Phonological Approach to Treat Consonant Clusters in Children with Repaired Cleft Palate via Telepractice

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INTRODUCTION

Cleft palate is the third most common craniofacial anomaly that occurs in 1 in every 2,000 births worldwide (Parker et al., 2010). Although children with cleft palate may undergo multiple reconstructive surgical procedures to repair structural anomalies, thirty percent of children with cleft palate exhibit a variety of speech errors during childhood (Bicknell et al. 2002). These errors may include obligatory, developmental or compensatory errors due to learned articulatory behavior (Peterson-Falzone, Jones, & Karnell, 2001; Lee & Parks, in preparation).

Children with cleft palate may also exhibit consonant cluster deletions or substitutions (Davis, 2019). Consonant clusters are critical for speech intelligibility because they play a large role in speech sound development, particularly in English. About one-third of all English monosyllabic words begin with a consonant cluster, and the majority of monosyllabic words also end with a consonant cluster (Locke, 1983). Although consonant clusters are important for speech sound development, very little research has been conducted examining consonant clusters in children with cleft palate with most studies being conducted over consonant cluster production in languages other than English.

A systematic review (Bessell et al. 2013) reported that intervention approaches for treating speech sound errors in children with repaired cleft palate include traditional motor approaches, phonological approaches, focused stimulation, and the whole language approach. Within limited evidence of efficacy of speech intervention for children with cleft palate, the phonological approach for children with cleft palate has not been applied to the English language.

Telepractice is an important provision of service to children with cleft palate in this particular study because the children lived in a rural area, about 1.5 hours away from the nearest speech clinic and required therapy and maintenance after repair surgery due to compensatory misarticulations and the existence of developmental errors. Although there is increasing evidence on the effectiveness of the telepractice service delivery model, telepractice has not been fully adopted for treating children with cleft palate.

The purpose of this study was to evaluate the effectiveness of a phonological approach to speech intervention for school-aged children with repaired cleft palate in a rural area of West Texas using telepractice.

Chapter one addresses current literature on cleft palate speech, consonant cluster acquisition, and intervention studies for children with cleft palate, impairment in consonant cluster production, and telepractice. Chapter two describes the methodology of this current study. Results of the study and discussion are presented in chapters three and four.

CHAPTER 1

LITERATURE REVIEW

1.1 Children with Cleft Palate

Cleft palate is the third most common craniofacial anomaly that occurs when all or some parts of the palate do not completely develop during the first three weeks in utero. The incidence of this disorder is about 1 in every 2,000 births worldwide (Parker et al. 2010; Dixon, 2011). Cleft palate is primarily caused by genetic etiologies such as chromosomal and genetic disorders. Other factors that lead to the development of cleft palate include environmental teratogens, maternal viruses and vitamin deficiencies, paternal and maternal age, as well as maternal obesity. (Kummer, 2014; Peterson-Falzone, Hardin-Jones, & Karnell, 2010).

Cleft palate may occur with or without the additional presence of a cleft lip. Classification of cleft palate is based on embryology (Kernahan & Stark, 1958). The division between the primary and secondary palates is the incisive foramen. The primary palate is anterior to the incisive foramen. Structures of the secondary palate include the remaining portion of the hard palate and the entire soft palate. Complete cleft of the primary palate affects the lip and alveolar ridge, whereas, an incomplete cleft only affects part of the lip. A complete secondary palatal cleft is a total cleft of all of the secondary palate, whereas incomplete cleft of the secondary palate results in a cleft of only one structure (Kummer, 2014). Secondary cleft palate involves poor development of important oral musculature including the musculus uvulae and levator veli palatine, which leads to inadequate velopharyngeal closure. Secondary cleft includes malformation and failed closure of the hard palate, soft palate, and velum. An additional type of cleft palate is the submucous cleft. A submucous cleft occurs when muscle tissues of the secondary palate fail to fuse (Kummer, 2014; Peterson-Falzone, Hardin-Jones, & Karnell, 2010).

1.2 Resonance Characteristics in Children with Cleft Palate

Abnormal resonance is a major characteristic that occurs in the speech production of children with cleft palate. Abnormal resonance, including hypernasality, hyponasality, and cul-de-sac resonance is associated with velopharyngeal insufficiency. Hypernasality refers to the presence of “too much nasal resonance,” most often affecting glides, liquids, and vowels (Peterson-Falzone et al. 2016). Hyponasality refers to reduced nasality that occurs when airflow is blocked in the posterior oral cavity. There are multiple causes of blocked airflow that leads to hyponasality, including enlarged tonsils or irregular adenoids. Cul-de-sac resonance is a muffled vocal quality that occurs when sound is blocked at the exit of the nasal, oral, or pharyngeal cavity due to an obstruction, leading the sound to be absorbed into the cavity (Kummer, 2008).

Albustanji, Albustanji, Hegazi, and Amayreh (2014) investigated speech sound production in 80 Saudi-Arabic speaking individuals with cleft palates aged 6 to 15. Out of the participants in the study, twenty-one were found to have normal resonance, while 59 individuals were found to have abnormal resonance and articulation secondary to cleft palate. Of the errors, hypernasality was found to be the most common error, occurring in 64% of the participants. The results indicate that hypernasality is a common error associated with the presence of cleft palate.

Watterson, McFarlane, and Wright (1993) examined nasality in 25 children with craniofacial anomalies aged 3 to 14 using instrumental and perceptual measures. They found that participants with cleft palate had greater nasalance scores than participants with velopharyngeal incompetence and maxillary hypoplasia.

Schönweiler et al., (1999) conducted a retrospective study where the data were taken from 370 German-speaking individuals with cleft palate post-palatoplasty for eight years. Investigators examined hypernasality and nasal emissions produced at the word level by children with cleft palate by dividing the data into five groups based on the type of cleft palate of the individuals: bilateral cleft lip and palate, unilateral cleft lip and palate, cleft soft palate, cleft lip and alveolus, and submucous cleft. During the study, listeners judged nasality using word-level speech samples consisting of stops, fricatives, and affricates paired with vowels with low nasal resonance. Listeners perceived an increase in nasal resonance and emission in all subjects with cleft palate. The investigators found that the majority of the subjects produced nasal resonance and nasal emission regardless of cleft palate type.

Sweeney and Sell (2011) evaluated nasality in 50 children using a perceptual evaluation paired with an instrumental evaluation using a nasometer. Participants were 50 children between the ages of 4 and 15 with velopharyngeal dysfunction or nasal obstruction. The investigators found a high rate of nasal emission (80%) in participants and a positive correlation between instrumental measured nasalance and perceptual ratings of the total speech sample used for testing.

