THE IMPLICATIONS OF REMOTE MONITORING AND TECHNOLOGY IN ORTHODONTICS

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Abstract:
The integration of technology into healthcare practices has emerged as a transformative advancement in patient care, particularly in the wake of technological evolution and the COVID-19 pandemic. With growing advances in technology in various sectors, one particular advancement has been the utilization of remote monitoring technology in orthodontics. This study investigates the extent to which remote monitoring technology can complement or replace traditional, in-person orthodontic appointments. The literature review highlights the growing adoption of remote monitoring in orthodontics, especially since the onset of the pandemic. Studies indicate promising results in terms of treatment effectiveness and patient satisfaction, although noting considerations for emergency situations and digital accessibility disparities. Furthermore, the review underscores the importance of technological reliability and patient experience in shaping the future of digital orthodontics. Utilizing the Delphi Research Method, expert opinions are collected to provide a comprehensive understanding of the implications of remote monitoring in orthodontics. By interviewing orthodontists and representatives from remote monitoring companies, insights are gathered regarding the benefits, practicalities, and patient perceptions of digital orthodontic care. The analysis portrays the pros and cons of remote monitoring, emphasizing its potential to enhance patient engagement, streamline scheduling, and improve treatment outcomes. Overall, the findings suggest that remote monitoring technology offers a promising avenue for advancing orthodontic care, with benefits including increased convenience, enhanced communication, and greater treatment efficiency, but will *not* be able to fully replace in person care. While challenges such as technical reliability and patient engagement persist, ongoing advancements in technology and patient education are poised to further optimize the efficacy of remote monitoring in orthodontic practices.

Introduction

Technology has taken the world by storm over the past couple of decades, slowly spreading across the globe to be used in various forms. One such result of this spread of technology has been in the healthcare industry, allowing for advanced patient care and treatments. One of the most prominent advances regarding technology in healthcare is the evolution of telehealth, and remote monitoring technology. This technology is essentially an advancement in which doctors or medical professionals can provide care for their patients without the need for in-person office visits. Telehealth is primarily implemented online using internet access on any technological device, such as smartphones and computers. The introduction of telehealth and remote monitoring into orthodontics and oral care in particular is one of the most notable advancements within healthcare technology. Such technology allows for patients to attend orthodontic appointments and check ups from the ease of their own home as opposed to traditional in-person appointments.

Several orthodontists have begun to implement this technology into their practices, and multiple remote monitoring companies have been created such as Grin, which provide remote monitoring services and technological appliances for the orthodontists and patients to use. Thus, this study aims to answer the question: To what extent can the introduction of teledentistry and remote monitoring using technology change or replace in person orthodontic care? An

orthodontist and company representative has been interviewed to assess the benefits, practicalities and general notions of digital orthodontic care amongst the patients and orthodontists. The information gathered has then been compared with traditional in-person office care to eventually determine the implications of digital orthodontics in the future.

Literature Review

Remote monitoring is essentially the implementation and use of technology in orthodontics, which "[enables] orthodontists to monitor patient oral health from anywhere," (Close-Up Media 2020). This could come in the form of "virtual consultation or live chats, treatment progress photo uploads by patients for orthodontic review… and AI assisted treatment monitoring with photos or videos taken by patients," (Park 2021). These virtual practices are typically ideal for patients who live further from an orthodontic office and thus are not able to commute as much- they are also ideal for times when it may not be possible to visit the orthodontic offices in person, such as if the patient/orthodontist is sick or any other form of conflict. Although these forms of technology in orthodontics were not used much previously, the use of remote monitoring and digital orthodontics has grown tremendously over the past few years.

A turning point in the use of remote monitoring in orthodontics was in 2020, with the outbreak of the Covid-19 virus. According to Jimmy Huh, the co-founder of the startup Live Dentist, "Covid-19 has been an inflection point in this business… people couldn't go to their dentist, and that sped up the demand for teledentistry" (Fine 2020). With the surge of the use of teledentistry and remote monitoring during the Covid pandemic, these technologies were able to advance, grow and develop in order to provide better and more effective orthodontic care from remote locations. Several companies such as "Grin, Dental Monitoring, Rhinogram, and SmileSnap" now offer remote monitoring services, employing orthodontists who use the technology to complete their patient's treatments virtually (Werner 2021).

