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The national CLEFTNET project for individuals with speech disorders associated with cleft palate

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Abstract

Although previous studies have demonstrated the benefits of using electropalatography (EPG) for treating therapy-resistant articulation errors associated with cleft palate, until recently access to this form of treatment has been limited. For the past 10 years, however, the CLEFTNET Scotland project has provided individuals with cleft palate access to EPG therapy. CLEFTNET represented a novel form of EPG service delivery – it linked the cleft palate centres throughout Scotland to Queen Margaret University College (QMUC) in Edinburgh through an electronic network. EPG data collected in the centres were sent to QMUC, where experts conducted detailed analysis leading to a precise diagnosis of each individual's specific articulation difficulty and suggested therapy guidelines to the specialist speech-language therapists based on their analysis. This form of service delivery has recently extended to include England, Wales and Northern Ireland to form CLEFTNET UK. This paper describes the CLEFTNET projects, discusses orthodontic issues relevant to EPG therapy for individuals with cleft palate, and presents a case study to illustrate how therapy guidelines for speech-language therapists are derived from data analysis.

Introduction

Children with a history of cleft palate are likely to exhibit speech disorders which could hamper communication and impair self-esteem. Past literature showed that the prevalence of compensatory articulations in preschool and school-age children ranges from 22% to 28% (Dalston, 1992; Hardin-Jones & Jones, 2005; Peterson-Falzone, 1990). As children grow older, these abnormal articulations become less likely to resolve spontaneously and are resistant to standard speech therapy techniques (Gibbon, 2004; Harding & Grunwell, 1993). Previous studies have demonstrated the benefits of using electropalatography (EPG) as a visual feedback for treating persisting articulation errors in these children (Gibbon, 2004; Gibbon & Paterson, in press). Until recently, however, EPG therapy was not available to most people with articulation disorders. The reasons for this are the high cost of purchasing an EPG system and the artificial plates required for each person receiving therapy, the lack of technical support for using the technique, and the long distances that some children and their

families have to travel to receive therapy (Gibbon, 2004; Gibbon, Crampin, Hardcastle, Nairn, Razzell, Harvey, & Reynolds, 1998).

CLEFTNET Scotland

CLEFTNET Scotland was initiated in 1996 by researchers based at Queen Margaret University College (QMUC) in collaboration with speech-language therapists (SLTs) working in the four cleft palate centres in Scotland (Aberdeen, Dundee, Edinburgh, and Glasgow) (Gibbon et al., 1998). CLEFTNET linked up these cleft palate centres with QMUC through an electronic network which allowed EPG data to be transferred to experts at QMUC. These EPG experts analysed the data and then sent back the results and therapy guidelines. It was an innovative form of service delivery for the treatment of articulation disorders in individuals with cleft palate and the facility was unique to people living in Scotland. The project also included technical support to the SLTs, particularly at the stages of speech recording and data transfer.

The anonymised articulatory data were archived in the CLEFTNET Scotland database, which has allowed researchers to study the speech patterns of a relatively large group of speakers with cleft palate, which has not been possible in the past. The database now contains speech samples collected from more than 30 speakers mostly from the Glasgow centre. The database has proved to be an important resource and provided data for several studies concerning articulation disorders associated with cleft palate (Gibbon, 2004; Gibbon, Smeaton-Ewins, & Crampin, 2005; Gibbon, Ellis, & Crampin, 2004).

An innovation at the time CLEFTNET Scotland was set up was the use of EPG portable training units (PTUs) (Jones & Hardcastle, 1995; Gibbon, Stewart, Hardcastle, & Crampin, 1999). PTUs are small, lightweight units that are relatively inexpensive and simple to operate. The PTUs allow visual feedback therapy to take place close to a child's home, which increases opportunities for practice and avoids long distance travel for therapy. Each of the four cleft palate centres in Scotland has a number of PTUs available so EPG therapy can be carried out at a local centre, or at home with appropriate supervision (Gibbon et al., 1998).