1.3 Speech Characteristics in Children with Cleft Palate

Speech articulation errors that occur secondary to cleft palate can be grouped into two categories: obligatory and compensatory. Children with cleft palate also exhibit developmental speech errors. Obligatory errors are those caused by structural anomalies, whereas compensatory errors are learned errors as responses to structural abnormalities (Kummer, 2001). Obligatory errors include hypernasality, and/or nasal emission. Compensatory errors typically affect the place of articulation. For example, a pharyngeal fricative may be produced for the alveolar fricative, or a glottal stop may be produced for an alveolar or velar stop.

Several studies examined speech articulation characteristics in children with cleft palate. Most studies focused on young children. Very limited studies are available evaluating school-aged children with cleft palate. Gibbon, Ellis, and Crampin (2004) investigated the place of articulation for the stops /t/, /d/, /k/, and /g/ in 15 children between the ages of 7 and 15 years old who had repaired cleft palates. Based on perceptual evaluations, the participants produced errors on alveolar phonemes more than velar phonemes. Using electropalatography (EPG) evaluation, investigators compared the EPG patterns of the participants to those of a typically developing child. The investigators found that the children with cleft palates produced velar targets with greater accuracy than alveolar targets, and they often produced alveolar sounds posterior to the alveolar ridge.

Another speech error caused by velopharyngeal dysfunction is nasal emission. Nasal emission is a form of articulation that occurs when air is directed into the nasal cavity during the production of pressure consonants. Velopharyngeal insufficiency in children with cleft palate leads to the inability to develop enough intraoral pressure (Kuehn, D. & Moller, K., 2000). Typically, high-pressure consonants are perceived as weak pressure consonants due to nasal emission. In particular, children with cleft palate have difficulty with sibilant phonemes. Misarticulation of /s/ is the most common articulation distortion in children with cleft palate (Harding & Grunwell, 1996). Phoneme-specific nasal emission where nasal emission occurs on certain sibilants is also observed in children with cleft palate due to faulty articulation absent of structural anomalies (Kummer, 2004).

In addition to obligatory and compensatory speech errors, children with cleft palate also exhibited developmental speech errors. Lee and Parker (in preparation) reported that children with cleft palate also misarticulated consonantal and vocalic /r/ in English, which is the most common developmental error in children with speech sound disorders. Davis (2019) evaluated consonants and consonant cluster production in 20 children between four and seven years old (10 children with cleft palate and 10 typically developing children) to investigate whether children with repaired cleft palate exhibited similar consonants and consonant cluster production accuracy similar to typically-developing children. The *Goldman Fristoe Test of Articulation, Third Edition (GFTA-3)* showed that typically-developing children achieved significantly higher mean scores than children with repaired cleft palate. Additionally, typically-developing children exhibited greater accuracy than children with a repaired cleft palate on percentage of consonants correct (PCC) and percentage of consonant clusters correct (PCCC) analyses. The children with cleft palate produced singleton consonants as well as all types of consonant clusters with lower accuracy than typically-developing children. The school aged children with cleft palate also exhibited all four of the error patterns evaluated (i.e., total deletion, partial deletion, substitution, and distortion), while the typically-developing children only produced two error types (i.e., substitution and deletion). Davis argued that although the children had repaired cleft palates, they produced significantly variable consonant and consonant cluster production compared to typically-developing children. These results suggest that ongoing articulation treatment is important for children with repaired cleft palate.

1.4 Speech Intervention in Children with Cleft Palate

Two primary intervention approaches used to treat articulation errors in children with cleft palate are the traditional motor approach and the phonological approach (Kamhi, 2006). The traditional motor approach was developed by Van Riper in 1939. In the traditional motor approach, therapists treat one disordered sound at a time following a hierarchy of complexity, starting with the sound in isolation and syllables, and working their way up to reading and conversation, one position at a time. The approach focuses on phonetic placement and shaping to teach motor skills for accurate phoneme production and includes the following process (Van Riper, 1978); *(1) identifying the standard sound, (2) discriminating it from its error through scanning and comparing, (3) varying and correcting the various productions until it is produced correctly, and finally, (4) strengthening and stabilizing it in all contexts and speaking situations" (*Van Riper, 1978 p. 179). The goal of Van Riper's approach is to teach children how to articulate individual phonemes to improve speech intelligibility.

In contrast to the traditional motor approach, the phonological approach focuses on identifying and treating classes of sounds with similar error patterns to produce system-wide change in individual's articulation. Although phonological approaches may target individual sounds, their goal is to target a few sounds based on their distinctive features to generalize to a child's entire phonological system (Dodd, 2005). Among several phonological approaches such as minimal oppositions (minimal pairs), maximal oppositions, empty sets, and multiple oppositions (Gierut, 1989; 1992; Williams, 2000), the minimal pairs approach uses pairs of words that differ by one phoneme or distinctive feature. These are typically used to teach contrasts in speech sounds that are not in a child's phonological system (Blache, Parsons, & Humphreys, 1981).

Bessell et al. (2013) conducted a systematic review comparing outcomes of motor and linguistic speech therapy approaches in children with isolated cleft palate in addition to children with cleft palate and cleft lip. Fourteen articles were included in the review, seven focusing on motor intervention approaches, and the remaining seven focusing on linguistic approaches for intervention including a phonological approach, focused stimulation, and whole language approach. The studies included in the systematic review covered a variety of service delivery methods including clinical settings, home, and speech summer camps. Participants in the studies ranged from ages 1 to 29. While the duration of the studies varied, only nine studies reported their duration. Of the nine studies, five were conducted over a period of 20 to 60 days while the remaining four were conducted during a period of 6 months to a year. Bessell et al. (2013) concluded that differences in treatment approaches, service delivery methods, duration, and ages of participants had no significant impact on treatment outcomes. Most studies included in the systematic review were small scale case studies; only a few studies were group comparisons with school-age children with cleft palate.

Van Demark and Hardin (1986) compared the effectiveness of traditional motor articulation therapy in public schools and intensive private programs for 17 children with cleft palate between the ages of 7 and 12. Private, intensive treatment was conducted for four days per week during one-hour sessions for three weeks. The children's performance before and after the private intervention was compared to their outcomes after nine months of school speech therapy services. The investigators found that severity rates decreased, and production accuracy increased in the children after they received private speech therapy. However, after nine months of school treatment, these children did not exhibit improvement in articulation. Van Demark and Hardin argued that intensive, private treatment programs are more effective than school-based treatment for children with cleft palate.