As this industry continues to grow, many studies were and continue to be conducted on the effectiveness of remote monitoring, and more specifically, how it can potentially replace in person oral care in the future. Such studies include that of virtual oral hygiene, treatment effectiveness and more. A study and experiment conducted to evaluate the effects of remote orthodontic care on patients concluded that "remote monitoring applied during orthodontic treatment showed encouraging results" in terms of oral health- however, the "incidence of [potentially needed] emergency appointments may not significantly improve" (Sangalli 2022). As a result, these findings suggest that this technology could be potentially implemented in clinical practice, but may not be as effective in the case of emergency situations where the patient is in need of urgent in person medical care.

Additionally, another means for which the question arises on whether digital orthodontics and remote monitoring could potentially replace in person orthodontic care in the future is the dependency it carries on adequate and working technology. Rebecca L. Boni, a professor in the Nursing department at Oakland University, states how ¨technology is the means to providing telehealth¨, and additionally ¨encompasses a variety of current and future uses of technology¨ (Boni 2022). With 8% of Americans and 37% of the world's population having no access to the internet at all, and many others using facilities such as schools and libraries as a temporary source of internet, these digital orthodontic practices have potential but do not fully encompass all of American society's needs and statuses, thus ¨making it difficult to extend its benefits to patients with limited digital access and literacy¨ (Calandra 2023). Though most of American

society could implement switching to technology-based oral care businesses, a significant portion of the people would not be able to, thus emphasizing the need for the continuation of in person orthodontic care along with remote monitoring. Another study was conducted by researchers at the University of California which found that ¨older adults and those with limited English proficiency were uncomfortable using a patient portal or unfamiliar technology¨, and instead often chose a ¨non reimbursable, audio-only appointment¨ (Calandra 2023). However, the translations used by these platforms were not always accurate. This again emphasizes how remote monitoring, though effective on many parts of society, does not encompass all of the population´s needs and desires.

As digital orthodontics and remote monitoring continues to show a bright future post-pandemic, a new era of the growing industry is potentially on the horizon. The market, though growing slowly, has faced increased challenges including "competitive intensity, pricing wars, and barriers to accessing care" (Bettencourt 2023). In order for companies using these remote monitoring technologies to grow and thrive among other competitors, it is crucial for them to ensure that their treatments offer efficiency, convenience and reasonable costs. This includes not only competing against other digital orthodontic providers but the current and ever-continuing in person offices. Such possible methods to advertise and allow customer bases to gain knowledge about these new technologies and companies include advertising on social media. Studies conducted have shown that social media can be "an efficient marketing tool to boost sales and revenue", and additionally allows health providers to "use social media to share information about treatments and services for specific diseases, educate the public about health issues, and stay in touch with patients" (Leung 2023). Doing this will not only allow new and upcoming digital orthodontic companies to start their businesses and allow the public to gain more knowledge about these various technologies and ways of oral care to come.

The Gap In The Research:

As a recently developed technology, one of the main gaps in the field of remote monitoring in digital orthodontics is evaluating the effectiveness and reliability of the remote monitoring system in orthodontics, as well as understanding to what extent remote monitoring technology can fully replace traditional in person orthodontics. This includes the comparison of the overall effectiveness and reliability of remote monitoring compared to traditional in-person visits, and specific cases where remote monitoring could be more or less effective. Additionally, a crucial factor to determine in regards to the digital orthodontic experience is exploring the patient experience with these remote monitoring systems, including patient satisfaction levels, along with preferences and concerns.

Methodology:

Research Method:

In conducting research for remote monitoring in orthodontics and its implications for the future, the research method that was implemented to achieve the best results and data was the Delphi Research Method. This methodology incorporates expert opinions through the form of interviews, which helps ensure a diverse variety of insights and credible information about the topic at hand. As there is little research done as of present day regarding remote monitoring in digital orthodontics, the Delphi method serves as an efficient way to gather information while using data collected from the experts in the field themselves.

