Journal of Orthodontic and Periodontal Biomaterials Research

2022, Volume 2, Issue 1, Page No: 42-50

Available online at: https://galaxypub.co/

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Perspectives on Telemonitoring in Orthodontics among Clinicians and Patients

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Received: 28 February 2022; **Revised:** 14 May 2022; **Accepted:** 16 May 2022

ABSTRACT

This study aimed to evaluate the perceptions of dentists and patients regarding Dental Monitoring™ (DM), a telemonitoring software for orthodontic care. To achieve this, two specifically designed questionnaires were administered to 80 dentists (40 general practitioners and 40 orthodontists) and 80 orthodontic patients. All participating dentists viewed telemonitoring positively, with 96.25% associating it with advanced technology and high-quality care, and 100% acknowledging its potential to reduce in-office appointments; 17.5% preferred weekly telemonitoring, 40% biweekly, and 42.5% less frequently. Similarly, 97.5% of patients had a favorable opinion of telemonitoring, 81.25% linked it to high-tech treatment, and 81.25% expressed interest in using it to minimize office visits; 27.5% were willing to take weekly self-images, 57.5% every two weeks, and 15% less often. Overall, both patients and dentists perceived telemonitoring as a technologically advanced approach that enhances treatment quality and precision, while showing interest in reducing office visits, even though not all were prepared to commit additional time or expense.

Keywords: Smartphone, Orthodontics, Telemonitoring

How to Cite This Article: Johansen NJ, Lund SY. Perspectives on Telemonitoring in Orthodontics among Clinicians and Patients. J Orthod Periodontal Biomater Res. 2022;2(1):42-50. https://doi.org/10.51847/8IAb1zWHJY

Introduction

Orthodontic treatment often extends over long periods, particularly when side effects arise that are only identified by the clinician after several months [1]. In recent years, diverse strategies—both surgical and non-surgical—have been proposed to accelerate treatment, focusing on enhancing the biological processes of tooth movement, customizing appliance fabrication, and designing clinical protocols that precisely guide tooth displacement while minimizing inefficient back-and-forth motions [2-7]. Regardless of the chosen method, close monitoring of treatment progression is essential to prevent delays and limit the impact of unforeseen complications [8].

The rapid adoption of digital devices such as smartphones, tablets, and computers—especially among adolescents—has fostered new communication habits, with increasing demand for immediate information and real-time support [9]. Dentistry has adapted to this "always-connected" environment through teledentistry, defined by the Association of American Medical Colleges as "the use of telecommunications technology to transmit data, graphics, audio, and video images between physically separated participants for clinical care purposes" [10]. Teledentistry encompasses a broad range of digital interactions, including web-based tools, distance learning, and thousands of healthcare applications designed for patient education, data collection, and ongoing monitoring [11-14].

The advantages of teledentistry are numerous: it allows clinicians to monitor treatment remotely, improves access to care, promotes patient education, enables early detection of dental issues, increases patient compliance, reduces travel, ensures appliance integrity, supports oral hygiene oversight, limits unnecessary visits, promptly alerts clinicians to emerging problems, and reduces both routine check-ups and emergencies [15, 16]. Innovative approaches include kiosks, web-based monitoring systems, wearable devices, and video consultations [17]. Given

the widespread ownership of smartphones [18], messaging platforms such as WhatsApp© (WhatsApp Inc., Mountain View, CA, USA), Telegram© (Telegram Messenger Inc., London, UK), and WeChat© (Tencent Holdings Limited, Shenzhen, China) have been effectively applied for emergency communication and oral health promotion [19–24].

