

## DISCUSSION

# Electropalatography (EPG) activities in Japan and the impact of the COVID-19 pandemic on EPG research and therapy: A report of presentations at the 7th EPG Symposium

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## Abstract

**Background:** At the 7th Electropalatography Symposium in Japan, held online on the 24 January 2021, a few speakers were invited to talk about how the COVID-19 pandemic had impacted their research and/or speech therapy that involved the use of electropalatography (EPG) as well as the procedures adopted in order to continue their work in a safe manner. The information on protective measures when using instrumental techniques in speech research and therapy may be useful for colleagues in research and the clinic.

**Aims:** The primary aims are: (1) to find out whether there are any published recommendations regarding protective measures for using EPG in research and clinic settings; (2) to discuss the impact of the pandemic and the corresponding restrictions and general protective measures directed (or advised) by local government and professional bodies at each stage of EPG work; and (3) to share experiences in using modified procedures for face-to-face EPG therapy sessions and combined EPG teletherapy. In addition, a brief overview of EPG and a summary of EPG research and clinical activities in Japan presented by one of the symposium organizers at the symposium are included.

**Methods & Procedures:** A review of the literature regarding protective measures recommended for using EPG for speech assessment and treatment or research, supplemented by a discussion of our own experiences.

**Main Contribution:** The literature review showed that there are no guidelines regarding protective measures for using EPG, but there is some advice regarding speech recording using microphones. Most published articles related to speech and language therapy (SLT) service during COVID-19 are about telepractice or general clinical guidelines for face-to-face speech therapy sessions. The

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protective measures for using EPG developed based on the general guidelines recommended by local government and professional bodies (e.g., using visors, transparent acrylic board) were described. Using EPG in telepractice was discussed as well.

**Conclusions:** It has been challenging to continue EPG research and therapy during the pandemic. In order to deal with this crisis, available knowledge regarding infection control and recommendations from local government and professional bodies were applied to design methods and procedures that allowed EPG research and therapy to continue.

#### KEYWORDS

COVID-19 pandemic, electropalatography (EPG), phonetics, speech science, speech therapy

#### What this paper adds

##### *What is already known on the subject*

- There are general protective measures recommended by local government and professional bodies regarding speech therapy sessions (e.g., using personal protective equipment (PPE), social distancing), but little is known about the measures for using instrumental techniques in speech research and therapy, particularly EPG. The equipment of each instrumental technique is different, so measures that are appropriate for one may not be suitable for others. Hence, specific recommendations are needed for EPG.

##### *What this paper adds to existing knowledge*

- This paper provides pointers to information about recommendations regarding protective measures for speech research and therapy, supplemented with suggestions specific to EPG provided by experienced users based on actual experience.

##### *What are the potential or actual clinical implications of this work?*

- In evaluating the impact of the COVID-19 pandemic on EPG research and therapy, an analytical approach was taken to break down the steps involved in carrying out those activities, and the challenges we faced and the possible alternatives for completing the tasks were discussed. A similar approach can be applied to evaluate other aspects of speech therapy service.

## INTRODUCTION

Since 2020, many academic conferences have been either suspended or held online due to the COVID-19 pandemic. This was also the case for the 7th EPG Symposium in Japan, which was held online on the 24 January 2021 (<https://epg-research.sakura.ne.jp/>). Participants from different disciplines, including speech and language therapy (SLT), dentistry, orthodontics, phonetics, English teach-

ing and oral health, attended the meeting. As for previous meetings, the symposium included topics such as recent electropalatography (EPG) investigations of articulation errors, and changes in tongue palate contact patterns after speech or surgical intervention. A few speakers were invited to give a presentation about the impact of the pandemic on research and speech therapy using EPG and their views regarding the direction of future developments of EPG. One symposium organizer gave an overview of EPG

research and clinical activities in Japan, as there have been significant recent developments in this regard. The presenters agreed to document and share this information with colleagues in research and the clinic.

Hence, this paper first gives a brief overview of EPG, followed by a summary of EPG research and clinical activities in Japan. It then discusses how the pandemic, the associated restrictions and protective measures have affected our research and speech therapy using EPG, the modified procedures that some of us used, and the advantages of EPG therapy during a lockdown situation, whereas the discussion on further developments of EPG is presented in another paper of the present authors (Lee et al., 2022).

