Teledentistry, Do-It-Yourself Orthodontics, and Remote Treatment Monitoring

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Your scientists were so preoccupied with whether or not they could, they didn't stop to think if they should.

—Michael Crichton, *Jurassic Park*

Teledentistry is the combination of telecommunications and dentistry to provide dental care across long geographic distances (Fig. 1). It involves the digital exchange of clinical information between a patient and a health-care center or provider. Teledentistry can be used for remote dental consultation, treatment planning and monitoring, appliance fabrication, or on-site job training.[1] Although modern systems of teledentistry are all Internet-based, teledentistry is vastly different from web browsing and distance learning. In essence, it is the sharing of digital information through communication technology, rather than direct personal contact, to provide dental care when distance separates the patient and the doctor.

Technological advances in computers, smartphones, and digital diagnostic imaging have made partial or complete management of orthodontic patients by teledentistry more feasible than ever before. This article reviews the history, applications, legal concerns, and potential abuses of teledentistry in orthodontics, as well as its role in the emergence of do-it-yourself (DIY) braces and remote treatment-monitoring software.

Historical Perspective

Teledentistry is just one segment of telemedicine, defined by the Association of American Medical Colleges as "the use of telecommunications technology to send data, graphics, audio, and video images between participants who are physically separated (i.e., at a distance from one another) for the purpose of clinical care".[2] At the most basic level, answering a late-night call to walk a patient through management of a wire poke is a form of teledentistry.

The first application of teledentistry occurred in 1994, in a U.S. Army plan referred to as the Total Dental Access (TDA) project.[2] Military dentists transferred information regarding radiographs and oral photographs to specialists at a remote location by telephone. This information was either communicated in real time or stored in a database to be forwarded as needed. The specialists then diagnosed the patient, recommended treatment plans, and even provided verbal training to the local dentist. The TDA project focused on improving three areas of dentistry: patient care, continuing dental education, and dental laboratory communication. Its primary goal was to increase patient access to dental specialty care. Above all, the project successfully demonstrated that teledentistry could extend dental care to remote rural areas while reducing patient costs.

Orthodontic Applications

Teledentistry allows orthodontists to provide oral health care to rural facilities, developing countries, or correctional facilities that may be unable to attract, afford, or retain orthodontists.[3] With the aid of live videoconferencing or a real-time image-sharing portal, a remote orthodontist can examine the patient, review the health history, diagnose the malocclusion, and offer recommendations for treatment to be provided locally.

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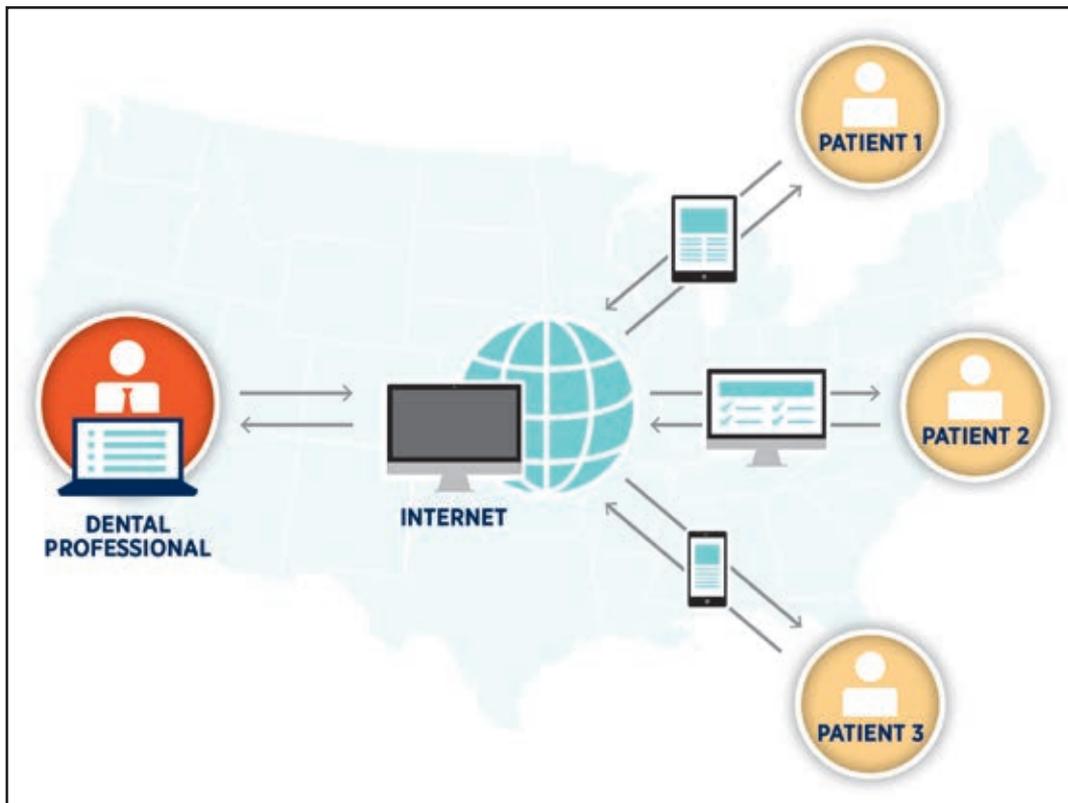
Fig. 1 With teledentistry, one dentist can monitor multiple patients remotely over long distances.

