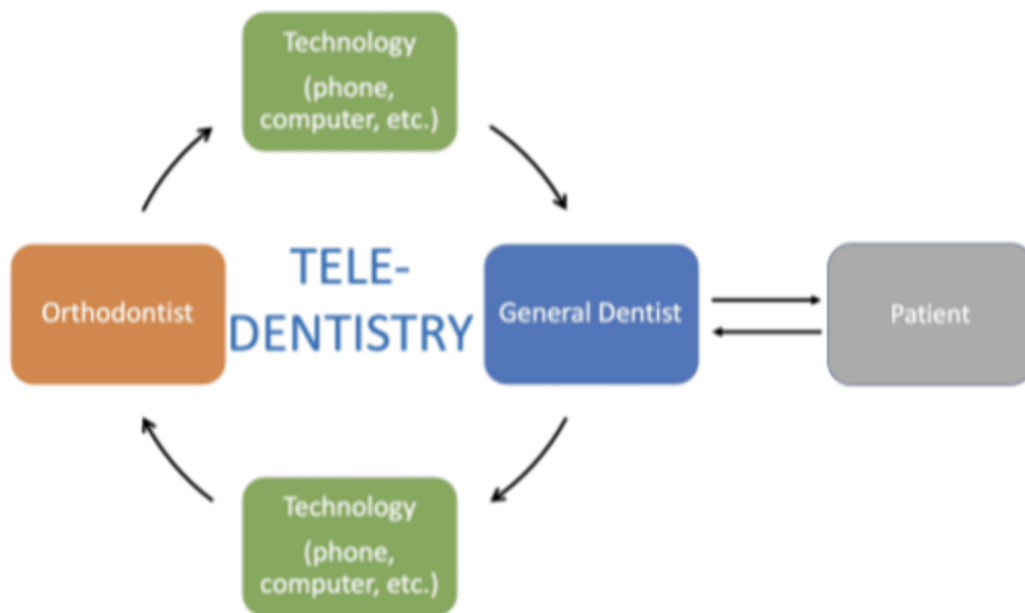
Remote Dental Monitoring: An orthodontist directly treats a patient utilizing remote technology, and may only meet with the patient in person when deemed necessary.
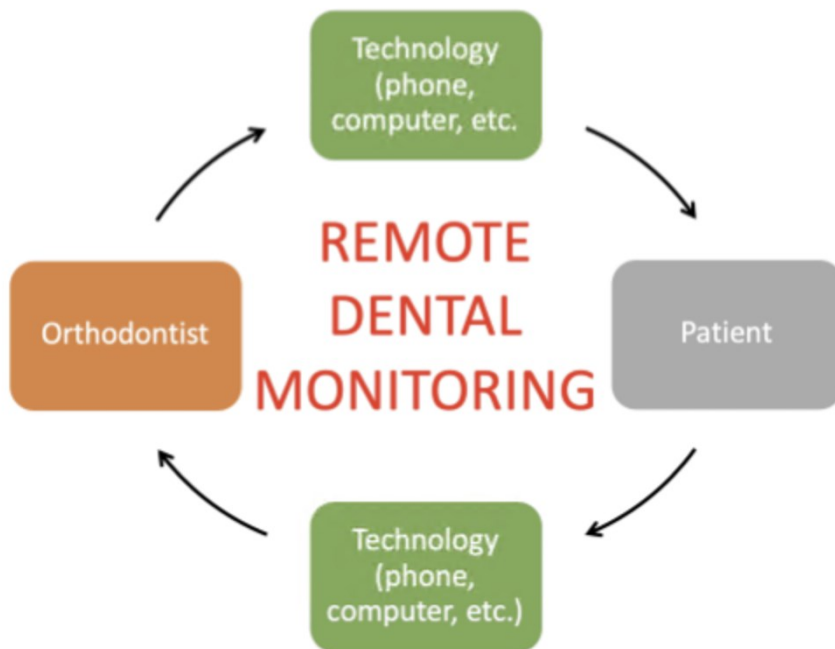
14. Are you currently practicing …
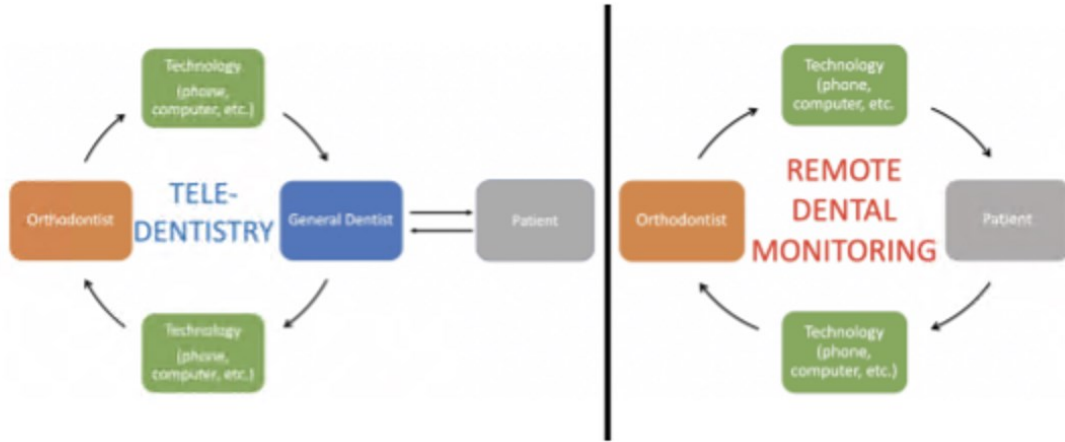
	Yes	No
Teledentistry	O	O
Remote Dental Monitoring	O	O
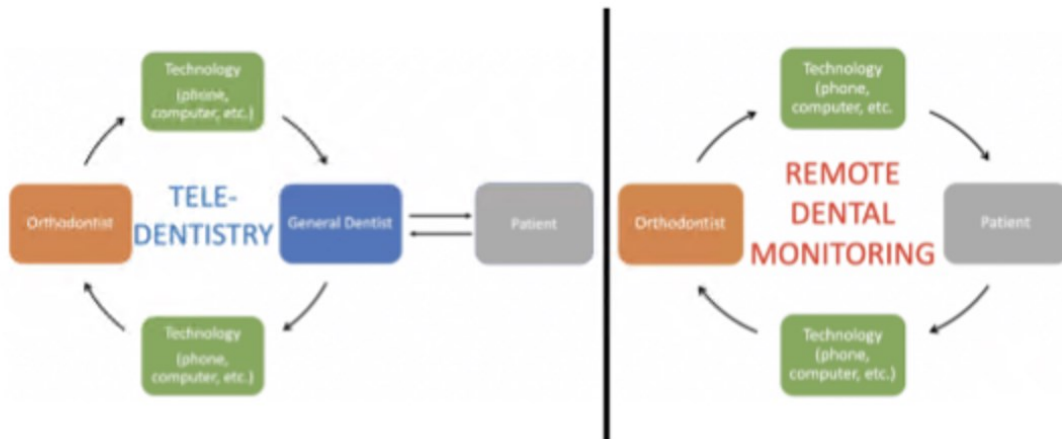
15. Since you do currently use teledentistry, what were your concerns about implementing it in practice, or barriers you had to overcome?
Please select all that apply.