Procedure:

To begin, it was essential to find individuals who had a background using or implementing remote monitoring in orthodontics and were experts in the fields they led. An orthodontist using remote monitoring in their practice is an ideal candidate for this, given their day to day experience in not only implementing digital orthodontics with their patients, but also growing their practices and engaging patients with successful and quick outcomes. A second informant was required as well for the study. Upon researching, several companies such as Grin, DentalMonitoring, and SmileSnap were discovered- these are companies that provide remote monitoring tools including the technological devices, websites as well as scanning programs. Both informants would be able serve as valuable sources of information to advance the study regarding remote monitoring in orthodontics.

A search was conducted on Google to find orthodontists near the area that had large digital orthodontic platforms and high patient engagement. The main orthodontist that stood out was Dr. Alyssa, the doctor and founder of Dr. Alyssa Orthodontics. With three offices located in Gainesville, Bonham and Sherman, Texas as well a variety of treatments offered including Invisalign, traditional braces, clear aligners and most importantly virtual and remote care, Dr. Alyssa offered a large diversification of options to her large clientele of patients while maintaining 5- Star reviews online. The interview process began by reaching out to her using her contact information located on her website. An email was sent regarding the study being researched and her valuable insight and data that could be used to help advance the studies. When she agreed to contribute to the study, she was given the option to have the interview conducted on email or phone call, to which she agreed to be interviewed over phone call in order to facilitate a more interactive and adaptive exchange of information.

The remote monitoring companies Grin, DentalMonitoring and SmileSnap serve as leading brands regarding digital orthodontics, with an emphasis on remote monitoring according to research conducted online. All three companies were reached out regarding the interview using their Contact Info pages. Grin's Chief Technology Officer, Yarden Eilat responded agreeing to the interview and requesting it be conducted over email. The use of the company Grin as an informant and source of information was significant due to their positions in the transformation and advancements of remote monitoring in orthodontics. With a rating of 4.7 on online reviews, Grin serves as a satisfactory brand amongst both patients and orthodontists in implementing treatments using the remote monitoring technology.

Research Instrument:

The interview questions used for each interviewee serve as the research instrument in this study. The interview questions curated for Dr. Alyssa centered more around the implementation of remote monitoring in her practice, the use of both in-person care and digital care side by side, as well as patient satisfaction levels. On the other hand, the questions asked to the Grin official center on the topics of technological implementations, ease of use and comparisons to in person care, security and privacy of patient care and overall future implications of remote monitoring in orthodontics. All questions were asked about the companies or practices general trends as opposed to individual patient stories in order to comply with the HIPAA laws. A total of 18 questions were asked to Dr. Alyssa, and 10 to the Grin official. The following table shows the interview questions created and asked to for each individual:

Interview Questions curated for Dr. Alyssa:	Interview Questions curated for Grin Official:
1) What percentage/how many of your patients use virtual dental monitoring? 2) What is the success rate of this type of orthodontic care? 3) Do every form of patients qualify for remote monitoring dental care? ^ Age groups, financial status, region where they live (rural, suburban, urban) 4) What are the patient satisfaction levels using this type of virtual care? 5) Why should someone use remote monitoring? 6) Is there any time where remote monitoring will not suffice, and the patient will need to come in for an in person appointment? 7) What is the potential, based on current satisfaction levels, that remote monitoring could potentially replace in person orthodontic care in the future? 8) Does using remote monitoring allow for more/less orthodontic control over the patient's treatment? 9) What motivated you to integrate remote monitoring technology into your orthodontic practice, and how has it impacted your overall approach to patient care? 10) Can you share specific examples of how remote monitoring has improved patient outcomes or treatment efficiency in your practice? 11) How do you communicate the benefits of remote monitoring to your patients, and what has been their response to this technology? 12) In what ways has remote monitoring changed the frequency and nature of in-person visits for orthodontic patients in your practice? 13) What challenges did you encounter during the implementation of remote monitoring, and how were they	1. Can you provide an overview of how remote monitoring is currently being utilized in orthodontics at Grin? 2. What are the key benefits that orthodontic patients and practitioners experience with the implementation of remote monitoring technology? 3. How has remote monitoring changed the dynamics of patient-practitioner communication in orthodontics? 4. In your opinion, what are the main challenges or concerns associated with remote monitoring in orthodontics, and how does Grin address them? 5. Can you share any success stories or specific cases where remote monitoring played a crucial role in improving patient outcomes (while obeying HIPAA laws, if possible)? 6. How does Grin ensure the security and privacy of patient data in the context of remote monitoring? 7. From a technological standpoint, what advancements do you foresee in the field of remote monitoring for orthodontics in the near future? 8. How does Grin collaborate with orthodontic practitioners to incorporate their feedback and continuously improve the remote monitoring system? 9. In what ways does remote monitoring impact the overall efficiency of orthodontic practices, both in terms of time and resources? 10. Are there specific patient demographics or orthodontic cases that benefit the most from remote monitoring, and how does Grin tailor its approach accordingly?