The primary benefit of teledentistry is that it reduces or eliminates the need for travel by the patient and the orthodontist. Other notable advantages include increased access to oral care, better patient education, earlier diagnosis, reduced oral-care costs, improved patient management, closer monitoring through digital follow-up, increased collaboration among health-care providers, savings in transportation costs, avoidance of missed work income for patients, enhanced access to consultations, elimination of unnecessary appointments, and improved outcomes of orthodontic treatment provided by primary-care dentists.[1,3-6] Simply put, teledentistry has the potential to allow more comprehensive care at lower overall costs to the patient and provider.

Legal Concerns

Because teledentistry allows orthodontists to practice across state boundaries, it raises some legal concerns, including out-of-state licensure, liability in cases of malpractice, and confidentiality of dental information across the Internet.[7]

The most significant obstacle to nationwide teledentistry is a licensure barrier between states. According to the traditional system of state-by-state dental licensing, a doctor in Virginia could not legally provide telemedicine to a patient in Arkansas, unless the doctor were licensed in both states. To address such barriers in medicine, Congress recently appointed a task force, known as the Joint Working Group on Telemedicine, to meet with licensing boards and professional credentialing organizations with the goal of developing regional agreements to overcome state licensure barriers.

The Federation of State Medical Boards has proposed a limited national medical license to enable telepractice across state lines. The proposal contains a "consultation exception" that allows an out-of-state physician to provide diagnostic services. Numerous states have adopted statutes to block this consultation exception. Although no limiting statutes occur in dental licensure, they may become a concern in the future.

In congruence with licensure matters, questions are also raised about liability. What standard of care would courts apply in a malpractice suit against an orthodontist practicing teledentistry across multiple states? Does a teledentistry consultation create a legally binding relationship? Would this orthodontist be covered by malpractice insurance if the telepatient crossed state lines? Most medical malpractice insurance covers only face-to-face encounters within the state in which the physician practices and is licensed. Theoretically, physicians who provide telemedicine to out-of-state patients could be exposed to uninsured claims.

Teledentistry also raises concerns about the confidentiality of dental information over the Internet. Privacy and security are difficult because of the transmission and storage of large volumes of electronic health information in various formats—including audio recordings, videos, and self-photography—that historically have not been part of orthodontic records. How and where is this information being maintained and secured, and can patients access the information under their legal rights? Who is responsible for maintaining these records? If one party experiences a security breach, could the other party be found liable under the Health Insurance Portability and Accountability Act (HIPAA)?