☐ Diagnosis accuracy
☐ Exam comprehension
☐ Legal issues (dental board laws, HIPPA violations, malpractice, etc.)
☐ Technology
☐ Expense
☐ Reimbursement issues with Medicaid/Insurance companies
☐ Time investment needed to initially learn and use it regularly
☐ Other

15a. You selected "Other" about your concerns when implementing teledentistry. Please elaborate here.

_____

15. Since you do not currently use teledentistry, what are your concerns about implementing it in practice?

Please select all that apply.

☐ Diagnosis accuracy
☐ Exam comprehension
☐ Legal issues (dental board laws, HIPPA violations, malpractice, etc.)
☐ Technology
☐ Expense
☐ Reimbursement issues with Medicaid/Insurance companies
☐ Time investment needed to initially learn and use it regularly
☐ I am not interested in changing my practice model
☐ I have no concerns, I just have not invested in these methods yet
☐ Other

15a. You selected "Other" for concerns about implementing teledentistry. Please elaborate here.

_____

16. Since you do currently use remote dental monitoring, what were your concerns about implementing it in practice, or barriers you had to overcome?

Please select all that apply.

☐ Diagnosis accuracy
☐ Exam comprehension
☐ Legal issues (dental board laws, HIPPA violations, malpractice, etc.)
☐ Technology
☐ Expense
☐ Reimbursement issues with Medicaid/Insurance companies
☐ Time investment needed to initially learn and use it regularly
☐ Other

16a. You selected "Other" about your concerns when implementing remote dental monitoring. Please elaborate here.

_____

16. Since you do not currently use remote dental monitoring, what are your concerns about implementing it in practice?

Please select all that apply.

☐ Diagnosis accuracy
☐ Exam comprehension
☐ Legal issues (dental board laws, HIPPA violations, malpractice, etc.)
☐ Technology
☐ Expense
☐ Reimbursement issues with Medicaid/Insurance companies
☐ Time investment needed to initially learn and use it regularly
☐ I am not interested in changing my practice model
☐ I have no concerns, I just have not invested in these methods yet
☐ Other

16a. You selected "Other" for concerns about implementing remote dental monitoring. Please elaborate here.

_____

17. Do you think orthodontists could improve access to orthodontic treatment (for example, help treat under-served populations) using...
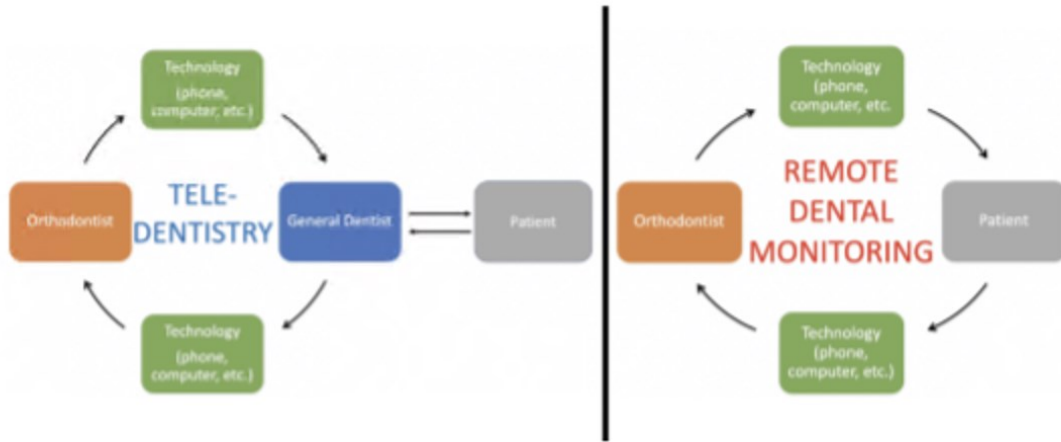
	Yes	No	I do not know
Teledentistry	O	O	O
Remote Dental Monitoring	O	O	O