Dental Monitoring™ (DM, Dental Monitoring©, Montreal, France) represents a significant advancement in orthodontic telemonitoring [25]. The system enables clinicians to track tooth movement, appliance condition, and oral hygiene remotely using patient-submitted images. DM combines a patient mobile app, a patented teeth-tracking algorithm, and a Doctor Dashboard® that allows clinicians to evaluate tooth-by-tooth progress, including angulation, inclination, and intrusion/extrusion. Patients provide pretreatment photos and a 3D stereolithography (.stl) model. Each new set of intraoral images is uploaded to the cloud, where DM aligns them with the 3D model to calculate baseline tooth positions, overjet, overbite, and interarch relationships, generating a comprehensive multidimensional information map (IM). These data are visualized for the clinician as graphs, photos, and interactive 3D models.

Since effective telemonitoring depends on active engagement from both clinicians and patients, this study aimed to explore the attitudes of orthodontists and patients toward Dental Monitoring™ using structured questionnaires.

Materials and Methods

This multicenter, cross-sectional study involved 80 dentists (ages 25–60) and 80 orthodontic patients (ages 12–50) of both genders, all undergoing treatment with either clear aligners or buccal multibracket appliances. Half of the dentist participants were orthodontists, while the other half were general dentists with a particular interest in orthodontics. Two separate questionnaires were designed to assess the perceptions of clinicians and patients, focusing on their attitudes toward telemonitoring and their views on its potential usefulness.

An initial literature review was conducted to determine whether any previously validated questionnaires existed, but none were found. Consequently, two concise, targeted questionnaires were developed based on expert input, literature findings, and interviews with patients and dentists. Each questionnaire consisted of simple items addressing a single issue. A pilot study with ten orthodontic patients and ten dentists was conducted to identify potential sources of misunderstanding and to test reliability and validity, leading to subsequent revisions of both questionnaires.

The dentists' questionnaire included closed-ended items covering demographic information, willingness to adopt the telemonitoring software, and the fees they would consider charging or paying to enhance treatment precision. The patients' questionnaire also collected demographic data and explored their willingness to actively participate in treatment and pay an additional fee to shorten treatment duration and improve accuracy. Inclusion criteria for dentists required ages between 25 and 60 years and current practice in orthodontics. Patient inclusion criteria included being under orthodontic treatment with clear aligners or multibracket appliances. Exclusion criteria encompassed severe medical conditions, age below 12 years, and craniofacial deformities. Questionnaires were completed individually at the office.

All participants provided informed consent prior to enrollment. Since no clinical interventions were performed and all responses were anonymous, the study protocol was not submitted for formal ethical approval according to the guidelines of the internal ethics committee. The study adhered to the Declaration of Helsinki.

Before completing the questionnaire, participants received an oral presentation detailing the Dental Monitoring™ (DM) system, supported by demonstrative videos and printed materials. Patients and orthodontists then attended practical training sessions on DM use and were allowed to test the software independently for one month. A study coordinator was available to answer questions, and completed questionnaires were collected in a closed box to ensure anonymity. The study protocol received approval from the Ethics Committee of Strengthening the Reporting of Cross-Sectional Studies (281322DM01, 5 May 2021).

Statistical analysis

Descriptive statistics summarized the data, with frequency distributions applied to categorical variables and means, standard deviations, and percentiles used for continuous data. Sociodemographic characteristics examined included sex, education level, occupation, age, country of residence, smartphone ownership, daily online activity, and prior awareness of telemonitoring systems.

Chi-square contingency tables assessed the influence of sex, age, and smartphone ownership on attitudes toward telemonitoring, and multiple regression analysis was used to estimate these effects. When questions were common to both questionnaires, responses from patients and orthodontists were compared. Primary outcomes from both surveys were tabulated, and chi-square tests evaluated associations such as gender and willingness to pay additional fees, age and willingness to take intraoral photos weekly or biweekly, and age and interest in reducing in-office visits among patients. All statistical tests were two-sided, with significance defined as $p < 0.05$. Data were recorded in Excel (version 15.5; Microsoft Excel, Microsoft, Redmond, WA, USA) and all analyses were performed using Excel spreadsheets.