A recent national survey about EPG therapy in Scotland between 1993-2003 reported demographic information about individuals undergoing EPG therapy and SLTs' opinions about the outcomes (Gibbon & Paterson, in press). The survey revealed that 27 individuals (15 males; 12 females) with cleft palate underwent EPG therapy during this time. All had received previous speech therapy prior to commencing EPG therapy and the majority started EPG therapy between the ages of 6-15 years. Most used the PTUs for home practice and all received between 1-20 clinic-based sessions of EPG therapy. The most frequently targeted

sounds in therapy were (from most to least frequent) /s/, /t/, /d/, /Σ/, /s/ clusters, /tΣ/, /dZ/, /k/ and /γ/. SLTs judged that the majority of those with cleft palate who received EPG therapy benefited to some extent in terms of improved articulation and increased awareness of their own speech difficulties. However, SLTs also reported that most individuals had at least some difficulties generalising newly learned articulatory skills into conversational speech. The study concluded that when using EPG, SLTs need to adopt specific strategies to promote generalisation and maintenance.

The Glasgow Team's Experience

For the past 10 years, the Glasgow team has been the most active of the four centres involved in CLEFTNET Scotland and the following section summarises their experience relevant to orthodontic and SLT issues that need to be considered when using EPG to treat individuals with cleft palate.

Orthodontic Considerations

In order to record the dynamic articulatory contact patterns in EPG, it is necessary to construct an artificial plate to fit against the speaker's hard palate (Hardcastle & Gibbon, 1997). The artificial plate is made from an accurate plaster model of the subject's hard palate and teeth. It is obviously important that the plate interferes as little as possible with normal speech production so an exact fit is essential and the plate should not move even when considerable pressure is exerted in the posterior edge as may happen, for example, during closure for a velar stop.

Making EPG plates that fit well throughout therapy is dependent on taking an accurate initial alginate impression and planning EPG therapy during a stable period of dental development. Hence, it is important to time EPG therapy to coincide with a "window" of relative stability in dentition. When using EPG in clinical work, it is a good practice for SLTs to consult the orthodontist in their cleft palate team to find out about an individual's current dentition and the likelihood of any changes in dentition that might occur during the proposed period of EPG therapy. Dental problems such as caries and attrition (i.e., tooth surface loss) can cause poor retention of the EPG plate on the teeth. Clasping teeth with doubtful stability or prognosis should be avoided. Furthermore, changes in tooth alignment due to caries and space loss can also affect the general fit and eruption of molars could interfere with the cable that runs behind the last tooth.

Any changes in dentition that occur from the time the dental alginate impression is taken to the completion of EPG therapy can be potentially serious. If there is any change in

dentition after the plaster model has been made and before therapy commences, which can be several weeks, then the plate may not fit well and EPG therapy is compromised. If a change in dentition occurs during EPG therapy, then once again, the plate may no longer fit and EPG therapy may not be completed. Table 1 lists the natural changes in dentition and possible hazards at each stage in terms of EPG therapy. Table 2 shows further potential problems for EPG therapy due to specific dental problems associated with cleft palate and other factors. See tables 1 and 2 at end.

Speech Therapy Considerations

Recommending EPG therapy for an individual with cleft palate relies on the SLTs' clinical judgement about the predicted beneficial outcome of this form of therapy. A wide range of factors can affect the progress in EPG therapy and there is a lack of knowledge about the most critical variables that predict and maximize progress in EPG therapy. A range of important variables related to the child (e.g., age, type and severity of articulation disorder, degree of motivation to change speech; the presence of associated factors such as cognitive delay, hearing impairment, or motor speech disorder), as well as clinician characteristics (e.g., ability to motivate client, experience in EPG therapy) are all likely to affect the outcome. In addition, Almost and Rosenbaum (1998) suggested that certain parenting styles and parental motivation and cooperation can have a beneficial impact on the effectiveness of any form of speech therapy, for example, positive skills including good turn-taking skills, frequent corrective feedback as well as regular attendance for speech therapy sessions. Practical factors such as the distance that individuals need to travel for therapy, tolerance to wearing the EPG plate and fear of the dentist are also relevant for individuals who undergo EPG therapy.