18. Do you think referrals could be better facilitated from the patient's dental home (for example, expedite the referral process or prevent in appropriate referrals) using....
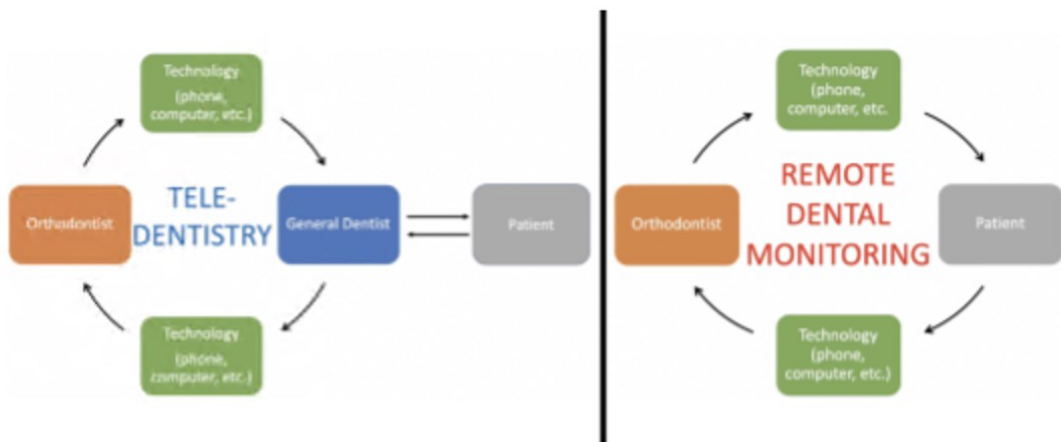
	Yes	No	I do not know
Teledentistry	O	O	O
Remote Dental Monitoring	O	O	O

19. Do you think you could help monitor patients' oral hygiene using...
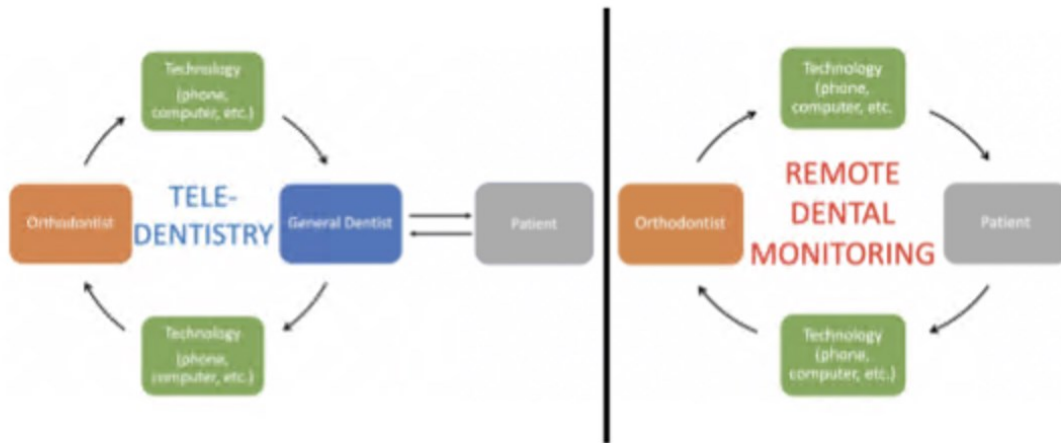
	Yes	No	I do not know
Teledentistry	O	O	O
Remote Dental Monitoring	O	O	O

20. Do you think orthodontists can treat patients to the current standard of care using...
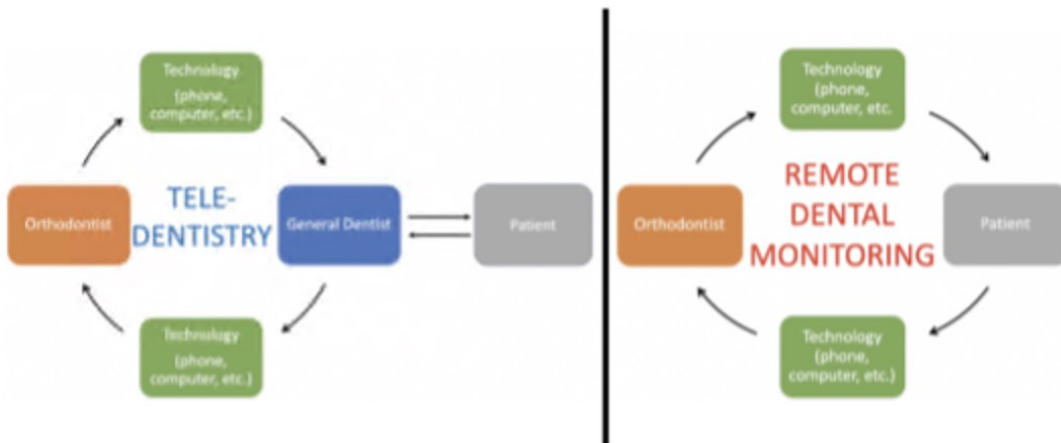
	Yes	No	I do not know
Teledentistry	O	O	O
Remote Dental Monitoring	O	O	O

21. Do you think traditional examinations conducted by an orthodontist in an office setting have similar accuracy when compared with limited visual examinations using...
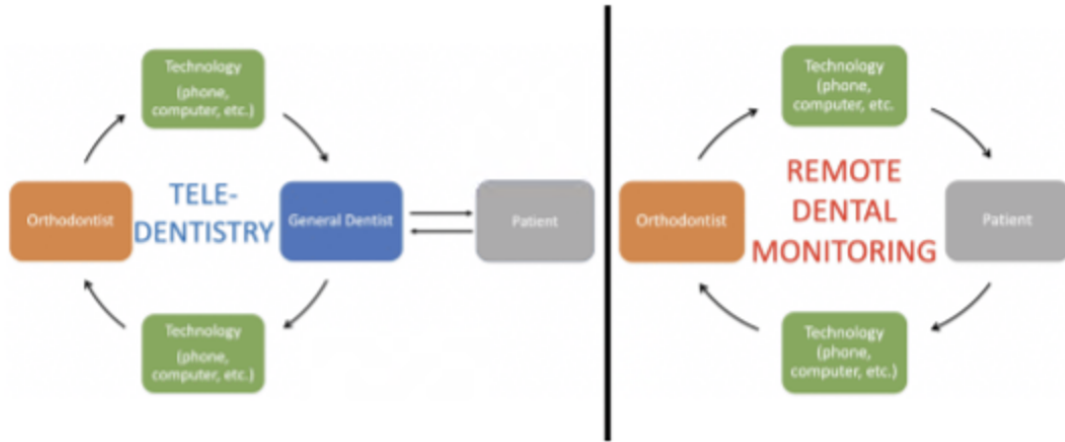
	Yes	No	I do not know
Teledentistry	O	O	O
Remote Dental Monitoring	O	O	O