Results and Discussion

The survey was conducted between October and December 2019. Sociodemographic details of the dentists are presented in Supplementary Table S1. The dentist cohort included 80 individuals (45 females and 35 males), with 46 aged 25–39 years and 34 aged 40–60 years. All participants resided in Italy. Regarding education, 57.5% had completed a postgraduate orthodontic program, 10% held a PhD, and 32.5% had a bachelor's degree in Dentistry. Patient sociodemographic characteristics are summarized in Supplementary Table S2. The patient group comprised 47 females and 33 males; 22 were younger than 14 years, 21 were aged 15–18, 20 were between 19 and 30, 11 were aged 31–40, and six were 41–50 years old.

The remaining survey items for dentists and patients are presented in Supplementary Tables S3 and S4, respectively. Analysis of sociodemographic factors indicated that neither age nor gender influenced patients' attitudes toward telemonitoring ($p = 0.73$ and $p = 0.81$, respectively; Supplementary Tables S5 and S6). Among dentists, telemonitoring received universally positive evaluations, irrespective of age or gender.

Smartphone ownership, however, was strongly associated with favorable opinions. Among dentists, 79 owned a smartphone and reported daily online activity, while the single dentist without a smartphone was not online daily. All patients owned a smartphone, though three reported they were not online daily.

Regarding awareness of smartphone-based telemonitoring, higher education correlated with greater familiarity: 53.75% of orthodontists were already aware of the technology, whereas 58.75% of patients had no prior knowledge.

Following an oral presentation and hands-on training, all 80 dentists rated the telemonitoring system positively. Nearly all (96.25%) associated it with advanced, high-quality treatment, and all agreed it could reduce the number of in-office visits. Among the dentists, 23 had previously used smartphones to monitor patients: 15 for 0–25% of patients, six for 25–50%, and two for 50–75%. The primary purposes included emergency monitoring (16 dentists), oral hygiene checks (one dentist), compliance with external devices (seven dentists), and tracking treatment progress (three dentists). One orthodontist, however, considered periodic measurement of tooth movements unnecessary.

Responses regarding the frequency of reviewing patient photographs varied: 46 dentists were willing to examine images every two weeks, while 14 preferred weekly review. Additionally, 50 orthodontists expressed concerns about the financial implications of implementing telemonitoring in their practice.

Regarding the patients, the majority found the Dental Monitoring™ (DM) software straightforward and easy to use, with only two individuals expressing a negative view of telemonitoring. A substantial portion—65 patients (81.25%)—reported interest in reducing the number of in-office visits, while an equal number (81.25%) perceived telemonitoring as a marker of advanced technology. Similarly, 49 patients (81.7%) associated its use with high-quality treatment. Willingness to take self-photographs varied: 68 patients (85%) were open to taking images every two weeks, whereas only 22 (27.5%) were willing to do so weekly. In terms of financial commitment, 52 patients (65%) were not inclined to pay an extra fee to incorporate a telemonitoring system into their orthodontic care.

When examining concerns about additional costs, male dentists appeared slightly more open to being charged, with 48.6% reporting no worries about the financial impact, compared to 35.6% of female dentists (Supplementary Table S7). No significant differences were observed based on professional category (orthodontist vs general dentist with orthodontic interest). Among patients, similar trends were observed: 36% of males and 28.5% of females were willing to pay an extra fee for telemonitoring. Chi-square analyses (Supplementary Tables S8 and S9) confirmed that gender was not significantly associated with concern about additional fees among either dentists or patients ($p = 0.26$ and $p = 0.54$, respectively).

Further analyses examined the relationship between age and willingness to participate in telemonitoring. For patients, age was analyzed in relation to their readiness to take intraoral photographs weekly or bi-weekly, and for orthodontists, age was analyzed relative to their willingness to review patient images on the same schedule (Supplementary Table S10). Among older orthodontists (40–60 years), equal numbers were willing to review images every two weeks, but none were willing to do so weekly. In contrast, among younger orthodontists (25–39 years), 22.2% were open to weekly image review. Overall, the proportion willing to review images bi-weekly was similar across age groups: 58.7% for younger doctors versus 52.9% for older doctors. The correlation between age and weekly image review among orthodontists was not statistically significant **(Table 1)**. Additionally, no significant differences were found when comparing professional category (general dentist vs orthodontist) regarding willingness to commit to weekly or bi-weekly image review ($p = 0.17$ and $p = 0.56$).