New Developments in EPG Therapy

Since the commencement of CLEFTNET Scotland, a reorganisation of cleft care in the UK has taken place and new developments in the EPG system has provided an opportunity to extend the CLEFTNET service to the rest of the UK. The following section provides a summary of these two developments and their impact on CLEFTNET.

Nationwide Reorganisation of Cleft Care

There has been a recent nationwide reorganisation of cleft services in England, Wales, and Northern Ireland. In the early 1990's, concerns were raised about variations in the standards and outcomes of treatment for those born with cleft lip and/or palate (CSAG, 1998). The CSAG (Clinical Standards Advisory Group) Cleft Lip and Palate Committee and its research team were assigned to review cleft care services. One of the recommendations

made in the CSAG report was to centralise the expertise and resources for cleft care by reducing the number of cleft units throughout the UK. This has led to the reorganisation of cleft services from 57 units to 8-15 regional centres. This reorganisation to a relatively small number of centres, and subsequent concentration of specialist resources in these centres, has made it feasible to extend the CLEFTNET project to include the rest of the UK.

Advances in Information Technology and the EPG system

There have also been advances in information technology as well as developments in the EPG system since CLEFTNET Scotland was first established. For example, 36K dial-up modems were used previously for transferring the EPG data electronically, while broadband is now available for internet access allowing for faster transfer of data. In the previous project, SLTs used the EPG3 system, whereas there is now Articulate Assistant™ software (Wrench, Gibbon, McNeill, & Wood, 2002) in conjunction with the WinEPG™ system (Scobbie, Wood, & Wrench, 2004). The new software is more user-friendly for SLTs and allows greater flexibility in data analysis.

CLEFTNET UK

CLEFTNET UK extends the EPG therapy service delivery to include England, Wales, and Northern Ireland. This project is bigger and more ambitious than the previous one, but in essence it operates in a similar way. It aims to involve all the regional cleft palate centres in the UK and each participating centre has agreed to: (1) purchase or intend to purchase the WinEPG™ system (and PTUs); (2) transfer their EPG data to QMUC; and (3) commit to funding EPG plates. As in the previous project, the roles of QMUC include: (1) running EPG workshops and providing technical and specialist EPG support to the SLTs, (2) analysing and archiving EPG data sent electronically from the participating centres, (3) providing advice on strategies for EPG therapy to the SLTs, and (4) managing the articulatory database. Regular two-day EPG workshops have been organised for SLTs in the form of self-directed hands-on tutorials with the WinEPG™ software, lectures, and clinical case discussions.

Materials have been redeveloped for CLEFTNET UK: new speech material for EPG recordings, an EPG brochure, information sheets, patient consent forms, and EPG data analysis reports. A major part of the CLEFTNET project has been obtaining the necessary research and ethical approvals to transfer data between the specialist centres and QMUC. A more systematic and clearer summary of the EPG analysis results has been developed. The analysis report includes a table summarising the EPG patterns for each target phoneme, with error patterns classified based on EPG error patterns described by Gibbon (2004); followed

by therapy guidelines, and EPG printouts for illustrating the error patterns and normal contact patterns.

Therapy guidelines serve as a reference for the SLTs as they embark on therapy for each individual. These guidelines are based on identifying the individual's error patterns and his/her correct EPG patterns. Patterns that are variable, particularly those produced correctly in some contexts but not others, are important to identify during the analysis process. Therapy for these targets may achieve success because there is evidence that a particular tongue configuration is achievable and already in the individual's repertoire. The presence of some EPG patterns can indicate potential 'facilitative' contexts that might assist individuals to achieve an articulatory configuration not currently in their repertoire. The concept of using facilitative contexts in speech therapy is not new (McDonald, 1964; Shine, 1989). The aim of contextual facilitation is to place a target sound in a specific context so that components of a preceding or following sound facilitate production of the target (Kent, 1982). Therefore, an important part of using EPG in therapy is first to assess the range of articulatory configurations in an individual's repertoire and identify contexts in which the individual is able to produce features, such as alveolar placement, bilateral contact, velar placement, an alveolar groove and so on. These contexts are then used to facilitate articulatory gestures that are incorrectly produced, for example with abnormally retracted placement, minimal EPG contact, or lack of a central groove.