22. Do you think either of the following treatment models could be a useful tool in addition to traditional orthodontic care? For example, reducing unnecessary appointments or properly managing emergency situations.
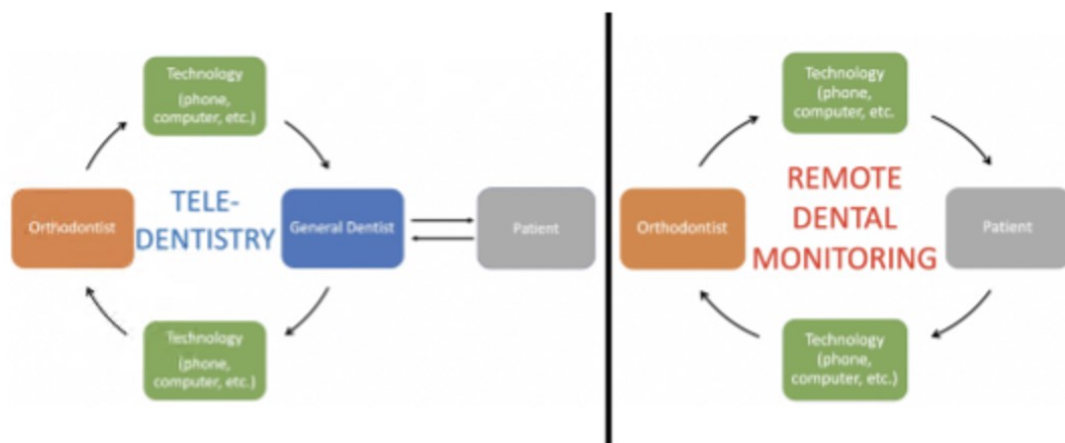
	Yes	No	I do not know
Teledentistry	O	O	O
Remote Dental Monitoring	O	O	O

23. After initial implementation costs, do you think you could reduce costs for your orthodontic practice using…
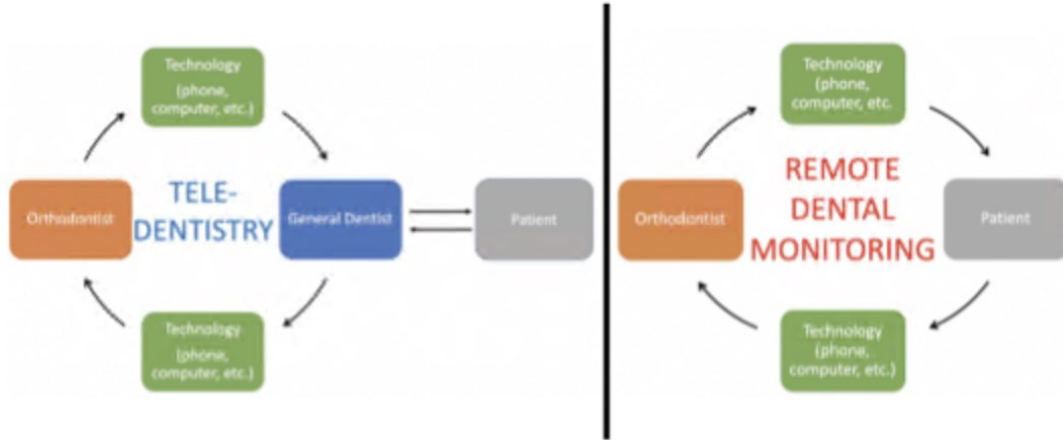
	Yes	No	I do not know
Teledentistry	O	O	O
Remote Dental Monitoring	O	O	O

24. After the initial learning time, do you think you could save time using…
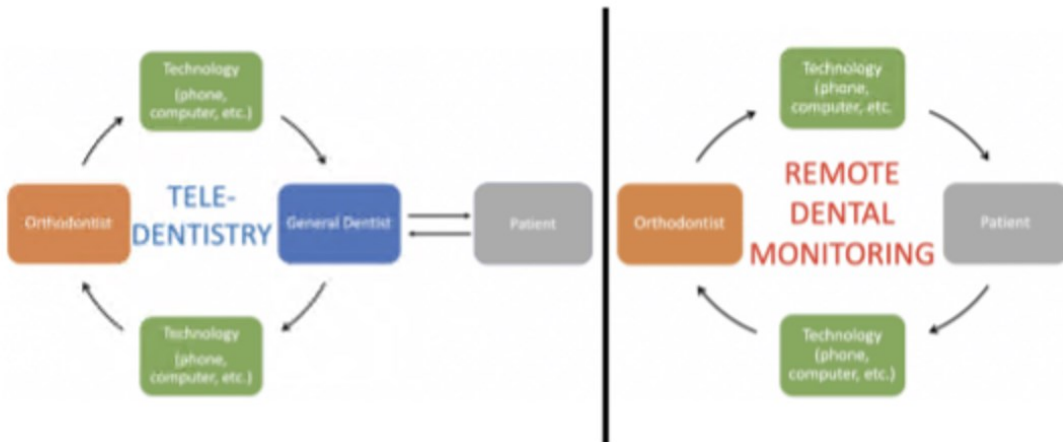
	Yes	No	I do not know
Teledentistry	O	O	O
Remote Dental Monitoring	O	O	O

25. What treatment modalities could be effectively treated using teledentistry (orthodontist helps general dentist) and remote dental monitoring (orthodontist conducts treatment remotely)?