Table 1. Chi-square tests performed among the orthodontists, investigating the correlation between age and availability to take/examine pictures bi-weekly or weekly, respectively

Doctors	**25–39**	**40–60**	**Dentists**	**Orthodontists**
Yes	27	18	26	20
No	29	16	14	20
Bi-weekly *p*-value	0.61		0.17	
Doctors	**25–39**	**40–60**	**Dentists**	**Orthodontists**
Yes	6	8	6	8
No	34	32	34	32
Weekly *p*-value	0.26		0.56	

Patients' responses were analyzed by age, dividing them into those younger and older than eighteen years. Notably, younger patients were generally more willing to take intraoral photographs. Specifically, 93% of patients under 18 agreed to take pictures every two weeks, compared to 81% of those over 18. A statistically significant difference was also observed for weekly commitment: 58% of patients under 18 were willing to take weekly photographs, whereas only 35% of older patients agreed ($p = 0.039$), as detailed in **Table 2**.

Table 2. Chi-square tests performed among the patients, investigating the correlation between age and availability to take/examine pictures twice-a-week or weekly, respectively

Patients	**<18**	**>18**
Yes	40	30
No	3	7
Bi-weekly *p*-value	0.11	
Patients	<18	>18
Yes	25	13
No	18	24
Bi-weekly *p*-value	0.04	

An additional analysis was performed on the patient data to determine whether age was associated with interest in minimizing in-office visits, based on the premise that Dental Monitoring™ could decrease the frequency of traditional chair-side appointments **(Table 3)**.

Table 3. Association between age and interest in reducing the number of in-office visits among the patients

Question	**Response**	**Patients**

		<18 Years Old	>18 Years Old
Would you like to decrease the frequency of your in-office appointments?	Yes	34 (79%)	32 (86.40%)
	No	9 (21%)	5 (13.60%)

Most patients indicated a preference for fewer in-office visits, regardless of age, with 79% of those under 18 and 86.4% of those over 18 expressing this desire. As reported in **Table 4**, the chi-square analysis revealed no statistically significant association between age and willingness to reduce chair-side appointments.

Table 4. Chi-square test examining the association between age and interest in reducing the number of in-office visits among the patients

Patients	<18	>18
Yes	34	32
No	9	5
p-value	0.38	

Teledentistry offers considerable potential to enhance the delivery of oral healthcare. Although this study focused on applications specifically developed for orthodontists, its principles can be applied to any dental professional seeking to improve diagnostic accuracy, obtain expert consultation, manage referrals, or closely monitor patients. Several quantitative systematic reviews have confirmed the effectiveness of teledentistry across multiple dental specialties, including endodontics, oral surgery, oral medicine, periodontics, prosthodontics, pediatric dentistry, conservative dentistry, and the management of orofacial pain [26, 27].

Questionnaires are a widely accepted method to assess potential patients' perceptions of digital healthcare tools. For instance, the "Health Effect and Readiness" questionnaire was validated among diabetic patients [28]. Gagnon MP *et al.* used a questionnaire based on the Technology Acceptance Model (TAM) to evaluate telemonitoring, focusing on face and content validity among nurses and doctors rather than patients [29]. Finkelstein J *et al.* assessed patients' attitudes toward technology, concluding that self-administered tests by patients without computer experience produced results comparable to those collected under professional supervision [30]. Similarly, Aamodt *et al.* surveyed physicians and nurses regarding the impact of telemonitoring on quality of care for heart failure patients [31]. Ruiz-Lopez del Prado *et al.* used questionnaires to evaluate oral health status in patients prior to anesthetic procedures [32], while Uribe *et al.* assessed the perspectives of patients, parents, and orthodontists on treatment duration and methods for accelerating tooth movement [33].