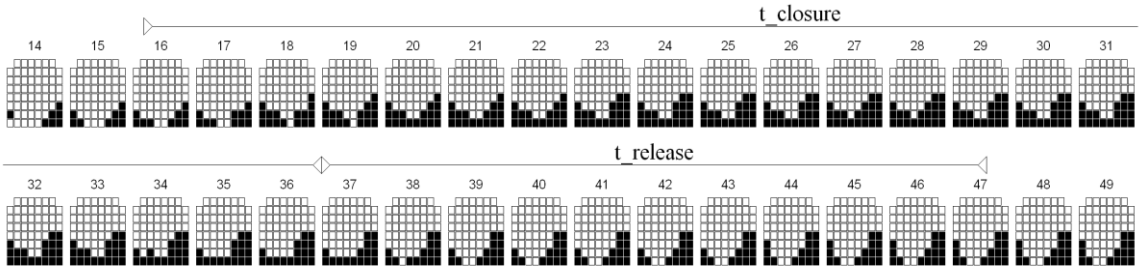
The following case study illustrates how therapy guidelines are derived from data analysis in the CLEFTNET project.

Illustrative Case Study

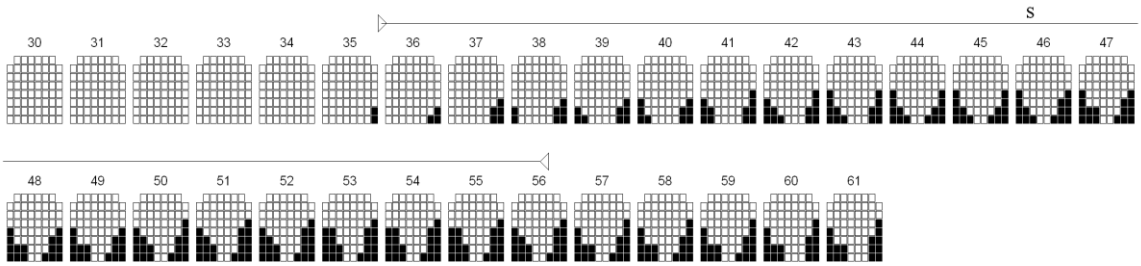
J is an 8-year-old Scottish boy. He was born with a unilateral cleft lip and palate. He had received lip repair at the age of 4 months, palatal surgery at 8 months and surgical repair of a small anterior fistula at 4 years 3 months. Data analysis based on his initial EPG recording showed that the major EPG error pattern was retraction from alveolar to velar placement (see Appendix and Figure 1). Retraction of placement to the velar region affected alveolar targets /t, d, n, s, l/ and postalveolar targets /tΣ, dZ/ at single word level and postalveolar /Σ/ at connected speech level. There was also increased variability for /t/, /s/ and /Σ/. The EPG analysis showed that J did not show evidence of a number of EPG error patterns that are known to occur in cleft palate speech, such as increased tongue palate contact for all lingual targets, fronted placement for velars (i.e. velars produced as middorsum

palatal stops), complete closure during sibilant and high vowel targets, and double articulations for oral plosive targets (Gibbon, 2004).

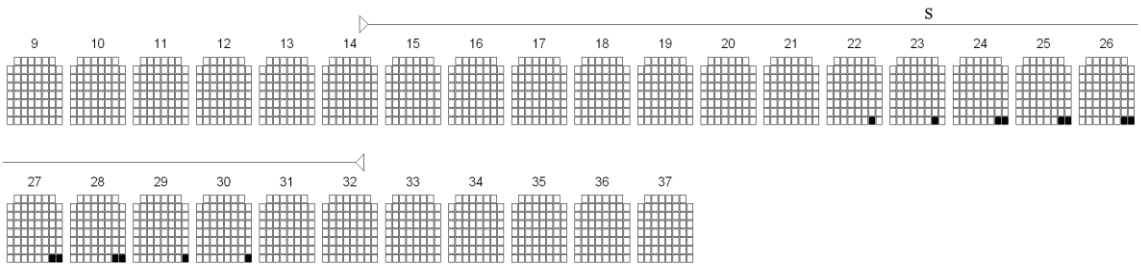
(a) /t/ in ‘a team’ [Retraction; Increased variability]