Check all that you agree with.
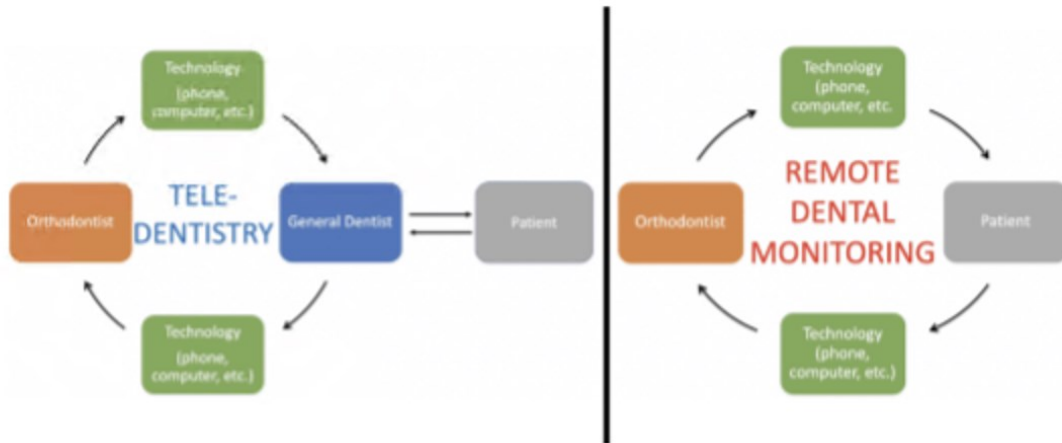
	Teledentistry	Remote Dental Monitoring
Elastic wear	☐	☐
Expander checks	☐	☐
Midline discrepancy	☐	☐
Progress using clear aligners	☐	☐
Oral Hygiene	☐	☐
Screening candidates for orthodontic treatment	☐	☐
Evaluation of relapse/retainer checks	☐	☐
Management of orthodontic emergencies	☐	☐
Other	☐	☐

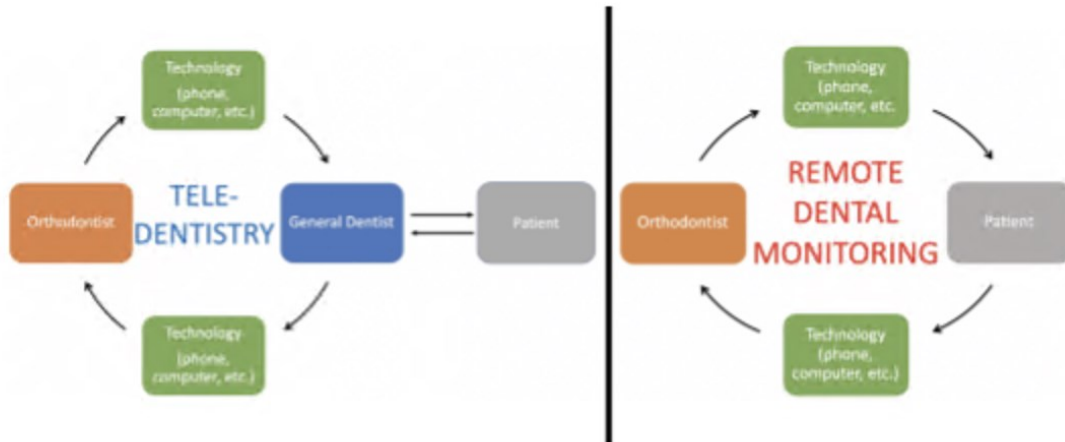You selected "Other" for effective treatment modalities using teledentistry. Please elaborate here.

_____

You selected "Other" for effective treatment modalities using remote dental monitoring. Please elaborate here.

_____

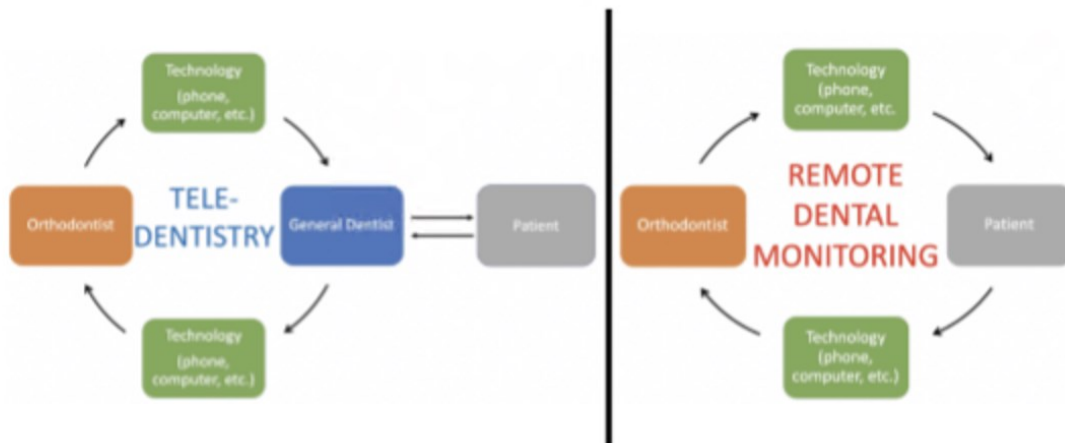**26. What are your overall opinions on the following treatment models being used in the field of orthodontics?**

	Strongly Positive	Positive	Neutral	Negative	Strongly Negative
Teledentistry	O	O	O	O	O
Remote Dental Monitoring	O	O	O	O	O

27. Have your overall opinions changed due to COVID-19 on the following treatment models being used in the field of orthodontics?
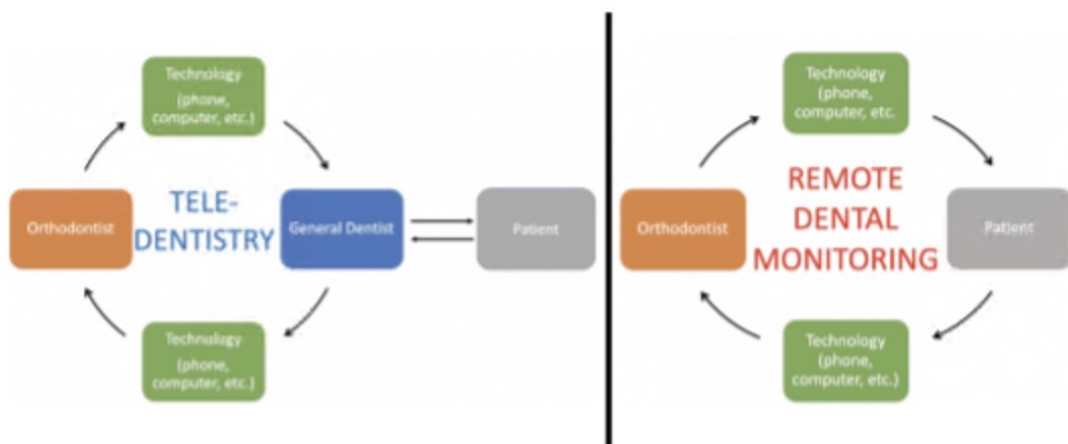