For now, orthodontists should approach telehealth documentation similar to an in-person office visit, making copies of all relevant electronic communications. As in the transition from paper to electronic records, orthodontists will need to actively monitor and adapt their security practices in response to the new risks associated with teledentistry.

DIY Orthodontics

Coincident with the growth of teledentistry is the development of DIY braces. Rudimentary DIY methods, such as using an elastic band to close a diastema, have always been used by patients to avoid the expense of visiting an orthodontist. Still, patients are often unaware of the serious inherent risks. In 2016, the AAO issued a consumer-awareness alert after observing the surge in DIY products advertised on social media and the national attention gained by a college student who provided his own aligner treatment by three-dimensionally printing models of his teeth.[8,9]

Most notably, there has been an increase in mail-order, direct-to-customer aligner systems that provide treatment without clinical examination by a professional. The appeal of this approach is not only the convenience, but the selling price—

usually about $1,500, or 30% of the cost of Invisalign* treatment at an orthodontic office.

In the United States, the most prominent direct-to-customer aligner company is SmileDirectClub** (SDC), which was started in Nashville, Tennessee, in 2013 by businessman David Katzman, his son Jordan Katzman, Alex Fenkell, and Doug Hudson as a lower-cost alternative to traditional orthodontics. This team has a track record of going directly to the customer with other medical products, such as contact lenses (1-800Contacts***), hearing aids (HearingPlanet,† SongbirdHearing‡), diabetic supplies (DiabetesCareClub, now owned by Arriva Medical††), and sleep-apnea devices (CPAPCareClub, now owned by Verus Healthcare‡‡).

To start treatment with SDC, the customer completes a short online questionnaire and purchases a refundable $95 impression starter kit, which is mailed to the customer's home (Fig. 2). Polyvinyl siloxane impressions are then taken by the patient, who contacts the company for pickup (Fig. 3). Seven intraoral photographs are uploaded by the customer to the company website. Alternatively, the patient can have a digital impression scan taken at a SmileShop (a regional SDC scanning center). SDC uses this information to create a customized 3D treatment plan.

SDC initially utilized ClearCorrect§ as its primary laboratory. In 2017, however, Align Technology announced a supply agreement with SDC and a 17% ownership stake in the company. Align now provides the case setup using its proprietary Treat§§ software. For SDC, the software is programmed to exclude attachments and interproximal reduction, which were possible under the ClearCorrect system. Furthermore, tooth movement is now limited to the anterior segments. Most important, these aligners are made of single-layer EX30 plastic, rather than the most current Invisalign aligner material (SmartTrack§§§). Given the simple nature of the cases that can be approved, treatment is limited to 20 sets of aligners per patient.

Fig. 2 SmileDirectClub** (SDC) starter kit with impression instructions and consent form.

A dentist or orthodontist affiliated with SDC is notified by e-mail that the customer's treatment plan is ready for review. The doctor logs into the SmileCheck portal—similar to ClinCheck*—to review the treatment plan and either approve or reject the case for treatment. SDC reports that approximately 30% of its cases are rejected by doctors due to their complexity. On review and approval, Align Technology manufactures the aligners and mails them directly to SDC, which mails them to the customer. At this point, the customer is billed, and the doctor receives a small compensation ($50) by direct deposit. Customers must submit their own requests for insurance reimbursement.

One of many concerns for orthodontists is that SDC can potentially keep resending "rejected" cases out to different SDC-affiliated doctors, particularly general dentists, until someone approves the customer for self-treatment. SDC and Align Technology argue that their direct-to-customer aligner system is not "DIY", but rather "doctor-directed", and that it increases access to care as part of a wider teledentistry revolution. Considering the minimal input and monitoring provided by the orthodontist, however, is this true teledentistry or an end run around it?

*Registered trademark of Align Technology, San Jose, CA; www.aligntech.com.

Fig. 3 How SDC works.

Remote Treatment Monitoring

Perhaps a more appropriate use of teledentistry is for remote treatment monitoring. A patient is now able to precisely capture his or her own tooth movements using a smartphone or mobile-device camera. These photos (or, in some cases, videos) are then communicated to the orthodontist, who is able to provide real-time monitoring of the patient's treatment away from the office.