(b) /s/ in ‘a seat’ [Retraction; Increased variability]



(c) /s/ in ‘a sob’ [Open pattern; Increased variability]



(d) /tΣ/ in ‘a chore’ [Retraction]

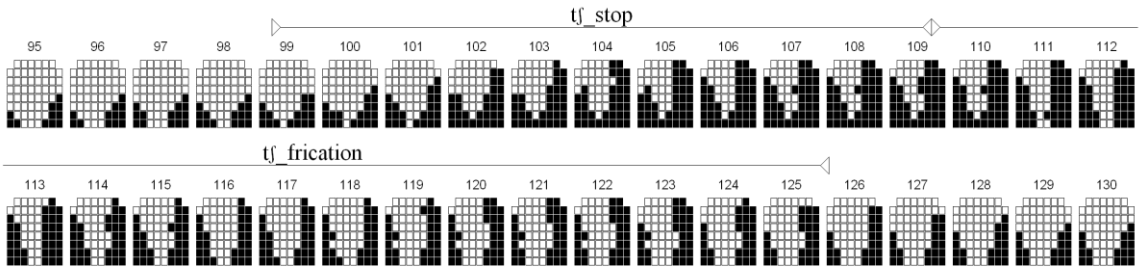


Figure 1. Examples of J’s error EPG patterns that were judged as abnormal for targets /t/, /d/, /n/, /s/, /Σ/, /tΣ/, and /l/, with error type(s) in brackets.

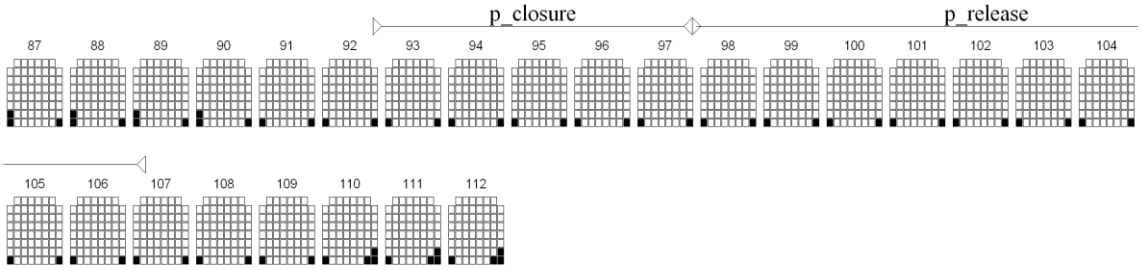
Tongue palate contact patterns for the targets /t/, /s/ and /Σ/ were variable, and appeared to be dependent on the phonetic context or the complexity of speech materials. The most striking example of variability was the place of contact for /s/, which showed retraction in a high vowel environment but had minimal contact in an open vowel environment (compare Figure 1b and 1c). Possibly /s/ was produced at a further posterior location due to the effect of the back vowel /□/. The EPG patterns for /Σ/ were more like normal EPG patterns for this target in the context of a high vowel (Figure 2d), but were retracted to velar in other contexts.