While Van Demark and Hardin (1986) adopted a motor approach, Pamplona and her colleagues conducted many studies to investigate the treatment efficacy of using a phonological approach to treat speech errors in children with cleft palate. The first study, conducted by Pamplona, Ysunza, and Espinosa (1999) compared phonological and phonetic (motor) approaches to articulation intervention in 29 children with cleft palate between the ages of three and seven. Participants were randomly assigned to two groups. Fifteen children received phonetic intervention, and another 14 received phonological intervention. Both approaches targeted the remediation of glottal stops and pharyngeal fricatives. They evaluated treatment efficacy based on the duration of treatment and found that the phonological intervention group eliminated misarticulations during a period of 6 to 22 months of treatment. Whereas, the phonetic intervention group eliminated misarticulations between 14 and 46 months. Based on the study's results, the authors concluded that using a phonological approach was more advantageous in eliminating compensatory misarticulations in children with cleft palate.

In another study, Pamplona, Ysunza, and Ramirez (2004) compared naturalistic intervention including the whole language approach to phonological intervention for 30 children, aged three to seven, with repaired cleft palate. The duration of naturalistic intervention was 6 to 22 months with an average of 14.5 months. The duration of phonological intervention was 4 to 27 months with an average of 16.2 months. Statistical analysis revealed no significant difference between the two modes of intervention, which led authors to conclude that naturalistic and phonological approaches were equally effective in treating misarticulations in children with cleft palate.

The previous studies treating speech sound errors in children with repaired cleft palate focused on singleton consonants. None of the studies treated consonant clusters in children with repaired cleft palate. Thus, further studies are warranted to investigate the treatment efficacy of consonant clusters in children with cleft palate.

1.5 Consonant Cluster Acquisition

While children with speech impairments often have difficulty producing consonant clusters accurately, consonant cluster acquisition often takes time in typically-developing children. Consonant cluster acquisition is traditionally believed to begin around age two, during the word spurt period (Ingram, 1991). Shriberg and Kwiatkowski (1980) found that 4-year-olds produced consonant clusters in spontaneous speech with 90% accuracy, while Smit, Hand, Freilinger, Bernthal, & Bird (1990) reported that the majority of consonant clusters are produced with greater than 90% accuracy between six and seven. However, oftentimes, mastery is still ongoing in children between eight and nine years old. Ingram (1991) reported that the emergence of consonant clusters may also represent the shift in early phonotactic structure as well as progression of oromuscular development.

Smit (1993) evaluated the production of English consonant clusters in 997 children between the ages of two and nine. Smit found that for obstruent + /w/, obstruent +/l/, and the obstruent +/r/ clusters, children typically omitted the sonorant consonants more frequently than obstruents. Children also omitted /s/ in clusters containing /s/ + glides, nasals, or stops. However, in the youngest participants, /sn/, /st/, and /sk/ clusters were reduced to /s/ in 5-15% of productions. Smit proposes that the acquisition of consonant clusters occurs in the following pattern: stops plus /w/ clusters, /l/ clusters except /sl/, /r/ clusters except /θr/, /s/ clusters including /sw/ and /sl/, the three-phoneme cluster /skw/, and all other three phoneme clusters.

Many children exhibit cluster reduction or cluster substitution. Cluster reduction, the elimination of one consonant in a cluster, is a long-lasting stage of consonant cluster production in addition to being the most common. Cluster simplification is the process of misarticulating one sound in a cluster. A variety of phonological processes can affect simplification of consonant clusters. The most common simplification is the gliding of liquids (Long, Fey, & Channell, 1998). Epenthesis, or the addition of a vowel between phonemes in a cluster often occurs in later stages of consonant cluster development. In a study conducted by Ingram, Pittarn, and Newman (1985), epenthesis occurred in the production of many second graders and less prevalently with children in grades three and four. As cluster reduction decreases, simplification is thought to increase.

McLeod, van Doorn, and Reed (2001) conducted a systematic review over normal acquisition of consonant clusters and identified the following patterns:

- Consonant cluster acquisition begins around the age of two.
- Two-phoneme clusters are produced and appear in children's phonemic inventories before three-phoneme clusters.
- Word-initial clusters develop later than word-final clusters.
- Clusters containing stops are mastered before clusters containing fricatives.
- Cluster reduction is an early phonological process that is typically explained by sonority and markedness.
- Homonymy occurs in young children, usually as a result of cluster reduction.
- Consonant cluster acquisition is gradual and varies on an individual basis.
- Cluster reduction and cluster simplification are related in the process of consonant cluster mastery. Typically, cluster reduction occurs first, and as cluster reduction decreases, cluster simplification increases while the frequency of correct productions increases until mastery.
- Consonant cluster acquisition is described as having significant variability as it is characterized by "reversals and revisions with considerable individual variation."

Consonant cluster production is important for this investigation because it is a prevalent pattern in the English language that has never been investigated in the cleft palate population before.

1.6 Consonant Cluster Intervention

There has been a shift in the paradigm of how to treat phonological disorders. Some speech-language pathologists (SLPs) have begun to use phonological approaches to treat severe speech disorders, while others have continued to use a traditional motor approach. In 1992, Hodson surveyed SLPs in the United States and Canada and found that fewer than 10% of respondents were using a phonological approach to treatment. In 2013, Brumbaugh and Smit surveyed elementary SLPs in the United States to investigate which intervention approaches they used with children between three and six who have speech-sound disorders. The majority of SLPs reported using a traditional motor approach to intervention. Many also described using forms of phonological intervention during treatment. However, which treatment approach was used to treat consonant clusters most often was not specified. Currently limited studies are available regarding speech intervention treating consonant clusters.

Dodd and Bradford (2000) conducted a case study that evaluated three children with speech sound disorders comparing three treatment methods: phonological contrast therapy, core vocabulary, and Prompts for Restructuring Oral Muscular Phonetic Targets (PROMPT). Participants in the study were three children between three and five years old with phonological impairments ranging from moderate to severe. Two of the children were treated for cluster reduction and phonological processes. Each participant was treated for six weeks with each type of therapy and given three-week withdrawal periods between each block of therapy. Each treatment block consisted of twelve 30-minute sessions with a home follow-up program. A final assessment was conducted three weeks after the second therapy session. The researchers found that either core vocabulary or the phonological approach led to an increase in the accuracy of consonant clusters and reduced occurrence of phonological processes, but the PROMPT treatment block did not increase production accuracy. The authors concluded that children respond best to therapy that targets the reorganization of phonological knowledge rather than therapy that focuses on the articulatory aspects of speech production.