	Yes	No	I do not know
Teledentistry	O	O	O
Remote Dental Monitoring	O	O	O

28. Do you think the number of orthodontists using the following treatment models will increase in the next decade?
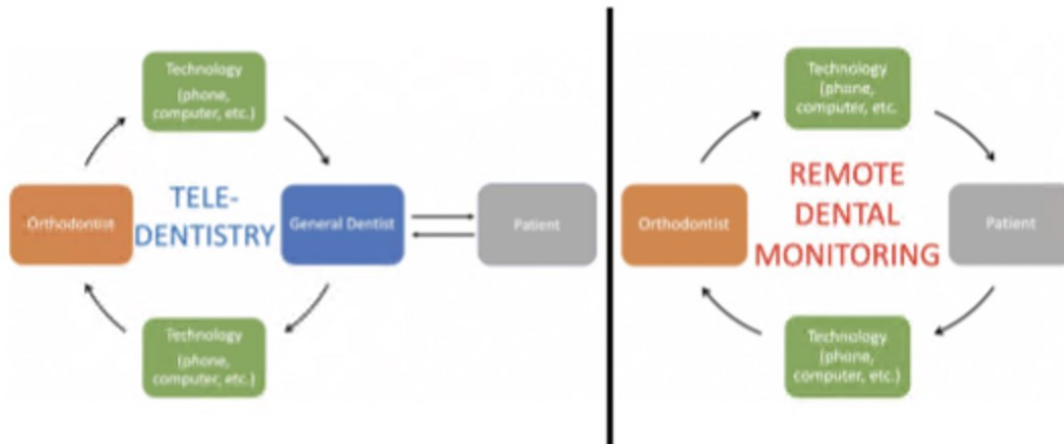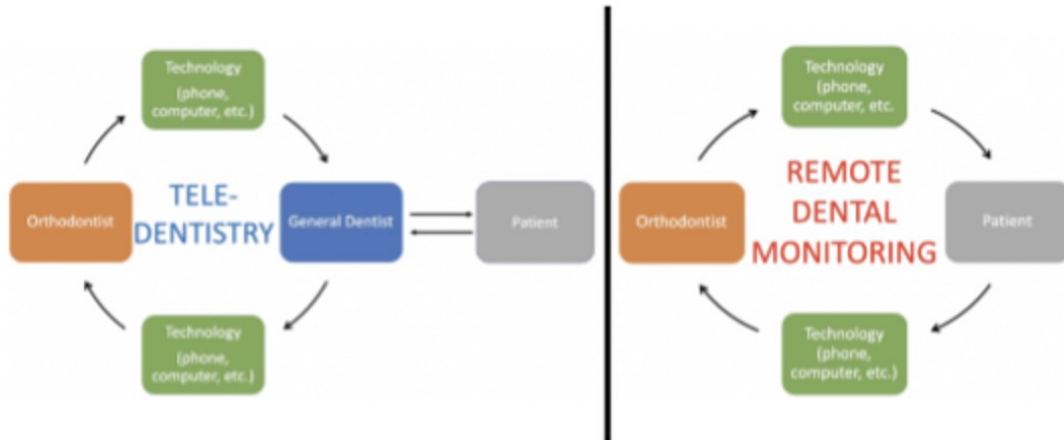

	Yes	No	I do not know
Teledentistry	O	O	O
Remote Dental Monitoring	O	O	O

29. Has COVID-19 changed your opinions on the number of orthodontists that will be using the following treatment models in the next decade?

	Yes	No	I do not know
Teledentistry	O	O	O
Remote Dental Monitoring	O	O	O

After answering the previous survey questions, would you consider practicing teledentistry?

○ Yes   ○ No   ○ I do not know

After answering the previous survey questions, would you consider implementing remote dental monitoring in your practice?

○ Yes   ○ No   ○ I do not know
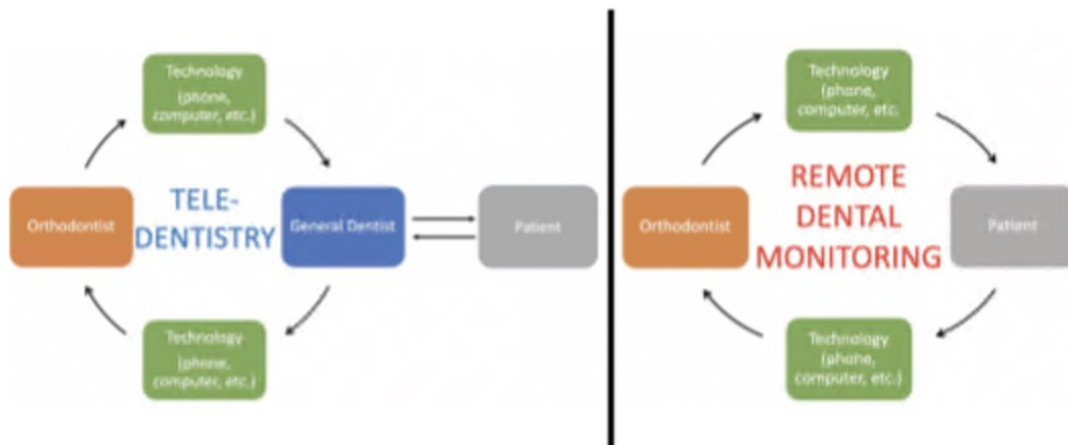
In closing, if you care to elaborate on how the COVID-19 pandemic influenced your opinions on teledentistry or remote dental monitoring, please do so here:

APPENDIX C

AAO SURVEY EMAIL PROMPT

Dear AAO Member,

My name is Grant Severs and I am an orthodontic resident and MS candidate in the Oral and Craniofacial Sciences at the University of Missouri-Kansas City. My thesis project is focused on orthodontists' opinions on teledentistry and remote dental monitoring in the field of orthodontics. The goal of this research is to better understand orthodontists' viewpoints on teledentistry and remote dental monitoring, as well as factors that may influence these opinions. To accomplish this goal, I am asking you to complete the survey that is accessible via the link provided below.