Insert figure 2 about here

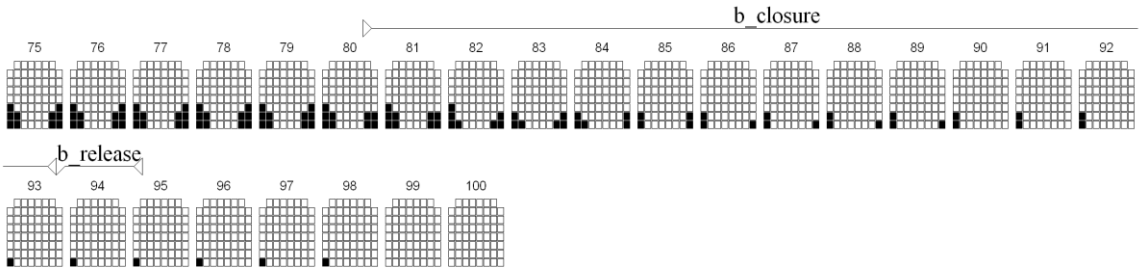
As indicated earlier, the data analysis process aims to identify tongue palate contact patterns that are normal, abnormal (identifying error patterns) as well as patterns that are variable. Despite a pervasive pattern of retracted placement for alveolar and post alveolar targets, J showed some normal EPG patterns (Figure 2), for example, for bilabial stops /p/, /b/ and /m/, velar stops /k/, /γ/ and /N/, and /Σ/ at single word level. Previous studies have shown that, unlike normal speakers, some individuals with cleft palate produce bilabial targets /p/, /b/ and /m/ with simultaneous lip and lingual closures (Gibbon, 2004; Gibbon & Crampin, 2002; Gibbon, Lee, & Yuen, in press). J did not show these types of double articulations and he also produced velar targets at the appropriate place. Particularly noteworthy in the analysis was J's variable production of /Σ/, which had a normal configuration in some contexts (Figure 2d) but was an error pattern (retracted placement) in other contexts.

The EPG data analysis showed that J had a pervasive pattern of retraction, which affected the alveolar /t/, /d/, /s/, /l/, /n/ and postalveolar /Σ/, /tΣ/, /dZ/ targets. The primary goal in therapy then is to produce normal anterior contact for these targets. In normal speakers, EPG contact for /t/, /d/ and /n/ are characterised by anterior closure, bilateral contact and lack of posterior central contact to form a characteristic horseshoe shape (Gibbon, Yuen, Lee, & Adams, this issue). To produce a correct /s/, this horseshoe shape needs to be modified to form an anterior central groove. J's current EPG patterns for anterior stops do not contain any features of normal anterior stops, in other words they do not have anterior constriction, or bilateral contact and they have contact in the posterior central region of the palate. EPG therapy needs to focus on developing a normal anterior lingual stop as a first priority.

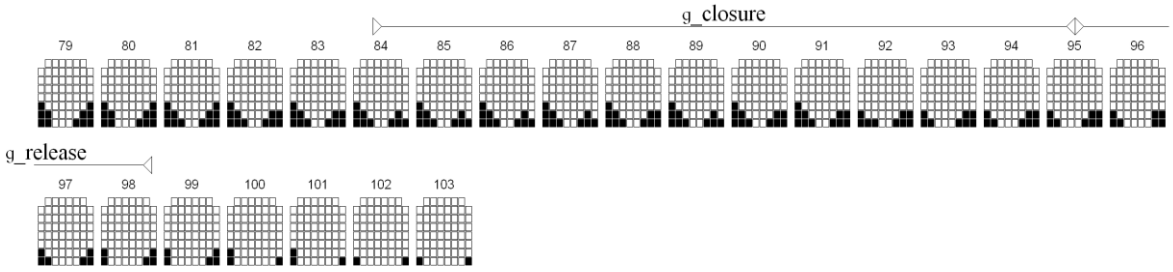
(a) /p/ in ‘playing’



(b) /b/ in ‘Bob’



(c) /g/ in ‘Gary’



(d) /Σ/ in ‘a sheet’

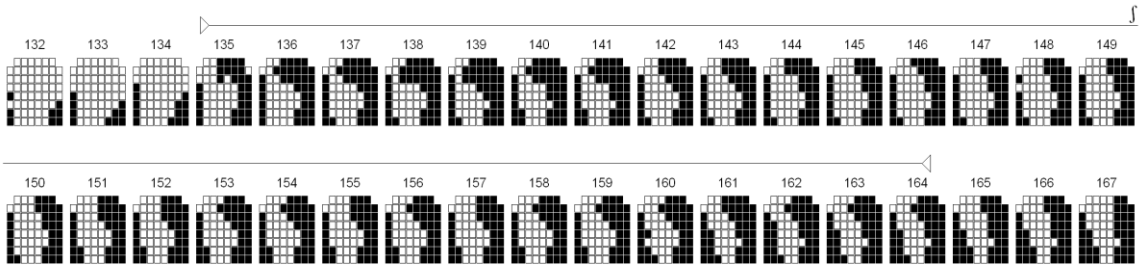


Figure 2. Examples of J’s EPG patterns that were judged as normal for targets /p/, /b/, /m/, /k/, /γ/, /N/, and /Σ/.