Young (1987) investigated the effects of phonological treatment on cluster reduction and weak syllable deletion in children with articulatory errors. Participants in the study were two children, ages 4;4 and 4;5. Both children produced a variety of misarticulations including cluster reduction, weak syllable deletion, and final consonant deletion. Young found that treatment led to increased accuracy of articulation and generalization to words that were not included in probes. Both children displayed improved production accuracy within six or seven sessions. In six-week follow-up sessions, both participants demonstrated sixty percent to one-hundred percent accuracy on trained and untrained probes for targets. These results suggest that targeting consonant clusters using a phonological approach is effective.

Hoffman, Norris, and Monjure (1990) compared a whole language approach and minimal pairs approach to treating consonant cluster reduction in two four-year-old brothers with noted phonological delays for three fifty-minute treatment sessions over six weeks. Posttreatment measures revealed that both participants improved in phonology and reduced consonant cluster reduction. However, the participant who was treated using the phonological approach had greater improvement in overall phonology and exhibited greater accuracy of consonant cluster productions than the child treated via the whole language approach. The investigators did not find a significant difference in the effectiveness of the two approaches. These data suggest that phonological approaches are effective for the treatment of consonant cluster reduction in children.

Baker and McLeod (2004) conducted a case study of two children with phonological impairment. Initial /s/ clusters were targeted to facilitate widespread change in the children's' phonological systems. Investigators used the minimal pairs approach with velar fronting as a control. Participants were treated for two 45-minute sessions until mastery using a computer-based activity that followed a minimal pairs approach. Participant A achieved 100% accuracy of all targets and 70% of untrained and trained words containing initial /s/ clusters without assistance from the investigator by the seventh session. Participant B achieved the same goal by the 11th session. However, his therapy model was changed because his response to intervention was not as high as Participant A. Velar fronting was targeted in addition to /s/ initial clusters, the number of /s/ clusters was increased from 10 to 15, and investigators added drill activities to elicit more natural articulation. Additionally, his parents were trained to provide feedback at home. Both participants continued velar fronting, but with decreased /s/ cluster reduction.

Overall, research supports the use of phonological approaches to treat consonant cluster production errors in children with speech impairments.

1.7 Telepractice

The American Speech-Language-Hearing Association (ASHA) defines telepractice as the application of telecommunications technology to the delivery of speech-language pathology and audiology professional services at a distance by linking clinician to client or clinician to clinician for assessment, intervention, and/or consultation (ASHA, 2002). The use of telepractice for the provision of services is expanding in the healthcare world, allowing SLPs to provide efficacious treatment in real time across geographic boundaries (Janota, 2012). Currently, there is a great need for telepractice services, especially in rural areas because of the significant shortage of SLPs in these areas (Mashima & Doarn, 2008). ASHA supports telepractice as an adequate and appropriate means of providing speech therapy services to a variety of underserved populations including those who lack access to speech therapy services due to geographic boundaries as well as populations who are homebound (ASHA, 2016).

Mashima and Doarn (2008) conducted a systematic review and found 40 studies where telepractice was used in speech-language services for adults and children. Another systematic review was done by Reynolds et al. (2009). These systematic reviews reported that the majority of studies with adequate evidence focus on adult populations while research on telepractice in the pediatric population is limited. Furthermore, the majority of articles were case studies; only a few experimental control studies were included. Recently, Keck and Doarn (2014) conducted another systematic review, reporting that among 26 telepractice studies conducted during 2008-2013, only four addressed services for children. Since 2013, a small number of studies examining the effect of telepractice intervention for children in the U.S have been conducted (Grogan-Johnson et al., 2013; Gabel et al., 2013; Blaiser et al., 2013; Constantinescu et al., 2014; Lee, Hall, & Sancibrian, 2017; Lee, 2018). These studies suggest that the effectiveness of telepractice intervention is equivalent to traditional in-person intervention.

In a study conducted by Grogan-Johnson et al. (2013) traditional in-person speech therapy was compared to telepractice. Participants were 14 children between six and ten years old. They received treatment for speech sound disorders twice a week during 30-minute sessions for five weeks. Investigators did not find a significant difference between traditional service delivery and telepractice. Progress was made via both methods of intervention, which suggests that telepractice is an effective means to provide speech therapy for children with articulation disorders. However, during the experiment, the SLPs providing telepractice provided substantially more visual and verbal cues when compared to SLPs providing services in the in-person model. This can be attributed to the fact that SLPs are unable to provide tactile cues or articulatory manipulation when treating clients via telepractice. The investigators argued that more cues are necessary for client success. Telepractice provides a multi-sensory approach to treatment excluding tactile stimulation, which, can be conducted by a caregiver in some cases if they are trained correctly.

Lee (2018) utilized a multiple opposition approach to treat two children with severe phonological disorders in West Texas. She trained caregivers to facilitate an interactive therapy program for two children aged four and six scheduled twice a week for 30-minute sessions over a period of 12 to 16 weeks. Lee found that the children treated using an interactive contrasting phonemic pair approach exhibited marked improvement from telepractice treatment. Additionally, they showed maintenance at two-week and two-month follow-ups and displayed generalization of most singleton consonants in probes. Lee concluded that telepractice is an effective method for delivering speech and language services to children with speech-sound disorders, specifically in the area of phonological treatment.

Still, relatively few studies have examined the effectiveness of a telepractice service delivery model in children with speech-language impairment. Limitations in the delivery of telepractice include the inability of therapists to assess and manipulate musculoskeletal aspects of speech and obtain extensive case history information

(Mashima & Doarn, 2008). Currently, only one study is available with children with cleft palate in Mexico (Whitehead, Dorfman, and Gosman, 2013). Nine children between the ages of 5 and 14 who had previously undergone cleft palate repair participated in their study. Participants were evaluated by SLPs in person or via telepractice in the following areas: oral muscle tone, resonance, lingual lateralization, oral pressure, and dentition. The investigators found no significant difference in evaluation between the two methods, which suggests that telepractice is an effective means of evaluating speech. Additionally, surveys completed by caregivers regarding satisfaction with telepractice for speech evaluation, they did not indicate any dissatisfaction. Caregivers reported that their children were comfortable during assessment and that they could easily understand, hear, and see the clinicians providing evaluations. The results suggest that telepractice as a means of assessment is an effective and equivalent alternative to traditional in-person assessment. Patient satisfaction in receiving services via telepractice was primarily favorable.

