

Critical Review: Electropalatography and the productive speech intelligibility of children and adolescents with hearing impairments

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This critical review examines the effects of electropalatography (EPG) on the productive speech intelligibility of children and adolescents with severe to profound hearing impairments. Study designs include: case study, case series and comparison study. Overall, research supports the use of EPG technology with this population in developing more typical tongue-palate contact patterns and improving speech intelligibility. However, the evidence base for this field of research is limited and the studies reviewed demonstrate methodological weaknesses. Recommendations for future research and clinical practice are provided.

Introduction

In spite of early aiding and speech therapy intervention, many school-aged children and adolescents with severe-to-profound hearing impairments have unintelligible speech. The development of their speech production skills can be compromised by difficulties amplifying differing speech sounds in the environment, as well as clearly seeing various tongue and mouth movements that distinguish speech sounds. As a result, this population typically produces vowels that are neutralized (e.g., replaced with the schwa vowel) and/or nasalized, as well as consonants that reflect inappropriate voicing (e.g., /d/ for /t/), reduction of consonant blends (e.g., /t/ for /st/) and nasalization (Yoshinaga-Itano, 1998). In addition, these individuals may also omit speech sounds in word positions of lower intensity and pitch (e.g., syllable-final position), as well as substitute difficult speech sounds with stops or front consonants (Bernhardt et al., 2003).

Current speech and hearing research has highlighted the use of various technologies that serve to demonstrate appropriate tongue placement and airflow using visual displays and feedback. Specifically, the research has discussed the use of Electropalatography (EPG), also known as Palatometry, to train the production of speech sounds in deafened individuals. EPG involves a custom-made thin acrylic 'pseudo-palate' that is mounted with 60-96 electrodes and placed in the mouth to cover the hard palate and maxillary teeth. A weak electric current is passed through the body, which details the location and timing of tongue movements as the tongue surface touches the electrodes. (Crawford, 1995; Dagenais & Critz-Crosby, 1994; Fletcher, Dagenais & Critz-Crosby, 1991). Contact

patterns can then be relayed to a video monitor for real-time displays, providing information on the accuracy of articulatory movement goals. In short, EPG represents a visual feedback system that assists in identifying and modifying articulatory movements, towards developing typical patterns of speech production.

Objectives

The primary objective of this paper is to critically evaluate existing literature regarding the use of EPG in improving the productive speech intelligibility of school-aged children and adolescents with severe to profound hearing impairments. The secondary objective is to propose evidence-based practice recommendations for clinical application and future research.

Methods

Search Strategy

The computerized databases of PsycINFO, CINAHL, MEDLINE and PubMed were searched with the following search strategy: electropalatography AND hearing impaired OR deaf. The search was limited to articles investigating children and adolescents between the ages of 6-18 years. Articles were also limited to those written in English with a publication year between 1990 to 2006.

Selection Criteria

Studies were chosen for inclusion in this critical review based on the following criteria: (a) a study of EPG treatment was completed; (b) baseline and post-therapy results were reported; (c) speech production skills were the variable of focus; (d) statistical analyses and figures were reported; (e) subjects were aided with hearing aids or cochlear implants; and (f)

conclusions and recommendations for the use of EPG were provided.

Data Collection

Results of the literature search yielded five articles congruent with the aforementioned selection criteria. Four of the studies employed a case study (2) or case series (2) design, whereby subjects served as their own control for pre- and post-therapy differences in their speech production abilities. One study employed a comparison study design, where subjects either participated in EPG or another therapy technique.

Results

Crawford (1995) detailed two single case studies involving profoundly deaf children (ages 10 and 11 years), aided with hearing aids. Subjects served as their own controls, as each had participated in previous speech therapy that was unsuccessful in attaining the target sound. Each subject received five individual sessions, approximately 40 minutes in length, as well as pre- and post-therapy assessments. The author found a significant increase in the accurate use and intelligibility in taught and untaught words and phrases post-therapy for both subjects. These findings were based on lingua-palatal contact patterns and listener ratings. Generalization was assumed with the accurate use of the sound in untaught words/phrases. Furthermore, at a follow-up, one of the subjects could improve production of the sound with a verbal reminder.

Panteleimidou, Herman and Thomas (2003) described a single case study (age 8;9), who was aided with a cochlear implant. The subject had received previous speech therapy that was unsuccessful in improving speech intelligibility. The subject participated in an EPG program over twelve 45-minute sessions, which occurred twice per week. The authors found significant improvement in the two target sounds immediately post-therapy, for both taught and untaught words. This was measured by lingua-palatal contact patterns and listener ratings. Generalization of skills was also concluded with the accurate production of untaught words, as well as significant improvement in the production of the sounds five weeks post-therapy.

Fletcher, Dagenais and Critz-Crosby (1991) investigated the use of EPG with five profoundly hearing-impaired children (ages 10-16 years). It is assumed that the subjects wore hearing aids as no statement was made regarding the use of cochlear implants. All of the subjects had received speech

therapy that was unsuccessful in developing speech intelligibility. Training sessions occurred twice per day for three to four weeks, with each session being 30-50 minutes in length. The authors found significant improvements in some of the consonant productions by all of the subjects, as measured by lingua-palatal contact patterns and listener ratings. However, the number of consonants that significantly improved ranged among the subjects (i.e. 21-100%). The authors attributed this finding to the pre-therapy status of the consonants. They found that more accurate productions were made for consonants that were not initially present, compared to consonants that had inaccurate approximations pre-therapy.