In order to attain the goal of achieving normal anterior stops, it is helpful to identify possible facilitative contexts in J’s speech. The analysis therefore identifies any examples in the data where anterior contact occurs. In fact, anterior contact was evident for /Σ/, which was produced correctly in high vowel contexts. Therapy could make use of this context to

facilitate the correct anterior contact pattern for other alveolar targets, such as /t/, /d/, /n/, and /s/. In order to use /Σ/ as a facilitative context, a preliminary goal could be to stabilise production of this target so that it is produced correctly in all contexts. The rationale for choosing this as a first goal is that there is a good chance of success, which is an important in the early stages of therapy. Individuals who receive EPG therapy have often experienced failure in previous speech therapy so measurable success early on is important in building motivation and confidence.

If the preliminary goal is achieved with J able to produce correct patterns consistently for /Σ/, then a subsequent goal could be to achieve correct placement for (a) /tΣ/, /dZ/ and (b) /s/ and /z/ targets. Recall that J had consistently retracted placement for affricates and sibilants. In the first instance, these targets could be facilitated by placing them close to /Σ/, for example, to facilitate correct pattern for / tΣ/ in *fish chips,* or /s/ in *fish supper*. Or alternatively these targets could be placed in nonsense sequences, such as *eesh-chee eesh-see* etc. For successful production of the affricate, J needs to anticipate anterior placement (facilitated by /Σ/) for the stop component of the affricate (see Liker, Gibbon, Wrench and Horga, this issue, for normal affricate patterns). For correct production of /s/, /z/, J needs to modify only slightly the EPG patterns that he uses for /Σ/. Once J can produce normal placement for sibilants and affricates, then he has many articulatory features, such as anterior constriction and bilateral contact, that he needs for correct placement for /t/, /d/, /n/ and /l/.

Initially it may be easier for J to produce all the above sequences silently, attempting to achieve the new patterns for targets without airstream. One of the advantages of using EPG visual feedback is that it allows the individual to practice the correct articulatory pattern before adding other articulatory demands, such as airflow for sound production. These suggestions on treatment target selection, strategies for enhancing the achievement of target contact patterns, etc., are stated in the EPG assessment report, as a reference for the SLTs. The assessment report is sent back to them electronically.

Conclusion

CLEFTNET UK promotes an innovative model of EPG service delivery, by linking specialist SLTs in the cleft palate centres and EPG experts at QMUC. This is a collaborative project where all of those involved are set to gain. Most importantly, individuals receiving therapy benefit by gaining access to a form of therapy that has previously been used primarily as a research tool. The specialist SLTs based in the cleft palate centres benefit from being involved in CLEFTNET because they have experts who can analyse their EPG data, which is

a time consuming and skilled task. SLTs usually do not have time, nor the necessary expertise, to do this analysis in their clinical day. They also receive technical support and guidance in using the technique. The data collected through the project is an invaluable resource for further investigation of frequent and also rarer types of EPG error patterns that occur in cleft palate speech. In terms of the future, the CLEFTNET network provides the necessary infrastructure for conducting research. By linking all the specialist centres throughout the UK together, it is now possible to conduct larger scale research projects than has been possible in the past, for example, a randomised controlled trial to investigate the efficacy of EPG therapy. Finally, although the CLEFTNET project has focused on widening access to EPG therapy for individuals with cleft palate in the UK, this model of service delivery could be extended to include other specialist cleft palate centres throughout the world. Furthermore, CLEFTNET could be an exemplar for EPG therapy provision that could be used with other clinical populations such as for those with hearing impairment and neurological disorders.

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Appendix. J's EPG Analysis Summary.