## EPG and its current applications

EPG is a computerized instrumental technique that detects, records and displays in real time the patterns and timing of contact between the tongue and hard palate, using electrodes embedded on the lingual surface of a custom-made dental device (commonly known as EPG plate) that fits securely against the user's hard palate (Gibbon & Lee, 2015; Hardcastle et al., 1991). The technique also simultaneously audio records speech signals, therefore, it has been used to investigate typical and atypical lingual articulation in speech production in dozens of languages, with some applications in the study of tongue movement in swallowing (for details, see e.g., Gibbon, 2013). As a clinical tool, EPG has been used to assess different articulatory phenomena (e.g., place of articulation, coarticulation) and to provide real-time visual feedback of tongue palate contact patterns in speech therapy. Historically, EPG has been used most frequently with those who had persistent articulation difficulties associated with cleft palate, followed by speech sound disorders of unknown origin (previously known as functional articulation disorders), and other aetiologies. Presently, there are three commercially available EPG systems: the *LinguaGraph* (Rose Medical Solutions Ltd, UK), the *WinSTARS* (Asahi Roentgen Ltd, Kyoto, Japan) and the *SmartPalate* system (CompleteSpeech, USA). Previous EPG systems included the *Dynamic Palatograph* (DP; Rion Ltd, Tokyo, Japan) and the *WinEPG* (Articulate Instruments Ltd, Edinburgh, UK) (for the history of EPG, see, e.g., Articulate Instruments, 2013; Lee, 2021; Lee et al., 2022). These systems are similar in terms of their general design, but differ in detail, such as the EPG plate construction, the number and placement of the sensors, and other hardware and software specifications (for a recent account, see, e.g., Lee, 2019, 2021).

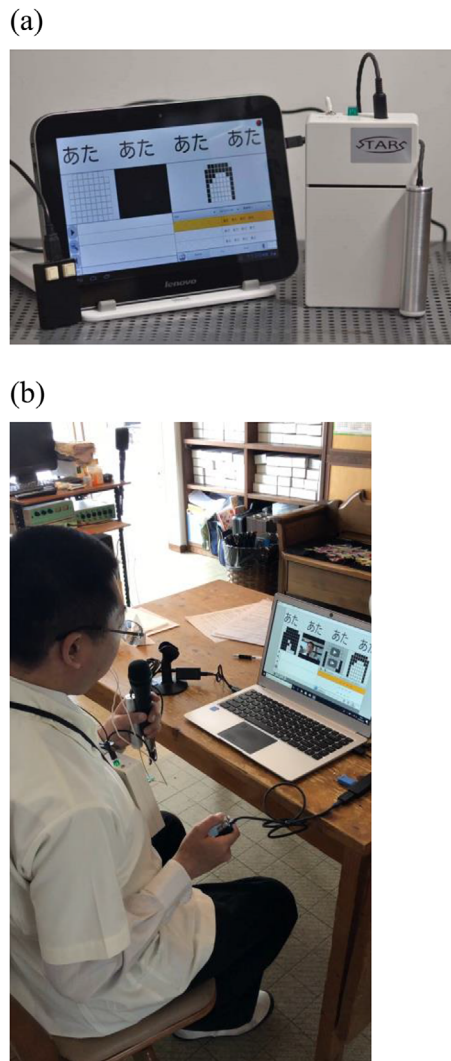
The process of manufacturing an EPG plate is the same whether it is going to be used in research or speech intervention (e.g., Lee et al., 2007; Lee et al., 2022). First the

EPG plate user has to visit a dentist or orthodontist who makes an accurate initial alginate impression of the palate and upper teeth, which is used to make a dental plaster cast. The dental model is then sent to a dental device company for making the EPG plate (see Lee, 2021, for practical advice). As the wearing of an EPG plate (which is an intra-oral device) is intrusive to a certain extent and is likely to interfere with normal articulation, users are usually asked to wear the device or a pseudo-EPG plate (i.e., an EPG plate without the electrodes) for about 2 h to get used to talking with the plate in the mouth before any articulation assessment (McLeod & Searl, 2006). Currently, EPG systems are available in some universities (e.g., in the disciplines of SLT, and phonetics) and speech therapy clinics, but the frequency of EPG use in research or speech intervention varies greatly. In Japan, there have been some recent developments in EPG technology and an increased use of EPG in research and speech therapy.