This 30-question survey should take approximately 10 minutes to complete. All responses to this survey are anonymous with no identifying marker linked to your responses. The results of the survey may be published, but your identity will remain confidential. Your participation is entirely voluntary; you may skip any questions that you don't want to answer or choose to stop participating at any time. If you decide to participate, please complete this survey within 10 days of receiving it. Any survey responses you provide will be a valued contribution to this project, and I thank you in advance for your time.

If you have any questions concerning the survey, you may contact me at seversg@umkc.edu. If you have any questions regarding your rights as a research participant, you may contact the UMKC IRB at 816-235-5927.

Gratefully,

Grant Severs, DMD

APPENDIX D

IRB APPROVAL LETTER

July 08, 2020

Principal Investigator: Mary P Walker
Department: Dean, School of Dentistry

Your IRB Application to project entitled "Orthodontists' Perceptions of Teledentistry and Remote Dental Monitoring in Orthodontic Treatment -- OCS MS Severs" was reviewed and determined to qualify for IRB exemption according to the terms and conditions described below:

IRB Project Number	2025235
IRB Review Number	267311
Initial Application Approval Date	July 08, 2020
IRB Expiration Date	
Level of Review	Exempt
Exempt Categories	45 CFR 46.101b(2)
Risk Level	Minimal Risk
HIPAA Category	No HIPAA

The principal investigator (PI) is responsible for all aspects and conduct of this study. The PI must comply with the following conditions of the determination:

1. No subjects may be involved in any study procedure prior to the determination date.
2. Changes that may affect the exempt determination must be submitted for confirmation prior to implementation utilizing the Exempt Amendment Form.
3. The Annual Exempt Form must be submitted 30 days prior to the determination anniversary date to keep the study active or to close it.
4. Maintain all research records for a period of seven years from the project completion date.

If you are offering subject payments and would like more information about research participant payments, please click here to view the UM system Policy on Research Subject Payments: https://www.umsystem.edu/oei/sharedservices/apss/nonpo_vouchers/research_subject_payments

If you have any questions, please contact the IRB at 816-235-5927 or umkcirb@umkc.edu.

Thank you,
UMKC Institutional Review Board

APPENDIX E

OPEN RESPONSE ANSWERS ON INFLUENCE OF PANDEMIC

Q: In closing, if you care to elaborate on how the COVID-19 pandemic influenced your opinions on teledentistry or remote dental monitoring, please do so here:

1. Both options are helpful if coming to the office is not an option, but I find them inefficient and usually minimally helpful in practice.
2. Covid has proven that remote monitoring and teledentistry can be a useful tool in the overall treatment of patients, but it is not a direct replacement for in person doctor/patient evaluation. Too many things are missed without accurate in person assessment leading to decreased treatment quality and a decrease in the overall patient care/experience.
3. COVID-19 created unique circumstances and limitations that needed to be overcome in order to maintain/resume patient care. These technologies became part of the solution and convinced many that this was a viable avenue for patient care. Previously many thought of these as futuristic options that were secondary to live patient visits.   As a side note, in the question regarding which region orthodontic training was completed, Canada and other countries were not an option. There should have been an 'other' choice.
4. COVID-19 has forced the implementation of some virtual strategies that make treatment better, and more efficient for patients and doctors.
5. gives a point of contact during prolonged interludes between patient visits in the office that might fend off increased treatment time and poor results
6. HI - Great survey! The pandemic changed my opinion because I now view having these options available as a necessity rather than a nice convenience or perk to the patients. The other thing that is really nice is that my conference time is all virtual. Therefore, we have added more virtual conferencing and then the clinic runs on-time more often. The patients that have questions either already have had a conference or they get one scheduled. There is much less stress in clinical time and reduced clinical time. Also, we are set-up for broken brackets, etc. so there are very few appointments that run differently than expected due to remote dental monitoring. We went from 25% remote dental monitoring to 95% remote dental monitoring during COVID and our collections went down only 2%. The pandemic simply sped the process of adoption. We want to make sure the quality of care is amazing and efficient - using AI to help do this increases both quality of care, better use of time and clinical efficiency.
7. I have always valued teledentistry and remote dental monitoring in certain cases such as monitoring oral hygiene, the amount of expansion, and the elastic wear especially for patients who live far. Covid-19 has further solidified my desire to continue to use these useful tools in addition to the tradition in-office comprehensive clinic care.
8. I have looked into ways to reduce number of physical appointments. However, I have found a hard time visualizing posterior teeth and proper occlusion/shifts. So have now been looking how to offer consultations online only after I have seen patient.

Want to save physical site visits to discuss treatment plans, plan changes, using photos/video to assess emergencies.

9. I think patients are much better served in person many clinical details are found by working on the patients much will be missed with in office observation.

10. I'm concerned that using teledentistry for diagnosis and recommending treatment in orthodontics will harm patients.

11. In the same way we train our clinical assistants to provide care, an orthodontist could train a general dentist to provide care for orthodontic patients with coaching via teledentistry. The challenge is it takes time and in-person coaching to convey treatment techniques and clinical diagnostic skills. I don't believe most ortho-GP models of teledentistry that I've seen invest the time needed to get excellent clinical outcomes. I don't think the pandemic has influenced my negative opinion about teledentistry. However, I've become more open to, and started using remote dental monitoring in my practice out of necessity during our practice closure, and have implemented RDM systems for observation, retention checks and screening exams as a direct result of the pandemic.