Bernhardt et al. (2003) studied EPG with four high school students, ages 16-18 years, with moderate-severe hearing impairments. All subjects were aided with bilateral hearing aids and had received weekly speech therapy prior to participating in the study. There were two blocks of treatment, the first having nine weekly sessions, and the second having five weekly sessions. Each session was 30 minutes in length. The authors concluded that all of the subjects demonstrated a significantly higher proportion of matches with treatment targets post-therapy compared to non-treatment targets. This was measured with listener transcriptions. In addition, targets that were absent or marginal pre-therapy showed greater gains than those that were more established pre-therapy. Generalization was concluded in some vowels that were untreated during therapy.

Dagenais and Critz-Crosby (1994) investigated the use of EPG in comparison to traditional aural-oral techniques. Two groups of nine children with profound hearing impairments (ages 10;6 to 15;7 years) were randomly assigned with matched pairs according to baseline measures and background information. All subjects had participated in speech therapy, both before and after the study. It is assumed that the subjects wore hearing aids because no statement was made regarding cochlear implants. Both groups participated in 26 therapy sessions, each 50 minutes in length. The sessions were given twice daily during three to four weeks. The authors concluded that subjects from the EPG group had significantly better lingua-palatal contact patterns immediately post-therapy and six months post-therapy, compared to the aural-oral group. In addition, listener judgements were generally better in the EPG group, compared to the aural-oral group.

Discussion

In general, the use of EPG appears to be successful for those with severe-to-profound hearing impairments and aided with either hearing aids or a cochlear implant. Treatment efficacy was concluded in all of the aforementioned studies. Subjects had developed more typical tongue-palate contact patterns that were often related to improved listener perceptual ratings post-therapy. These findings represent both objective and subjective findings for improved productive speech intelligibility. Many studies used 'untrained' listeners to judge speech intelligibility, which represented a realistic measure of the level of impairment in the subjects' environments.

Treatment efficiency was also demonstrated in the studies, as the subjects acquired accurate representations of the targeted speech sounds in a relatively short amount of time (i.e. 1-4 months). This was in comparison to a lack of success for particular speech sounds that was documented in the subjects' history of traditional speech therapy.

Despite positive conclusions, the findings and the research methodologies must be considered with caution. Case study designs can reflect typical clinical practice since therapy is conducted on an individual basis and treatment effects are compared to baseline measures. However, case studies lack generalizability since they cannot represent the population. It was also unclear whether these studies were published simply because they were successful. Furthermore, treatment effects could only be assumed since subjects could have matured in their abilities or previous speech therapy could have taken effect during the study. Finally, the maintenance of skills could not accurately be concluded since it was unclear whether subjects immediately returned to speech therapy following EPG treatment.

The case series studies represented similar weaknesses in sample sizes, experimental control and the maintenance of skills. In addition, convenience sampling may have been employed since subjects were recruited from the same schools. The samples may have been biased to neighbourhood characteristics, such as socioeconomic status or culture.

The comparison study design represented the best attempt at valid and clinically relevant conclusions. It compared traditional speech therapy with randomization and encouraged a follow-up on subjects to determine the maintenance of skills.

However, it would have been appropriate to control the speech therapy that was provided in between follow-up periods as the study's results may not have accurately reflected improvements solely related to EPG treatment.

Recommendations

As demonstrated in this review, the evidence base is limited for the use EPG with children and adolescents having severe to profound hearing impairments. Further investigation is required to compare EPG treatment to traditional speech therapy techniques, using randomization to treatment groups, matched pairs of abilities and background information, subject selection criteria (i.e. visual acuity, pure-tone average, non-verbal intelligence) and multiple baseline measures of target and non-target sounds. Such studies must include controlled post-therapy programs that encourage and strengthen the use of accurate tongue placement patterns. In addition, follow-up procedures must be conducted beyond one year, with the goal of transfer to spontaneous speech and natural environments. With this information, it can be determined whether EPG treatment provides exceptional benefit to children and adolescents over traditional speech therapy techniques. The field of research can then follow-up on the results of studies, which could improve on the availability of the technology and increase the confidence of clinicians adopting the treatment approach.

Despite the cost of initial set-up and manufacturing of pseudo-palates, EPG technology can have several benefits in the clinical practice of speech therapy. First, subjects recruited for study participation can be similar in abilities to those on a speech-language pathologist's caseload, which encourages generalizability. Second, the visual display and feedback of the technology can provide diagnostic information of the individual's error patterns than what is normally available. It can also provide on-line monitoring for therapeutic feedback. Third, EPG can be useful in the early stages of speech sound production to help individuals acquire new articulatory patterns (Bernhardt et al., 2003). These patterns can then be strengthened and generalized with other speech therapy techniques. Finally, the efficiency of therapy can maximize therapy goals, while effectively managing caseloads. Therefore, with the support of continued research, EPG technology can provide a complement to traditional speech therapy techniques that improve productive speech intelligibility among children and adolescents with hearing impairments.

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