## Overview of EPG research and clinical activities in Japan

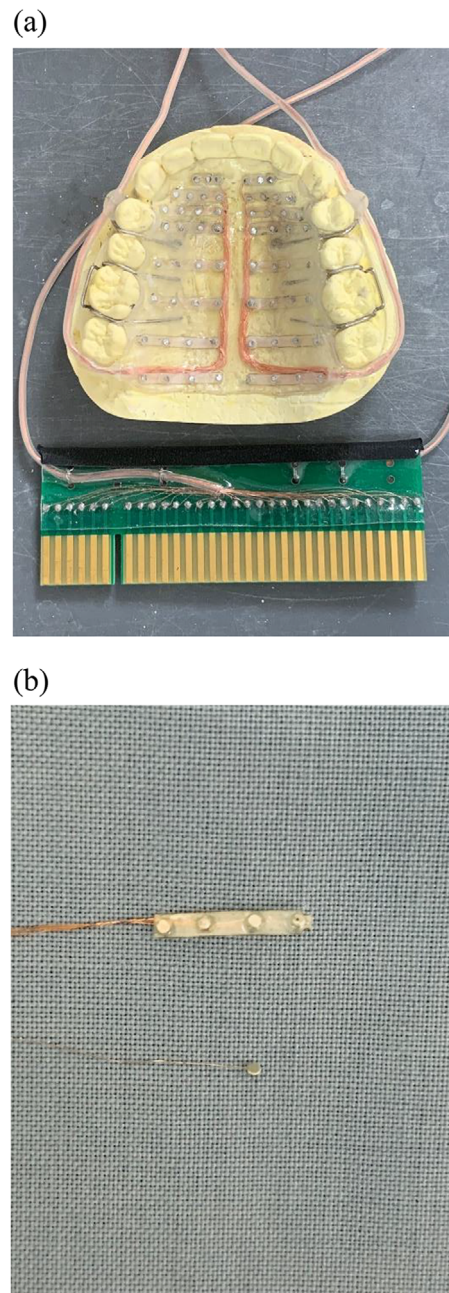
The clinical application of EPG in Japan has been actively stimulated for almost two decades at Yamamoto Dental Clinic, Nishinomiya. The DP (Rion) was used initially; however, this system was not ideal for regular clinical use because of the relatively time-consuming recording process, problems with synchronizing the speech signal and EPG frames, and unstable artificial EPG plates (as dental glue, instead of metal clasps, was used to keep the plate on the hard palate). For this reason, the *WinEPG* system (Articulate Instruments) was introduced and EPG plates for both speech and language therapists and clients in the clinic were ordered from a dental device company in the UK. Technical support was also provided from the UK (Queen Margaret University, Edinburgh, UK) with regard to using the *WinEPG* system. In total, more than 180 clients with articulation disorders have undergone visual feedback training using EPG. According to a retrospective study on EPG therapy (Fujiwara & Yamamoto, 2017), most of these clients had sufficient velopharyngeal function, but many had palatal fistulae. The average age at which they received EPG therapy was 11 years. The most frequently targeted speech sounds in EPG therapy were the alveolar consonants. The most prominent atypical contact patterns were 'retraction', followed by 'increased contact', 'fronting', 'complete closure', 'asymmetry' and 'alveolar-velar double articulation'. Overall, EPG therapy was effective for older clients with residual speech sound disorders, particularly errors with the alveolar consonants.

In order to meet the research and speech intervention needs in Japan, several improvements have been



**FIGURE 1** (a) STARS (Asahi Roentgen Ltd, Kyoto, Japan), a tablet-type speech training and recording system; and (b) WinSTARS (Asahi Roentgen), with the EPG plate inside the speaker's mouth and plugged into a multiplexer worn around the neck that transmits the tongue palate contact signal to the laptop via Bluetooth [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

introduced to the EPG equipment and the artificial plate. A portable device compatible with tablets—STARS (Asahi Roentgen) (Figure 1a)—was developed as a substitute for the portable training unit (PTU; Articulate Instruments). The sole function of the PTU is the real-time display of tongue palate contact patterns during speech, while STARS also allows recording of the contact patterns, speech signal and lip movement. In addition, it has a playback facility. WinSTARS (Asahi Roentgen) was also developed for computers and laptops. A special feature of WinSTARS is the transmission of the tongue palate contact signal by Bluetooth from the multiplexer (an external processing unit) to the computer (Figure 1b). Thus, attachment to a med-



**FIGURE 2** (a) A Mcyam-type EPG plate displayed on a dental plaster cast; and (b) an electrode sheet with four electrodes (top) compared with an individual electrode used in a traditional reading EPG plate (bottom) [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

ical isolation transformer is not needed and this makes the system more compact.