Place	Manner	Targets	Contact Pattern	Error[a]	Tx[b]
Bilabial	Oral stop	/p, b/	Complete constriction across palate during bilabial closure, which is an error pattern shown in some speakers with cleft palate, was not observed.	Nil	N
	Nasal stop	/m/	No complete contact across palate during closure.	Nil	N
Alveolar	Oral stop	/t, d/	Retracted to velar region. Variable contact patterns for /t/.	E2, E7	Y
	Nasal stop	/n/	Retracted to velar region.	E2	Y
	Fricative	/s/	Retracted to velar region before high vowels. Minimal contact when adjacent to open vowels.	E2, E5, E7	Y
		/Σ/	Acceptable patterns at single word level, especially when preceding /i/. Retracted to velar region at connected speech level.	E2, E7	Y
	Affricate	/tΣ, dZ/	Retracted to velar region.	E2	Y
	Lateral	/l/	Retracted to velar region.	E2	Y
Velar	Oral stop	/k, γ/	Adequate place of contact.	Nil	N
	Nasal stop	/N/	Adequate place of contact.	Nil	N

Note. Tx = Treatment.

[a]Error patterns were: E1 = Increased contact; E2 = Retraction; E3 = Fronted placement; E4 = Complete closure; E5 = Open pattern; E6 = Double articulations; E7 = Increased variability.

[b]Is treatment recommended? Y = Yes; N = No.

Table 1. Natural changes in dentition and possible problems for fitting an EPG plate at each stage.

Dentition	Description	Possible dental problems for EPG
Deciduous dentition	Established by the age of 3.5 years and remain stable until 6 years, hence, there may be a 1 year window for EPG therapy.	– Poor retention of EPG plate on baby teeth. – May not be able to get an accurate impression with very young child. – May require careful adjustment of the EPG plate. – A theoretical option is to modify the surface of the molars to make EPG plate fit. However, this causes permanent change to the dental morphology. – Caries. A minimum of 3 teeth are needed for a plate to fit. – Attrition (that is, tooth surface loss).
Early mixed dentition	Age 6 to 9 years.	– First molars erupt which may interfere with the cable. – Incisors erupt which may interfere with general fit, especially if the person has crowded dentition.
Mid mixed dentition	Age 9 to 10 years. One year stable window for EPG therapy.	– Caries and space loss could lead to change in tooth alignment, affecting the fitting of EPG plate. – Need to ensure conservation (such as making crowns and filling cavities) complete before tailor-making an EPG plate. – Need to avoid clasping teeth with doubtful stability or prognosis.
Late mixed dentition	Age 10 to 13 years. Deciduous molars are	– Lingual roll (deciduous teeth may bend in as premolars erupt),

	shed. First molars drift forward and second molars erupt.	affecting fitting of plate. – Cable interference due to eruption of molars. – Lack of cable space. – A theoretical option is to use a night time only retainer to avoid spontaneous movement of teeth. However, this may cause caries if dental hygiene is not adequate.
Permanent dentition	Age 13 years and above. However, dentition is not necessarily stable.	– Cable interference due to eruption of second molars. – Crowded second premolars may erupt under the plate, hence, interfering with the fit. – Cable interference due to eruption of wisdom teeth.

Table 2. Further problems for EPG therapy due to specific dental problems associated with cleft palate and other issues.

Problems specific to cleft palate
– Late development of secondary (permanent) dentition, hence, it is not easy to predict the time of the stable window for EPG therapy.
– Poor eruption of teeth in general (e.g. short crowns) and possible poor tooth morphology could cause poor retention of EPG plate.
– Susceptible to caries.
– Timing of bone graft and associated arch expansion could interfere with EPG therapy.
Other issues
– Some clients may wear dentures, however, it is possible to include teeth on the EPG plate.
– Some clients may be having long term orthodontic treatment, which could change the dental alignment causing fitting problem of the EPG plate.
– EPG plates may break, thus advice on how to care for the acrylic plate is needed.
– Both an upper and lower impression and a wax bite are required for information on the occlusal relationship of the upper and lower jaws, particularly to ensure there is clearance for the cable.
– Models should extend well distal to the standing teeth for the same reason.
– General dental practitioners may treat without realizing the possible effect on EPG plate.