Based on previous research studies, there is a significant lack of research to examine the effectiveness of telepractice for children with cleft palate. It is not certain whether telepractice is useful for children with cleft palate; therefore further studies are warranted to investigate its effectiveness.

1.8 The Purpose of the Study

The purpose of this study was to investigate the effectiveness of using a minimal pairs approach to treating consonant clusters in children with repaired cleft palate in a rural area of West Texas via telepractice. It was expected that the children's production accuracy of consonant clusters would increase as a result of phonological treatment via telepractice.

CHAPTER 2

METHODS

2.1 Participants

The present study evaluated two females with repaired cleft palates. Child A was 5 years and 2 months old (5;2), and Child B was 4;9. Child A had a repaired cleft palate, and Child B had a repaired cleft palate and lip. Both children were born in China and completed lip and palate surgeries when they were three years old in the US after being adopted by an American family. These children lived in a small town in West Texas, a 1.5-hour drive from a major city, where limited speech pathology services are available.

Oral examination indicated normal occlusion in Child A, and a class III malocclusion (i.e., under-bite) was found in Child B. The children revealed no concomitant disorders, syndromes, or disabilities. *The Kaufman Brief Intelligence Test, Second Edition (KBIT-2)* was performed with each participant to test IQ. Both children scored within the average range (i.e., 85-115 standard score) for their age group. Child A received a standard score of 93, and Child B received a standard score of 90. The *Clinical Evaluation of Fundamental Language Screening, Fifth Edition (CELF-5)* was performed and revealed that both children passed the screening tests, indicating typical language development. The children were brought to the Speech-Hearing Clinic at TTUHSC to receive ultrasound intervention for 12 weeks and demonstrated significant improvement in their speech production accuracy. However, their consonant clusters and a few consonants were still produced incorrectly.

2.1.1. Child A

Child A's speech characteristics were assessed using the *Goldman-Fristoe Test of*

Articulation, Third Edition (GFTA-3) Sounds-In-Words Subtest. Child A received a raw score of 74, which converted into a standard score of 40. The confidence interval at 95% was 37 to 48. She scored below the 10th percentile and received a test-age equivalent of <2.0.

Table 1 shows Child A's consonant inventory. Her phonetic inventory consisted of a variety of sounds appropriate for her age. However, interdental fricatives, the rhotic sound, and affricates were not produced. Child A produced /b, p, k, f, h, m, ŋ, l, w, j/ with 85% accuracy, and produced /t, d, g/ with 50%-84% accuracy. The remaining consonants were produced with less than 50% accuracy. Alveolar and palatal fricatives were inconsistently produced with nasal emission. However, hypernasality was not observed.

Child A only produced two initial consonant clusters (/bl, pl/) correctly. During the production of the remaining initial consonant clusters, one consonant was either partially deleted or substituted with another consonant. More specifically, consonant clusters with /r/ were consistently produced with /w/. Additionally, /s/ was omitted in consonant clusters with /s/; for example, /sp, sl, sw/ were produced with /p/, /l/, and /w/, whereas /st/ was produced as /d/.

Table 1: Child A Consonant Inventory

	Bilabial	Labio-Dental	Inter-dental	Alveolar	Palatal	Velar	Glottal
Stop	p, b			t, d		g, k	
Nasal	m			n		ŋ	
Glide	w				j		
Fricative		f, v		s, z	ʃ		h
Liquid				l			
Affricate							

2.1.2. Child B

Child B's speech characteristics were also assessed using the *GFTA-3*. Child B received a raw score of 49, which converted into a standard score of 65. The confidence interval at 95% was 60 to 74. She scored in the 1st percentile and received a test-age equivalent of 2;6 to 2;7.

Table 2 shows Child B's consonant inventory. Child B produced /b, p, k, g, d, f, s, h, m, n, l, w, j/ with 85% to 100% accuracy, /t, v, θ, z, ʃ, tʃ/ were produced with 50% to 84% accuracy, and /ŋ/ was produced with less than 50% accuracy. Phonemes /r, ð, ʤ/ were not produced. Child B produced initial consonant clusters (bl, sl) accurately. However, all other initial consonant clusters were partially deleted, or one consonant was substituted for another. The most common substitution was /w/ for liquids in the consonant clusters containing /r/ and /l/. Initial consonant clusters containing /s/ were produced with variability. The consonant cluster /sl/ was produced with a slight nasal emission while /st/ was produced as /ʃ/. The consonant cluster /sp/ was produced as /b/, and the cluster /sw/ was produced as /hw/. Nasal emission was produced with fricative (/ʃ/) and affricates (/tʃ/, /ʤ/) at the word-medial position.

Table 2: Child B Consonant Inventory

	Bilabial	Labio-Dental	Inter-dental	Alveolar	Palatal	Velar	Glottal
Stop	p, b			d, t		k, g	
Nasal	m			n		ŋ	
Glide	w				j		
Fricative		f,v	θ	s, z	ʃ		h
Liquid				l			
Affricate					tʃ		

2.2 Study Design

This study was conducted using a single-subject, multiple-baseline-across-behaviors design replicated across two participants. A single-subject study was conducted by collecting baseline data for four or five sessions using probes for each participant. There were a total of 40 probes, ten for each initial target and the control sound. The probes and the *GFTA-3* were administered prior to intervention and re-administered at the one-month follow-up session. The probes were also administered at the end of each session. The treatment effect was primarily identified by visual inspection.

2.3 Target Sounds

Based on evaluations, three s-stop consonant clusters (i.e., sp, st, sk) were selected as treatment targets for both children. The participants demonstrated production of most age-appropriate singleton consonants; however, /s/ consonant clusters were produced incorrectly although both children produced stops and /s/ with moderate accuracy. In addition to the target sounds of each child, the /r/ phoneme was also treated. The /r/ sound was originally selected as the untreated control sound for both children to identify the generalization effects of treatment. However, due to the fast progress of consonant cluster production during treatment, /r/ was also treated when the children produced the target sounds with 80% or greater accuracy consistently. Ten words were selected as probes for each target sound. The first half of the experimental probes were used during treatment sessions. Table 3 includes the probes used in this study.