At the forefront of this technology is Dental Monitoring**** (DM), a software system that helps an orthodontist maintain control over treatment progress from the first consultation to the retention period. It consists of three integrated platforms: a mobile app for the patient, a patented movement-tracking algorithm, and a web-based Doctor Dashboard where the orthodontist receives updates on the patient's progress (Fig. 4).

To begin the process, following an initial clinical consultation, the orthodontist provides DM with the patient's pretreatment photographs, the

****Trademark of Rocky Mountain Orthodontics, Denver, CO; www.rmortho.com.

Fig. 4. How Dental Monitoring**** (DM) works. A. App guides patient through self-photography (simulated by orthodontic assistant in this picture). B. DM algorithm three-dimensionally matches patient's self-photo with digital model. C. Orthodontist reviews tooth-movement data on Doctor Dashboard.
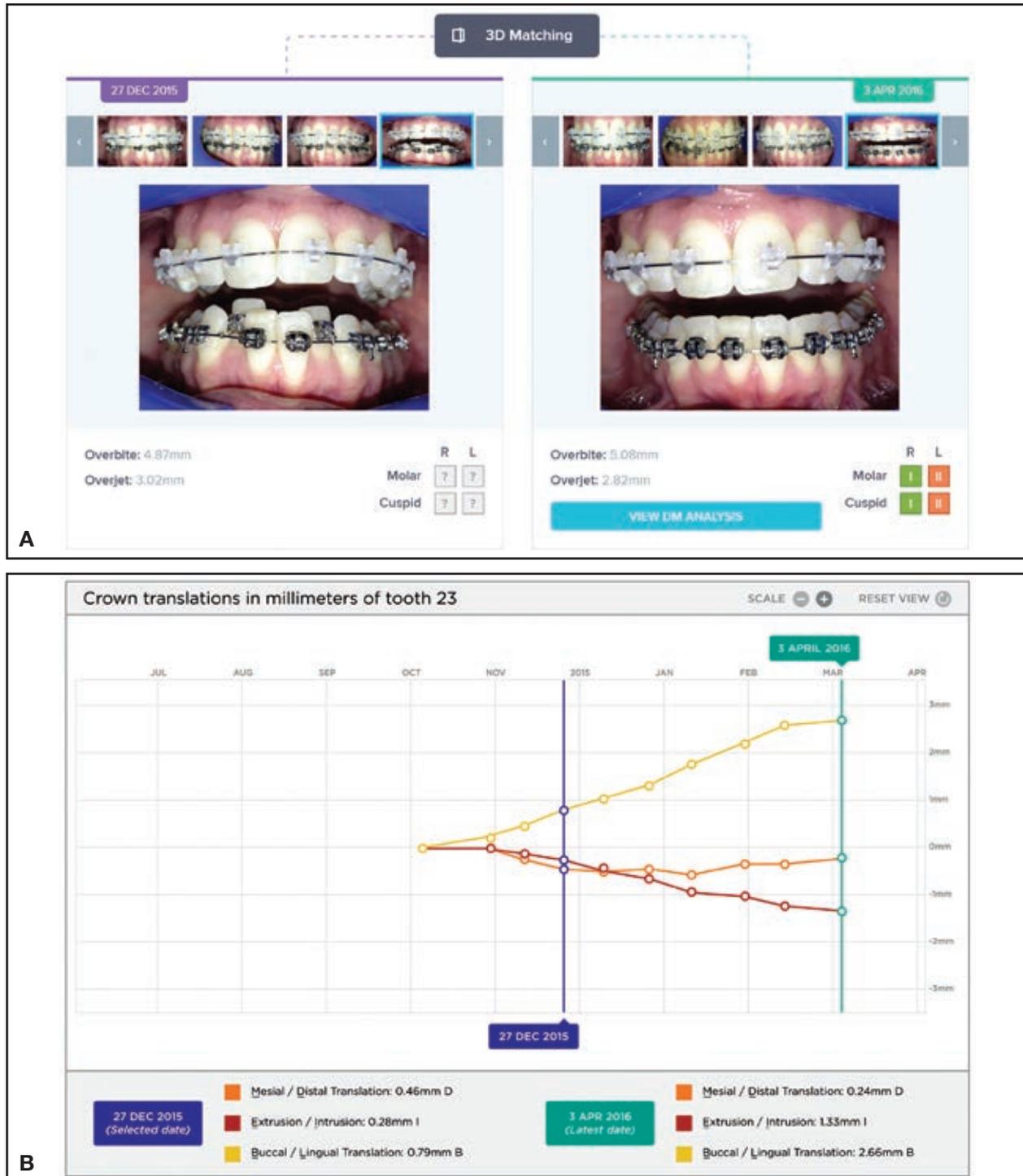
Fig. 5 A. Self-photography of patient undergoing remote DM. B. Chart displayed on Doctor Dashboard, showing translation of lower left lateral incisor.