Another technical challenge was the production of the EPG plate, particularly the one of the Reading system (Hardcastle et al., 1989), which requires a high level of skill in arranging the 62 electrodes. To reduce manufacturing time and cost, a Mcyam type EPG plate was developed (Figure 2a). By measuring the distance between



consecutive electrodes of various upper jaw impressions, 12 sizes of electrode sheet (2.0–7.4 mm) were developed. Each sheet has a module of four electrodes in a set (Figure 2b). By combination of these 12 sizes of electrode sheets, it is possible to fit into a variety of maxillary arch shapes in clients with repaired cleft palate. The 62 electrodes are placed according to the same anatomical landmarks as the Reading type plate; thus, data obtained using the Mcyam plate can be compared with those recorded using the Reading plate. The production time of an EPG plate is reduced to two-thirds of the previous time and, hence, the cost is reduced to half.

In terms of EPG research in Japan, many research papers using the DP were published in the 1980s, but into the 1990s there was a reduction in EPG studies and the manufacture of DP ceased in 1996 (Fujiwara & Yamamoto, 2006). From the 2000s, research papers using EPG started to increase again. Most of the studies used WinSTARS or STARS (Asahi Roentgen) with a Mcyam type EPG plate. Initially, EPG research focused on reporting typical tongue palate contact patterns for Japanese speakers in order to provide EPG target patterns for use as visual feedback in speech therapy (see Appendix A in the additional supporting information). This is because the EPG data published in the 1980s were based on the EPG plate of the Rion system, which is different from the current Mcyam EPG plate in the number and placement of electrodes (Fujiwara & Yamamoto, 2020; Fujiwara et al., 2008). Recent EPG studies carried out in Japan have covered a wide range of topics, but most of them focused on articulation errors associated with cleft palate, followed by those related to skeletal malocclusion, and hearing impairment (see Appendix A online). As shown in Appendix A, there has been a growth in EPG research in Japan in the last couple of decades, with more researchers joining the research community and a wider range of topics being investigated using the technique. However, the global spread of COVID-19 could have halted many research and clinical activities, without safe alternative measures or procedures for assessment or data collection using EPG.

## Guidelines for using instrumental measures during the pandemic

COVID-19 is caused by the virus SARS-CoV-2 or severe acute respiratory syndrome coronavirus 2 (World Health Organization (WHO), 2020a). Generally, most people who test positive for COVID-19 show mild symptoms; but the illness can be serious for the others (especially those aged 60 years and above and/or with underlying medical conditions) and can cause death due to respiratory failure or other complications (Centers for Disease Control & Pre-

vention (CDC), 2020; WHO, 2020a). In addition, different variants of the virus have been identified and their transmissibility and infection severity vary (European Centre for Disease Prevention & Control (ECDC), 2021).

In terms of viral transmission, the current understanding is that the virus can be passed on from a person who carries the virus with or without COVID symptoms to another through contact, fomites, droplets and airborne transmission by means of aerosols (Asadi, Bouvier et al., 2020; Asadi, Wexler et al., 2020; Jin et al., 2020; for reviews, see also, e.g., Doll et al., 2020; Naunheim et al., 2021). In addition to sneezing and coughing, previous studies have shown that events such as breathing and speaking can generate droplets and aerosol, and a few studies have investigated the airflow during these activities (e.g., Abkarian et al., 2020; Asadi et al., 2019; Asadi, Wexler et al., 2020; Giovanni et al., 2021). The most recent study by Abkarian et al. (2020: 25238) reported the generation of a ‘jet-like, conical’ airflow with a speed of 0.3–1.0 m/s when their speaker (a typical male adult) breathed out through a slightly open mouth. Moreover, during the production of short sentences, the ‘airflow is more jerky and changes direction, depending on the sound emitted’; for example, for a voiceless bilabial plosive /p/, ‘a conical jet with average velocities of tens of centimetres per second and over long distances of about 1 m’ was observed (Abkarian et al., 2020: 25239). Breathing and speaking are the main activities that take place during speech research and speech therapy (Chacon et al., 2021), although coughing and sneezing may also occur, with the result that appropriate measures are needed to protect research participants, researchers, clinicians and clients if the research and therapy activities are to be carried out as scheduled.