addressed to ensure a smooth transition? 14) Have you observed any differences in treatment adherence or patient engagement since incorporating remote monitoring into your practice? 15) How do you balance the use of remote monitoring with the need for in-person consultations, and what criteria do you use to determine when each is most appropriate? 16) From a practitioner's perspective, what advice would you give to other orthodontists considering the adoption of remote monitoring technology? 17) How does remote monitoring impact the efficiency of your practice, in terms of time management and resource allocation? 18) Can you discuss any notable cases or success stories where remote monitoring played a crucial role in achieving optimal treatment outcomes?	

Table 1. *Interview questions curated for Dr. Alyssa and Grin official*

By using insights from both Dr. Alyssa as a professional orthodontist as well as Grin, a well-rounded perspective was analyzed that was able to fully answer the studies' goals. The information from Dr. Alyssa regarding both in-office experiences with patients and remote monitoring implementation alongside in-person traditional oral care, along with the information from Grin regarding technological advances, implications for remote monitoring in various demographics as well as implementations of the technology have been analyzed to determine future implications of remote monitoring as a form of orthodontic treatment.

Results:

Adoption and Utilization of Remote Monitoring

In both Dr. Alyssa's practice and Grin's implementation, remote monitoring has significantly reshaped orthodontic care. Dr. Alyssa reported that 90% of her patients actively use remote monitoring, replacing some in-person appointments with frequent virtual check-ins. Similarly, Grin's remote monitoring technology allows patients to undergo checkups without visiting the clinic. Both approaches emphasize convenience for patients and cost-effectiveness for practitioners.

Pros:

- Patients can manage checkups remotely, reducing travel and clinic time.
- Both Dr. Alyssa and Grin observed increased efficiency in patient care, as orthodontists can monitor progress more frequently and adjust treatments in a timely manner.
- For Grin, remote monitoring reduces overhead costs associated with frequent in-office visits.

Cons:
- Remote monitoring lacks the ability to perform essential physical interventions like wire adjustments, which still require in-person visits. Both Dr. Alyssa and Grin acknowledge this limitation.
- The quality of remote monitoring depends on patients' ability to follow instructions and submit high-quality scans. Inconsistent adherence can affect monitoring accuracy, especially with Grin's platform.

Eligibility and Scheduling
Dr. Alyssa's practice integrates personalized remote scheduling for patients, allowing virtual check-ins once a week and in-person appointments as needed based on individual treatment progress. Grin's remote monitoring offers similar flexibility by minimizing clinic visits and allowing orthodontists to monitor patients' progress without strict scheduling.

Patient Satisfaction and Engagement
Both Dr. Alyssa and Grin emphasize that patient satisfaction correlates with understanding the value and convenience of remote monitoring. Dr. Alyssa observed that patients who fully grasp these benefits reported higher levels of engagement and satisfaction. Grin similarly noted that patients who can communicate directly with their orthodontists via virtual messaging feel more involved in their treatment, leading to higher engagement.

Pros:
- Both systems allow for direct messaging between patients and practitioners, facilitating timely interventions and responses to patient concerns.
- Patients become more involved in their care, understanding their treatment progress better, which improves compliance and overall satisfaction.