treatment objectives, and a 3D model in stereo-lithography (STL) file format. The orthodontist may also choose to provide cone-beam computed tomography data in STL format to incorporate root positions. DM algorithms segment the 3D model and calculate baseline tooth positions, interarch relationships, overjet, and overbite.

The orthodontist provides the patient with a cheek retractor that is specially designed for photo calibration with the DM app. The app requires a camera flash and a recent version of the iOS (iPhone 4S or newer) or Android (3.0.1 or newer) operating system. It guides the patient through the process of taking dental pictures, which are automatically uploaded to cloud-based servers. DM's patented algorithm "matches" these photos to the 3D model to create a multidimensional information map (IM) of the teeth, with an error of less than .1mm for movement and less than .5° for tip and torque. The results are then uploaded to the Doctor Dashboard in the form of graphs, photos, and 3D visualization (Fig. 5). The orthodontist can set parameters to receive alerts in situations that require immediate attention, such as broken brackets, abnormal pathologies, adverse tooth movements, or poor oral hygiene. In such a case, the clinician is notified of the new results and can communicate back with the patient through the app.

During the course of treatment, the patient continues to submit intraoral photographs taken with the cheek retractor. The IM generated from the photographs is matched with a virtual IM generated from the patient's latest 3D model. This creates a new 3D model that will serve as the basis for tooth-movement calculations and for matching with the next set of photos. Each photo submission generates thousands of iterations and as many as four hours of calculations.

DM currently has a limited application. It may be most useful in communicating with active patients who move away from the office (for example, college students or military personnel), patients in clear-aligner therapy, patients requiring close monitoring (as with poor oral hygiene), or patients in retention. One day, some offices may use remote treatment monitoring to take the place of routine adjustment appointments, having the patient come to the office only when necessary.

Ethical Concerns

Despite the apparent benefits of teledentistry, there are serious ethical concerns. SDC customers are utilizing direct-purchase orthodontic appliances to change their dental conditions without the benefit of initial in-person clinical evaluations by orthodontists to evaluate for potential pathology. After 20 sets of aligners, many patients may be left with less-than-ideal occlusions than could otherwise have been achieved under in-office orthodontic supervision. Furthermore, there is little chance the patient and orthodontist will ever come in contact. To that end, treatment is not "doctor-directed" at all. Above all, SDC is a DIY business model. As this business grows and Align Technology increases its ownership percentage, what is to stop them from simply replacing private dentists and orthodontists with their own review board of company professionals to determine case acceptance?

On the other hand, remote monitoring still requires a clinical diagnosis with full records. Initial appliances must be placed by the orthodontist. How to monitor treatment and at what frequency is up to the clinician and the patient. Nevertheless, remote monitoring opens the door for potential abuses. At what point do fewer in-office visits and increased convenience become unmonitored treatment that diminishes the standard of care?