One way to reduce the risk of contracting the coronavirus is to deliver speech therapy virtually using telepractice (detailed in a section below with a focus on speech intervention using EPG). If the therapy sessions or research data collection have to be carried out face to face, the protective measures and distancing policy as determined by local government or professional bodies will have to be followed. Doll et al. (2020) provided a succinct summary of recommendations for SLTs regarding the use of personal protective equipment (PPE), distancing and room requirements for performing both aerosol-generating procedures (AGPs; e.g., endoscopy) and non-AGPs in the context of voice and upper airway disorder management. The recommendations summarized are based on those given by the CDC, the Occupational Safety and Health Administration of the US Department of Labor, the American Speech–Language–Hearing Association (ASHA), and three published articles on guidelines for healthcare workers in the area of otolaryngology. When performing (1) AGPs on clients who are



COVID-19 positive within the previous 10 days, or positive 11–30 days and asymptomatic; (2) non-AGPs on those who test positive within the previous 10 days and are symptomatic; and (3) AGPs or non-AGPs on those who are under test for COVID-19, a facemask (N95 or PAPR), gown, gloves, eye protection or face shield are recommended. The procedures are to be carried out in a negative pressure room with an institution-specific turnover time. For other cases, barrier masks, gloves, eye protection or face shields are recommended; and the AGPs and non-AGPs can be carried out in a standard room with cleaning and turnover time, and 6-foot distancing is to be kept (Doll et al., 2020). Other SLT professional bodies have similar recommendations. The Royal College of Speech and Language Therapists (RCSLT) recommends ‘access to FFP3 or equivalent respiratory protective equipment when caring for a patient with confirmed or suspected COVID-19’ (RCSLT, 2021). Speech Pathology Australia (SPA) has produced infection prevention and control guidelines that detail the procedures for hand hygiene, PPE, management of physical environment, aseptic technique and waste management (SPA, 2020). Similar documents are available for SLTs in different countries (e.g., Interorganizational Group for Speech–Language Pathology & Audiology, 2010, for Canada; and The Irish Association of Speech & Language Therapists, 2021).

Using EPG in speech therapy or speech data collection is similar to using other instrumentation investigating speech production (e.g., speech recording for acoustic analysis; ultrasound tongue imaging), which usually involve clients and clinicians or research participants and researchers sitting close to each other while engaging in therapy activities or speech tasks. Furthermore, clients or participants will be in close proximity to the equipment (e.g., microphone) and/or a computer screen. Hence, more specific advice on how to sterilize specialist equipment would be useful.

A search of literature using the terms ‘(Covid) AND (speech therapy)’ was carried out in PubMed. The results showed that most of the publications are about providing speech therapy through telepractice and guidelines or recommendations for swallowing assessment, tracheotomy care and voice evaluation; and this general finding concurs with the article list provided by the ASHA (n.d.). Relevant papers by Doll et al. (2020) and Castillo-Allendes et al. (2021) are on recommendations for clinical practice in the area of voice management. Regarding the handling of recording equipment, Doll et al. (2020: 3) stated that microphones ‘cannot be submerged’ and suggested to ‘disinfect per manufacturer instructions’ and ‘consider microphone cover’; however, the authors added that the ‘effect of microphone cover on acoustic results is unknown’. Castillo-Allendes et al. (2021: 720) recommended that the ‘micro-

phone should rest in a stand on the patient’s side of the plexiglass with a standard distance of 30 cm ... from the patient’s mouth’ and that ‘headsets are not recommended at this time’. However, no advice on equipment cleaning was given. Both papers concern audio recording of speech which is just part of the EPG procedure. Hence, one of the topics presented at the 7th EPG Symposium was about the measures adopted to make EPG research and therapy possible during the pandemic and these are detailed in the following two sections.