Table 3: Experimental Probes

/sp/	**/st/**	**/sk/**	**/r/**
Spit	Step	Score	Rose
Speck	Staff	Scott	Read
Speed	Stud	Scoop	Ring
Spy	Stage	Ski	Rope
Spice	Stare	Scab	Red
Space	Star	Skid	Rug
Spike	Stop	Skate	Race
Spa	Stone	Skip	Road
Spell	Stove	Scope	Run
Spot	Store	Sky	Rip

2.4 Intervention

Treatment was provided twice a week during 30-minute sessions for 10 weeks via telepractice using the Cisco WebEx video conferencing platform. The children's parents were trained over procedures regarding the use of the telepractice platform before intervention began. Microsoft PowerPoint software was used to present pictures of target stimuli. The children viewed the pictures using the shared screen function. The program was interactive, and the children were allowed to draw lines and circles or move pictures using the manipulation tools. Therapy sessions primarily employed a minimal pairs approach. The minimal pairs approach focused on contrasting two phonemes in a pair of words. For example, a picture of “skate” was contrasted with a picture of a girl named “Kate.” Children were presented with blank lines and letters to drag to spell out the probe words. Additionally, a few visual cueing techniques such as modeling and phonetic placement were utilized.

After the baseline was established, the first target consonant cluster was treated until its accuracy reached 80%. Then, the second consonant cluster was treated while the first and third consonant clusters were not targeted. When the second consonant cluster was produced with 80% accuracy, the third consonant cluster was treated.

2.5 Transcription Reliability

All probes collected were transcribed into IPA by graduate student clinicians. Probes were reviewed by the research team, and transcription inter-rater reliability was established by comparing two graduate students’ transcriptions of the probes. All probes collected before and during treatment were compared, and the total number of agreements was divided by the total number of collected probes. Inter-rater reliability for Child A was 96%. Inter-rater reliability for Child B was 95%.

CHAPTER 3

RESULTS

3.1 Child A Results

3.1.1 Baseline

Child A's performance accuracy is displayed in Figure 1. Baseline data were obtained for child A for four sessions prior to intervention. During all four baseline sessions, /sp/ and /st/ clusters, and /r/ remained at 0% accuracy while /sk/ production reached 10% accuracy during session 3 and returned to 0% at session 4.

3.1.2 Intervention

After the establishment of the baseline, treatment for /sk/ clusters was conducted between sessions five and nine, where she reached 100% accuracy. The /sk/ was chosen for treatment first because Child A exhibited some knowledge of the cluster during baseline. Child A's production accuracy steadily increased during the intervention period and remained at 100% accuracy through session 24 with the exception of session 10, where production accuracy regressed slightly to 90%.

Next, the /sp/ cluster was targeted between sessions 10 and 12. Production accuracy started at 50% at the beginning of the treatment period (session 10) and peaked at 90% accuracy during session 12. Production accuracy regressed to 80% accuracy during session 13. Child A reached 100% accuracy during session 14 and remained at 100% accuracy through session 24, with the exception of regression to 90% accuracy during session 18.

The /st/ cluster was treated last, between sessions 13 and 24. Production accuracy was at 80% accuracy during session 13 and increased steadily until session 16, where accuracy reached 100%. There was a slight regression during sessions 18 and 19 where accuracy dropped to 70% accuracy. However, production reached 100% accuracy during session 21 and remained at 100% accuracy through session 24 with the exception of a regression to 90% accuracy during session 22.

Although /r/ was initially tested as a control sound, it was treated from sessions 18 to 24 because Child A's three consonant cluster targets were produced with greater than 80% accuracy consistently. The accuracy of /r/ remained at 0% until session 18. However, its accuracy increased to 30% when treatment was initiated and fluctuated until session 24.

3.1.3 Maintenance

Maintenance skills were assessed one month after all treatment sessions were completed using probes used during treatment (see Figure 1). Child A produced the target consonant clusters with 100% accuracy but produced the /r/ with 10% accuracy during the follow-up session. The *GFTA-3* was readministered and showed that Child A received a raw score of 36, which converted into a standard score of 64. The confidence interval at 95% was 60 to 71. She scored in the 1st percentile and received a test-age equivalent of 2;10 to 2;11. Child A's post-treatment *GFTA-3* scores improved from pre-treatment to post-treatment although her standard scores remained at two standard deviations below mean. All /s/ consonant clusters in the *GFTA-3* (i.e., /st/, /sp/, /sl/, /sw/) were produced correctly. Besides the /s/ + stop clusters, she produced clusters /dr/, /kw/, and /gl/ accurately. However, Child A frequently exhibited gliding and deletion of /r/ in other /r/ clusters.

3.2 Child B Results

3.2.1 Baseline

Child B's performance accuracy is displayed in Figure 2. Baseline data were obtained for child B for five sessions prior to intervention. During the five baseline sessions, production accuracy of /st/ improved to 20% accuracy during sessions three and five. /sk/ remained at 0% accuracy until session 5 where accuracy improved to 10% accuracy. /sp/ and /r/ production accuracy remained at 0% accuracy throughout the baseline period.

3.2.2 Intervention

The /st/ cluster was targeted first with Child B during sessions six to ten because Child B exhibited the greatest production knowledge of the cluster during baseline. Child B exhibited steady progress with the cluster, starting at 10% and reaching 90% accuracy at the end of the treatment period. After treatment, between sessions 11 and 13, progress regressed to 80% accuracy to 70% accuracy. Overall progress was unsteady, but reached 100% accuracy during sessions 16 and 17, regressed to 80% accuracy during session 18, increased to 100% during session 19 and remained at 100% accuracy through session 25 with the exception of 80% accuracy during session 24.

The /sk/ cluster was treated between sessions 11 and 16. Child B exhibited steady progress during the intervention period, reaching 100% accuracy during session 16 and remaining at 100% accuracy through session 25 with the exception of session 24, where accuracy regressed slightly to 90%.

The /sp/ cluster was treated last, between sessions 17 and 25. Child B started session 17 at 20% accuracy, regressed to 0% accuracy during session 18, and reached

20% accuracy again during session 19. There was a substantial increase in progress to 90% accuracy during session 20. Child B reached 100% accuracy during session 21 and remained at 100% through session 25 with the exception of session 24, where her production accuracy regressed slightly to 90% accuracy.

The /r/ sound was also treated from sessions 22 to 25. Unlike Child A, Child B produced /r/ with 0% accuracy throughout intervention.