Cons:
- Despite enhanced communication, there is a risk of reduced personal interaction, with patients possibly feeling detached from their orthodontists due to the virtual nature of the interactions.

Impact on Orthodontic Control and Treatment Efficiency
Remote monitoring, in both Dr. Alyssa's practice and Grin's system, enhances orthodontic control by enabling orthodontists to detect issues like misalignments or broken brackets early, leading to timely interventions and minimizing delays in treatment.

Pros:
- Regular virtual check-ins allow orthodontists to monitor patients more frequently than in traditional in-office visits, ensuring smoother treatment progress.
- Early detection of issues through remote monitoring results in more efficient treatment plans and better outcomes.

Cons:
- Both systems depend on technology that, if malfunctioning or misused, can disrupt patient care. This introduces a level of uncertainty, especially in cases where scans may not capture problems requiring physical intervention.

Future Technological Advancements
The future of digital orthodontics holds promise, with the potential for greater automation and advancements in treatment tracking. Both Dr. Alyssa and Grin recognize the potential of technologies like artificial intelligence to optimize remote monitoring.

Pros:
- Future advancements could enhance the remote monitoring process, allowing for automated tracking of treatment progress and reducing the need for manual oversight.
- Innovations such as 3D printing aligners and AI-based monitoring could streamline the entire orthodontic process, further reducing the need for in-person appointments.

Cons:
- Relying on advanced technology introduces risks like technical malfunctions, which could disrupt the flow of treatment if not carefully managed.

Summary:
Both Dr. Alyssa's practice and Grin's implementation of remote monitoring illustrate the transformative potential of digital orthodontics. The technology improves patient engagement, treatment efficiency, and communication between practitioners and patients, resulting in better outcomes. However, while remote monitoring addresses many aspects of orthodontic care, it cannot entirely replace in-person interventions, underscoring the need for a hybrid approach.
Moving forward, integrating advancements such as AI, enhanced automation, and personalized treatment tracking could further refine the practice of remote monitoring, balancing its convenience with the necessary hands-on elements of orthodontic care.

Conclusion:
In conclusion, this inquiry into the adoption and utilization of remote monitoring in orthodontic practices, as exemplified by interviews with Dr. Alyssa and representatives from Grin, sheds light on the transformative potential of digital orthodontics in revolutionizing patient care. The findings underscore the significant strides made in enhancing patient engagement, treatment efficiency, and communication between practitioners and patients. Remote monitoring technology offers unparalleled convenience and accessibility, allowing for more frequent check-ins and timely interventions, ultimately leading to improved treatment outcomes. However, it is evident that while remote monitoring can replace many in-person appointments, it would not be able to completely supplant the need for physical interventions and personal interactions in certain cases. This limitation underscores the importance of maintaining a balanced approach, integrating remote monitoring with traditional in-person care to ensure comprehensive and effective orthodontic treatment.
The inquiry addresses the identified gap in understanding the nuanced dynamics of remote monitoring adoption in orthodontic practices. By analyzing the perspectives of both a practicing orthodontist and a technology provider, this study provides a comprehensive overview

of the benefits and challenges associated with remote monitoring implementation. This holistic approach offers valuable insights into the factors influencing patient satisfaction, treatment efficiency, and practitioner-patient communication in the context of digital orthodontics.

Moving forward, further research could focus on optimizing the integration of remote monitoring into orthodontic practices, addressing specific challenges such as patient education, technology usability, and regulatory compliance. With the advent of aligners such as Invisalign, which can be 3D printed, it is envisioned that in future the scans can be performed remotely and new aligners directly being shipped to patients, underscoring the need for appointments to even install braces. Exploring innovative ways to enhance the effectiveness of remote monitoring, such as leveraging artificial intelligence for automated treatment tracking and decision-making holds promise for advancing the field. Ultimately, by continuing to explore the potential of remote monitoring while recognizing its inherent limitations, orthodontic practitioners can refine their approach to patient care, ultimately improving outcomes and enhancing the patient experience.

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