## Impact of the pandemic on EPG research

Research into speech—whether it is an investigation of typical or atypical speech production or a treatment study—is complex because speech is uniquely human, and whenever human subjects are involved there are specific restrictions on experimental designs and manipulation of variables. During the COVID-19 pandemic human interaction and communication became heavily regulated, so inherent complexities of speech research became increasingly complicated because humans are both the experimenters and the source of data. This is especially evident in cases where instrumental kinematic techniques such as EPG are needed. The challenges that COVID-19 pandemic imposes on EPG research are twofold: data collection challenges and ethical challenges.

The impact of restrictions on EPG research activities as a result of COVID-19 depends on the stage of the research procedure. During the participant recruitment stage, the negative effects of a pandemic can be dealt with by following general guidelines and recommendations, because participant recruitment can be, at least partly, done remotely. During the EPG plate production stage, the challenges increase slightly, because this stage necessarily requires face-to-face interaction between orthodontists and/or dental technicians and participants. Visits to the orthodontist are usually regulated via national and local health authorities so this will vary across countries, but will likely cause delay. Delays should also be anticipated when sending plaster casts to the manufacturer and receiving the finished EPG plate. Once the plates are received, participant desensitization and data recording can begin. At this stage the issue of plate and lab equipment disinfection must be adequately addressed as well as experimenter–participant interaction. Depending on the EPG plate design and construction (Wrench, 2007), different constraints should be taken into account when disinfecting the plate. Based on the currently available information on the virus (WHO, 2020b), lukewarm water and soap should be enough in most cases. The plate should be disinfected each time it is handed from one person to

another, while wearing disposable protective gloves and a facemask.

Disinfecting microphones is more problematic, as mentioned above, but if possible microphone covers should be changed or washed between sessions (Doll et al., 2020). Enough time should be allowed to disinfect all contact surfaces and to ventilate the lab between recording sessions. During the recording session, the experimental setup can be managed in order to increase safety. For example, the experimenter and the participant can be faced away from each other and the experimenter can operate the participant's screen and EPG equipment remotely from a safe distance of more than one metre. For example, the CROCO corpus was recorded in such a way that the experimenter and the participant wearing a cochlear implant performed a modified map task and the participant was unable to see the experimenter (Liker et al., 2019). The primary purpose of this set up was to facilitate a communicative situation which would draw participants' attention away from the laboratory environment or experimental context and to immerse themselves in their task. Naturally, facing away from participants will not be possible in all experimental designs and in all research contexts, but even then, it might be beneficial to consider a variety of communicative situations in the laboratory and to manipulate distance and position in order to increase safety.

Since participants cannot wear a mask during EPG data collection, the use of a protective visor or face shield might be considered (current data on the benefits of protective visors for COVID-19 prevention is not conclusive; National Health Library & Knowledge Service, 2020). Some speech research centres have their own internal COVID-19 protocols, but they often remain unpublished (e.g., the speech recording protocol used in the Institute of Phonetics and Speech Processing (IPS) in Ludwig-Maximilians-Universität München). Therefore, we propose a checklist for COVID-19 protocols applicable in EPG data collection contexts (see Appendix B in the additional supporting information). The measures include the use of PPE, disinfection of equipment and desktop, physical distancing, and sufficient time for room ventilation and disinfection. They are compatible with the general protective measures recommended by governments and SLT professional bodies. The COVID-19 pandemic also highlighted the benefits and the importance of speech corpora collection, maintenance and sharing (see, e.g., the DELAD initiative reported in Lee et al., 2021; and van den Heuvel et al., 2020). Existing speech corpora enable researchers to undertake research on large datasets during the pandemic without the risks associated with speaker recruitment and speech data recording.

Apart from data collection challenges, EPG research during the COVID-19 pandemic also involves ethical chal-

lenges. Powell (2012) proposes six ethical principles relevant for phonetic and linguistic research, especially in clinical contexts: (1) beneficence (acting in the best interest of others), (2) nonmaleficence (minimizing risks and harm to others), (3) competence (accepting responsibility for quality of work), (4) integrity (avoiding conflicts of interest and communicating honestly), (5) compliance (working in accordance with rules and regulations), and (6) respect (protecting individual autonomy and accepting differences). The COVID-19 pandemic directly relates to at least three of these principles (beneficence, nonmaleficence and compliance). Researchers should therefore ensure that they identify potential ethical issues brought about by the pandemic and address them by careful planning of each research stage and necessary revisions to the informed consent forms. Informed consent forms should clearly state the measures taken to prevent the spread of the virus, as specified by the WHO and local health authorities. It is advisable that researchers also evaluate potential benefits of their investigation and speech research in general for COVID-19 prevention, such as screening and diagnosing COVID-19 patients from acoustic and physiological data (e.g., Han et al., 2020; Quatieri et al., 2020).