3.2.3 Maintenance

Child B's maintenance skills were assessed one month after the completion of treatment using probes from the experimental treatment (see Figure 2). Child B produced the three /s/+ stop clusters with 100% accuracy, but accuracy of /r/ in probes remained at 0% during the follow-up session. Child B's speech characteristics were also assessed using the *GFTA-3*. Child B received a raw score of 37, which converted into a standard score of 67. The confidence interval at 95% was 63 to 74. She scored in the 1st percentile and received a test-age equivalent of 2;10 to 2;11. When compared to Child A, Child B showed little improvement in standardized test scores after treatment. Child B also produced s-clusters, (i.e., /st/, /sp/, /sl/) clusters correctly. Additionally, she also produced /pl/ accurately. /sw/ was produced with nasal emission. Like Child A, she frequently exhibited gliding and deletion of /r/ in clusters.

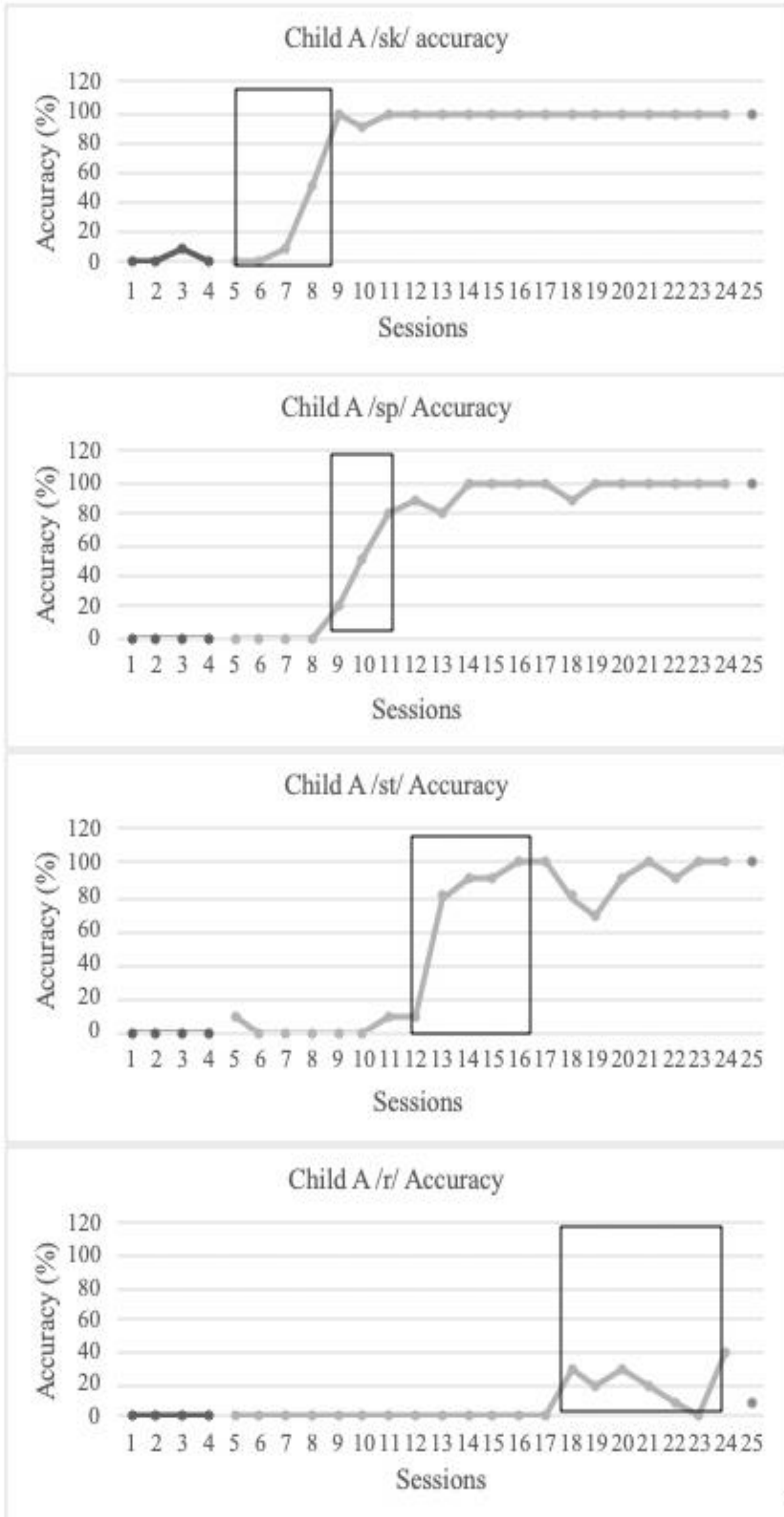

Figure 1: Child A's Results

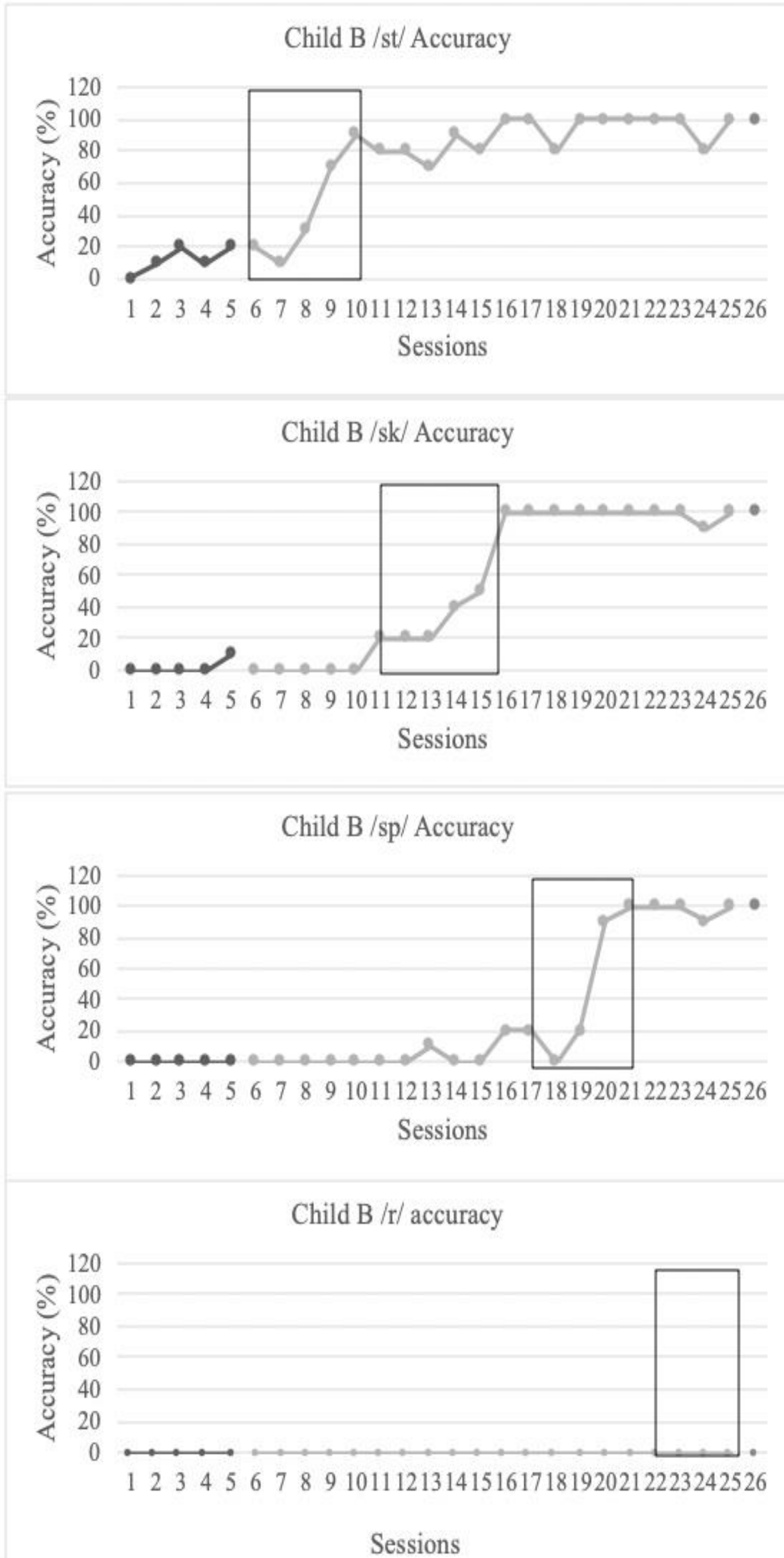

Figure 2: Child B's Results

CHAPTER 4

DISCUSSION

The purpose of this study was to examine the effectiveness of using a phonological approach to treat consonant cluster errors in two children with repaired cleft palate. A minimal pairs approach was utilized to treat /s/+stop consonant cluster errors and the /r/ phoneme. This study also employed telepractice to provide further evidence of the effectiveness of a telepractice service delivery model for children with repaired cleft palate. The present study found that three /s/ consonant clusters were produced with 100% accuracy during a post-treatment maintenance session, thus exhibiting a significant increase in production accuracy of consonant clusters in both children via telepractice.

4.1 Intervention Approach

Although Bessell et al. (2013) reported that previous studies utilized both articulation and phonological approaches, currently, the studies addressing the phonological approach to treat speech sound disorders in children with cleft palate are very limited and were mainly conducted by one research group in Mexico (Pamplona et al., 2005; Pamplona, Ysunza, and Espinosa, 1999; Pamplona, Ysunza, and Morales, 2014; Pamplona, Ysunza, and Ramirez, 2004). Pamplona and colleagues have conducted several studies evaluating the effectiveness of phonological approaches in treating misarticulations in children with cleft palate. While they investigated the effectiveness of the phonological approach as compared to the articulation approach in only one study, the other three studies examined treatment variable effects such as intensity and cueing strategies using the phonological approach. Thus, the current study provided additional information on the effectiveness of a phonological approach in children with cleft palate. The findings of the current study were consistent with Pamplona and her colleagues in that children's production accuracy improved using a minimal pair approach, suggesting that a phonological intervention approach may be an effective way to address English consonant cluster errors in children with cleft palate. However, the current study only examined two children with cleft palate. Therefore, more research on consonant cluster intervention in children with cleft palate is necessary.