12. It forced us to rethink how we practice and figure out how to evaluate patients remotely when necessary.

13. It has forced me to adjust to remote - which is good as I've realized there are some procedures that can be monitored through remote.

14. It hasn't. There are so many things you cannot see remotely. Ethically I see big problems with it. The orthodontists who wish to use it to save office time and only make money will use it. The professionals with ethics will use it very little.

15. It made me research it more. We tried it, but I realized in my hands that a quick clinical exam is much more productive and accurate.

16. It would have been easier to adopt if we had more software to facilitate virtual appointments.

17. Made me make the jump to offer virtual care and consultations

18. Most of us are able to collaborate with referring DDS fairly well. IF we can help them evaluate patients preOrtho ,we could save everyone time and money and increase referrals. Doctor to patient interaction can increase significantly remotely to help with elastic wear or solve concerns. Clear aligner treatments benefit the most as we lose no time and can mail additional aligners saving office visits, within reason.

19. Neither generally helps me in practice, too difficult to see on phone/ camera. Problems need to be seen in an office anyway. We have managed emergencies over the phone for years and can describe how to alleviate many issues. Both methods just don't help me treat patients.

20. neither of those have changed think there will be more consolidation of the market with increased corportate penetration into the market

21. Once I was allowed to re-open my offices, I am practicing direct patient care. The protocols create some inefficiencies, but the quality of direct care is superior to the two models discussed here.

22. Patients do not want to drive and wait in the waiting room for a 'quick check' anymore. I do not want to spend resources on PPE to see them either. It works for both parties and when something is in question, we ask to see them physically. If teledentistry is helping a GD treat ortho patients, my concern is that it would take a lot of my time that would be unreimbursed. If it is to discuss the patients needs during treatment or a referral, that is already being done.

23. Smile Direct Club has had more of an effect on teledentistry and remote dental monitoring than COVID-19.

24. The implementation of teledentistry in my practice allowed me to monitor my orthodontic patients progress while they were not allowed to come to the office during the lockdown period. Teledentistry will remain an important part of my practice going forward. My concerns with remote dental monitoring is that practitioners will use it exclusively forsaking face-to-face monitoring of a patient's orthodontic progress. As much as patients try to get good images of their dentition, they many times do not. If the doctor could be insured that the images were of an excellent quality for diagnostic purposes then it may work in some cases but many times there is information that we cannot discern in photos compared to face-to-face. An additional concern is that right now aligner treatment is viewed as an orthodontic 'money grab' by general dentists. Can you imagine what would happen if these GPs would think 'Wow, I can make money by doing aligners in my office and I don't even need to see them in the office. Just give them the aligners and 'monitor' how they're wearing them.'?

25. The pandemic has accelerated the paradigm shift regarding when and how often we need to see our patients.

26. Very useful but with limited use Useful to reduce the number of patients in the waiting room by spreading their visit interval longer up to 8-10 weeks while still being 'somewhat' monitored. But at somepoint patient still need to come (even if it is clear aligner patients

27. we are using an app we created long before covid called VOV or virtual orthodontic assistant. It has really helped during covid.

28. We currently are not allowed to practice teledentistry in Texas. When we were shut down for 7 weeks, it would have been a great tool to keep in touch with our patients.

29. We have utilized remote dental monitoring with photos pre-covid to assist patients with emergencies. We have long utilized teledentistry advising referring doctors on cases they had questions with. During covid, we utilized Zoom to track progress. It is difficult with lighting, photography, consistency and documentation with remote dental monitoring in addition to diagnosing occlusal disharmony. Ultimately hands on is the best for an orthodontic patient as the details in a sub-millimeter specialty are not readily available on a computer screen.

30. We initiated teledentistry aspects in practice only to find them unwieldy and ultimately a time drag. Poor images confounded issues. For screening emergencies it was useful. We dropped this quickly once we were able to see patients in-person.

We were invited to initial testing of a monitoring system. We provided the units to patients and NOT ONE ever used it.
31. We rarely used remote dental monitoring pre COVID-19. Now we use it regularly and are glad to have it as a backup in case we get closed down for a period of time.
32. We used both of these modalities during Covid closures in our office. We have continued to use these to help us see more patients while keeping patient numbers in our office lower. We have continued to use virtual consultations for repair visits, retainer checks, observation and growth checks.
33. We were already using remote dental monitoring prior to Covid. Orthodontist should be in an orthodontist's hands.
34. While teledentistry and/ or remote dental monitoring is a good application to serve the patient, it does NOT eliminate the need for in person appointments. I also feel that despite teaching patients and parents how to take good home photos, the quality of photos I have received are sub-par and non-diagnostic for pretty much all of my needs to treat a patient remotely. Teledentistry and remote dental monitoring are pretty much only good for Invisalign patients in my opinion!
35. Your definition of Teledentistry to me would be training the general dentist to become comfortable performing orthodontics him/herself, and you have now lost a referral source and all those patient starts. Remote dental monitoring means fewer patient visits and no traveling for the patients for routine retainer checks.

VITA

NAME: Grant Severs

DATE AND PLACE OF BIRTH: June 30, 1992; Macomb, IL

EDUCATION:

5/2011	Diploma	Macomb High School Macomb, IL
5/2015	BS/Biology	Western Illinois University Macomb, IL
5/2019	D.M.D.	Southern IL University Edwardsville School of Dental Medicine Alton, IL

RESIDENCY:

2019-Present	Orthodontics & Dentofacial Orthopedics	University of Missouri-Kansas City School of Dentistry Kansas City, MO

PROFESSIONAL ORGANIZATIONS:

2019-Present American Association of Orthodontists
2015-Present American Dental Association

HONORS:

2020   Chief Resident, UMKC Department of Orthodontics
2019-2021   American Association of Orthodontics Resident Champion, UMKC
2019   Omicron Kappa Upsilon Inductee