### Impact of the pandemic on speech therapy

Clinicians face similar challenges when trying to maintain SLT services while abiding by the protocol on social distancing and other protective measures recommended by their national professional associations (e.g., Doll et al., 2020, who referenced to ASHA and the equivalent organizations in Canada, Australia, New Zealand, the UK and Ireland; Namasivayam-MacDonald & Riquelme, 2020). For example, the Japanese Association of Speech-Language-Hearing Therapists (JAS) announced a set of general guidelines regarding face-to-face clinical sessions on their website (JAS, 2020a). Besides hand washing and wearing a facial mask to guard against the spread of viruses, a number of other measures are listed, including keeping an appropriate distance between the clinician and their client; not to take off the facial mask when showing or imitating an oral movement to the client, but using letters, pictures, or video clips to provide the demonstration if needed; and avoid using any therapy techniques that might cause droplet production (e.g., strong expiration).

During the lockdown period (e.g., the first state of emergency from 7 April to 24 May 2020 in Japan), residents were requested to stay at home except when absolutely necessary. Careful decisions regarding maintaining or suspending outpatient clinical care had to be made by hospitals and clinics. According to a survey conducted by the JAS in May 2020 (JAS, 2020b), about 14% of the respondents





**FIGURE 3** (a) Speech therapy session before the COVID-19 pandemic where personal protective equipment (PPE) was not required; and (b) speech therapy session during the pandemic where clinicians are required to use PPE when seeing clients [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

(310 of 2147) stopped outpatient therapy, 31% ( $n = 668$ ) provided limited face-to-face therapy, near 20% ( $n = 418$ ) continued face-to-face therapy without restrictions, 31% ( $n = 668$ ) did not provide outpatient therapy before the pandemic, and 4% ( $n = 83$ ) selected others but no further information was specified. For example, for Showa University Dental Hospital (with which one of the present authors is affiliated), which is located in the centre of Tokyo, all outpatient speech therapy was cancelled for 2 months, and face-to-face therapy resumed in June 2020. Before the COVID-19 pandemic, no PPE was used during clinical sessions (Figure 3a). However, since resuming face-to-face therapy in June 2020, a set of PPE including face shield, mouth shield, disposable gowns and caps are worn by clinicians to prevent virus transmission during speech therapy. Clients are asked to wear face shields, and an acrylic board is placed between the clinician and the patient (Figure 3b). The use of PPE and acrylic boards are essential in carrying out face-to-face speech therapy safely but there are some drawbacks (Corey et al., 2020; Hampton et al., 2020). Observing tongue movements through face shields and

an acrylic board and identifying subtle sound distortions when clients have their face masks on can be challenging. Clinicians cannot look into the client's mouth to check articulatory movement, nor can they clearly demonstrate lingual articulatory movement to their clients.

The situation in the UK seemed to be more severe. According to Patrick (2021), there was no face-to-face therapy for children in some hospitals for at least 6 months in 2020. When face-to-face speech therapy sessions resumed, measures of social distancing and the use of PPE were in place. Similar to the situation of using EPG for research, the clinical use of EPG has also been limited by restrictions within the orthodontic service including EPG plate making. Although clinical practice has slowly returned to 'normal', many people are avoiding medical appointments as they are worried about the potential contraction of COVID-19. Online appointments have been taking place and will continue to be a part of service delivery in the future. However, there are several difficulties with online services. The sound and picture quality can be poor due to variable quality of internet connection. Even with very good sound quality, it is difficult to hear audible nasal emission and turbulence, and articulation errors (e.g., palatalization, lateralization, and double articulation) during online sessions. Many clients rely on their mobile phones for online therapy (due to various reasons, e.g., lack of internet access or computer/laptop) and the small screen makes therapy sessions challenging. Furthermore, online therapy may not be effective for very young children. Some of the challenges stated above, particularly those related to lingual articulation can be helped by using EPG, for example, the combination of using online therapy sessions and a portable EPG device (PTU or STARS) by the clients (personal communication with K. Patrick). In this regard, colleagues in Japan have some positive experience and this is discussed in the next section.