The Future of Teledentistry

Many orthodontists are unaware that they are already actively engaging in teledentistry. Educational Facebook forums (such as www.facebook.com/groups/PragmaticOrthodontics) and interactive web-based coaching (such as www.yourorthocoach.com) are popular examples of situations in which orthodontists use teledentistry to review cases and plan better treatment. These methods of remote consultation between professionals will only increase in the future.

Teledentistry is also revolutionizing doctor-patient interpersonal relationships. In the past,

teledentistry was applied only in unique circumstances when access to treatment was unavailable. In the future, teledentistry may influence many aspects of routine patient care. Notable innovations already in use include school- or work-based diagnostic health stations, handheld telemedicine kits for conducting first-line patient exams, smartphone attachments with a "lab on a chip" for rapidly analyzing bodily fluids, and Internet-based video-conferencing. School nurses may soon be able to communicate with orthodontists by means of an app to manage emergency appointments from school.[10]

We may be entering a new era of democratized, digitized dentistry, with the smartphone as the hub.[11] Orthodontics could be instantly delivered on demand, following telemodels already adopted in retail, travel, dining, entertainment, and banking. Patients may generate data from their own devices to be immediately analyzed, graphed, displayed, stored, and shared. They will then be the chief operating officers of their own bodies. The old adage "the doctor will see you now" has changed; in teledentistry, it is "the patient will see you now".

Conclusion

Teledentistry is not a new specialty, but rather an alternative way to deliver existing dental services. Above all, teledentistry has the potential to improve access to oral health care, reduce overall costs to the patient and orthodontist, and facilitate control of patients who infrequently visit orthodontic offices. Serious concerns regarding licensure, liability, patient confidentiality, and unmonitored DIY treatment remain to be addressed.

REFERENCES

1. Jampani, N.D.; Nutalapati, R.; Dontula, B.S.; and Boyapati, R.: Applications of teledentistry: A literature review and update, J. Int. Soc. Prev. Commun. Dent. 1:37-44, 2011.
2. Chen, J.W.; Hobdell, M.H.; Dunn, K.; Johnson, K.A.; and Zhang, J.: Teledentistry and its use in dental education, J. Am. Dent. Assoc. 134:342-346, 2003.
3. Khan, S.A. and Omar, H.: Teledentistry in practice: Literature review, Telemed. J.E. Health 19:565-567, 2013.
4. Berndt, J.; Leone, P.; and King, G.: Using teledentistry to provide interceptive orthodontic services to disadvantaged children, Am. J. Orthod. 134:700-706, 2008.
5. Costa, A.L.P.; Silva, A.A.; and Pereira, C.B.: Tele-orthodontics: Tool aid to clinical practice and continuing education, Dent. Press J. Orthod. 16:15-21, 2001.
6. Institute of Medicine Committee on Evaluating Clinical Applications of Telemedicine and Field, M.J.: *Telemedicine: A Guide to Assessing Telecommunications in Health Care*, National Academies Press, Washington, DC, 1996.
7. Sfikas, P.M.: Teledentistry: Legal and regulatory issues explored, J. Am. Dent. Assoc. 128:1716-1718, 1997.
8. American Association of Orthodontists, Consumer alert: Risks involved with "do it yourself" teeth straightening products, http://res.cloudinary.com/dorhu9mrb/image/upload/v1448045671/Buyer-Beware-Press-Release.pdf, accessed Nov. 22, 2016.
9. King, H.P.: College student 3D prints his own braces, CNN Money, March, 16, 2016, http://money.cnn.com/2016/03/16/technology/homemade-invisalign/, accessed Nov. 22, 2016.
10. Stein, C.D.; Xiao, X.; Levine, S.; Schleyer, T.K.; Hochheiser, H.; and Thyvalikakath, T.P.: A prototype mobile application for triaging dental emergencies, J. Am. Dent. Assoc. 147: 782e1-791e1, 2016.
11. Topol, E.: *The Patient Will See You Now: The Future of Medicine is in Your Hands*, Basic Books, New York, 2015.