In contrast to previous studies, the present research examined both orthodontists' and patients' attitudes toward a long-distance monitoring system, Dental Monitoring™. The dentist sample was divided into two categories: clinicians who provide only orthodontic treatment and those with a general practice who have a special interest in orthodontics.

Analysis of responses from the two dentist groups revealed no statistically significant differences. A portion of the clinicians was already aware of telemonitoring options, and more than half had previously used such systems for various purposes, highlighting that many practitioners are already incorporating teledentistry into their practice. Common applications include educational orthodontic blogs, Facebook® forums (Facebook Inc., Menlo Park, CA, USA), and interactive web-based coaching. Dentists who were previously unfamiliar with telemonitoring generally demonstrated a positive attitude toward its use; however, only a few were willing to review patient images frequently. Very few accepted weekly image reviews, likely due to the time and effort required. Traditionally, clinicians prefer in-person interactions with patients, which may explain some negative responses. Additionally, concerns regarding the potential economic impact of implementing telemonitoring may have contributed to their hesitation.

On the patient side, most participants were initially unaware of the option of telemonitoring, corroborating findings reported by Sharif *et al.* [34]. A subset of patients expressed that telemonitoring did not necessarily reflect a high-tech or high-quality treatment. This perspective may stem from the idea that patients do not equate the sophistication of technology with treatment excellence; even conventional methods are considered high-quality if

they achieve effective results. Additionally, underestimating the potential for precise dental calculations via the app may have influenced this perception.

Younger patients were generally more willing to take self-photographs, although only a small proportion agreed to weekly submissions. Orthodontists' responses mirrored this trend, indicating that weekly monitoring is perceived as overly demanding, with both groups favoring the traditional monthly check-ups. Some patients indicated a willingness to pay an additional fee for telemonitoring, motivated by potential time savings and the perception of advanced, high-quality care.

Most patients were interested in reducing the number of in-office visits, with older patients showing a slightly stronger preference for fewer appointments. However, the association between age and interest in decreasing visits was not statistically significant. A few patients preferred maintaining regular chair-side visits, likely due to the high value placed on the doctor–patient relationship. Technological advances, while beneficial, can also present challenges [35]. A strong doctor–patient relationship relies on factors such as communication, interpersonal care, familiarity with the patient's context, and trust [36]. Numerous studies emphasize the importance of face-to-face interactions, often favoring in-person consultations over exclusive reliance on telemonitoring [37]. The successful integration of remote monitoring in the future will require balancing technological benefits with the maintenance of direct patient–clinician rapport. High-quality care can be achieved by combining the convenience and cost-efficiency of remote monitoring with individualized patient interactions [38].

In summary, the strengths of this study include the development of two highly valid and reliable questionnaires, which can be applied in future research by other groups; the direct involvement of patients, who are the ultimate beneficiaries of telemonitoring; and the focus on a software specifically designed for orthodontic applications. The main limitations, however, include the lack of objective evaluation of real-life adherence by patients and clinicians to telemonitored orthodontic treatments and the absence of assessment regarding the software's impact on outcomes such as patient satisfaction, treatment compliance (during both active and retention phases), oral hygiene, treatment duration, costs, and overall quality. Future research should therefore address clinically meaningful endpoints, including the effects of telemonitoring on treatment duration and outcomes for compliance-intensive orthodontic appliances, such as clear aligners, its influence on patient quality of life, satisfaction with treatment management and results, and its utility in daily oral hygiene maintenance and emergency management [39–48].

Conclusion

In this study, patients demonstrated a generally more favorable attitude toward telemonitoring than the dentists. Both groups viewed telemonitoring positively, recognizing it as a technologically advanced tool that can enhance the perceived quality and precision of orthodontic care. While both patients and clinicians expressed interest in reducing the frequency of in-office visits, not all were willing to commit additional time or financial resources to implement it.

Acknowledgments: None

Conflict of interest: None

Financial support: None

Ethics statement: None

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