### Using telepractice to deliver EPG therapy

The level of impact of COVID-19 on EPG therapy depends on the stage of the therapy procedure. The application of EPG in speech therapy is considered through perceptual assessment of the client's speech, their speech and language development, and the client's or caregiver's need and motivation for intervention. This initial evaluation is done remotely in an online session, but face-to-face sessions are preferred. For current clients, further speech assessment and consultation with caregivers are carried out online.

After receiving the EPG plate, the initial speech recording using EPG is made at facilities which have an EPG system—either the WinEPG (Articulate Instruments) or



the WinSTARS (Asahi Roentgen). This is the most difficult stage during the pandemic as clients have to physically go to the facility and engage in speech recording using EPG without a mask. Some clients are reluctant to undergo these procedures and, in such cases, with instructions from the clinician, STARS (Asahi Roentgen) is lent to the client and his/her caregivers to do EPG recordings themselves. Another possible alternative is lending a PTU (Articulate Instruments) to the clients and their speech samples and corresponding contact patterns displayed by the PTU (as it does not record any EPG data) are then recorded using the recording function of a web conference system during an online session. If a web conference system is not available, caregivers are instructed to use their mobile phone to film the PTU tongue palate contact display and send the video clips to their clinician for data analysis. The alternative assessment procedures described have been used and it works fine for both clinicians and the clients and parents.

Analysis of the EPG data and treatment planning can be done remotely; for example, the model used in the two CLEFTNET projects: CLEFTNET Scotland (Gibbon et al., 1998) and CLEFTNET UK (Lee et al., 2007). The two projects were a collaboration between researchers based at a university (Queen Margaret University) and clinicians in cleft palate centres throughout the country. The clinicians carried out speech assessment using EPG and the data were sent to the researchers for detailed analysis and therapy recommendations. Although a similar cleftnet infrastructure has not been established in Japan, there have been researcher–clinician collaborations in analysing EPG data collected by clinicians or EPG videos provided by caregivers.

After the initial EPG assessment, a therapy plan is developed for each client. Before the lockdown, clients typically see their clinician once a month in an SLT clinic. The clinician demonstrates the tongue palate contact pattern of the target sound(s) and explains the difference between the client's pattern and the clinician's model to both clients and their caregivers. It is important that caregivers also see the difference and understand typical EPG patterns, as they can apply this knowledge when they carry out the home practice with their children. At the end of each clinician-led EPG training session, appropriate home practice is assigned with written instructions and printed EPG pattern(s). Clients take home a STARS or PTU and complete the home practice every day using the EPG visual feedback (Fujiwara, 2007). During the period of restricted movement due to the COVID-19 pandemic, all of these procedures were done remotely. Telepractice was carried out once a week, with each session running for 30–40 min. Clinicians were able to see their client on a computer screen and they could check their clients' speech using both perceptual assessment and

visual inspection. In those circumstances, it is sometimes difficult to differentiate between mild distortions of speech sounds. By also looking at the tongue palate contact pattern display shown by STARS or PTU, clinicians can check whether clients are using suitable lingual gestures and they can also demonstrate typical patterns to their clients. Clients can then modify the tongue palate contact patterns according to the model. Similarly, after an online session, an assignment is sent to clients and their caregivers as daily home practice. The EPG teletherapy has been shown to lessen the impact of restricted movement due to the COVID-19 pandemic on the provision of speech intervention. It also makes more efficient use of the technology to carry out more frequent and continuous speech therapy.

## CONCLUSIONS

It has been challenging to continue EPG research and therapy during the pandemic, but recommendations from local government and professional bodies, available knowledge regarding infection control and the expertise in using EPG were applied to design alternative procedures that allowed EPG research and therapy to continue. The current crisis has created an opportunity to reflect on and improve research and clinical practice.

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## CONFLICT OF INTEREST

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

## DATA AVAILABILITY STATEMENT

Data sharing is not applicable as no new datasets were created for this article.

## ETHICS STATEMENT

This study does not involve any research experiment being carried out on human or animal subjects. It does not contain any copyrighted material.

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## SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher’s website.

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