The results of this study were also consistent with findings in current literature that the phonological approach is effective for treating consonant clusters in children with speech sound disorders (Baker and McLeod, 2004; Dodd and Bradford, 2000; Hoffman, Norris, and Monjure, 1990; Young, 1987). The previous studies argued that the phonological approach was effective in treating consonant clusters and led to generalization. In the current study, both children generalized to untreated probes during intervention and produced all /s/ consonant clusters with 100% accuracy during treatment as well as the maintenance follow-up session. Additionally, production knowledge of /r/ in consonant clusters emerged in one child. Child A exhibited production knowledge of /r/ in clusters (i.e., /dr/ and /br/) during *GFTA-3* administration. While Child B's *GFTA-3* standard score increased by two points, Child A exhibited a 24-point increase in her standard score between the pre-treatment and post-treatment scores. These results provided additional evidence on the effectiveness of using a phonological approach for correcting consonant cluster errors, leading to generalization and maintenance.

The most recent national outcome measures (NOMS) published by ASHA reported that pre-kindergarten children with articulation errors required 17 to 20 hours of treatment to improve their articulation production, finding that 36.1% of children who received fewer than 10 hours of treatment improved on one level, and 27% improved on multiple levels. In terms of treating consonant clusters, it seems treatment of shorter duration could be effective. The majority of the studies that addressed consonant cluster intervention indicated that treating consonant clusters requires about six weeks (three to nine hours of therapy) to eliminate errors (Dodd and Bradford, 2000; Hoffman, Norris, and Monjure, 1990; Young, 1987) although Baker and McLeod (2004) reported that children may require a longer duration (seven to nine weeks) to treat consonant clusters. The children in the current study mastered each target consonant cluster within 6 or 7.5 weeks. This dosage was similar to the previous studies that were conducted via the face-to-face service delivery model, suggesting that the phonological approach was equally effective when administered via telepractice.

It is not certain, however, whether the phonological approach is more effective than the traditional motor approach in treating consonant clusters. Only one study (Dodd & Bradford, 2000) reported that phonological contrast therapy was more effective than the PROMPT approach, which is based on oral muscular phonetic gestures. They argued that either a phonological approach or a core vocabulary approach would increase in the accuracy of consonant clusters. Because limited studies have directly addressed phonetic and phonological approaches to treating consonant cluster errors, further studies are warranted.

<u>4.2 Effectiveness of the Telepractice Service Delivery Model</u>

Telepractice is considered a useful service delivery model because it provides intervention for children in rural areas who have limited access to speech pathology services. Limited research is currently available on using telepractice to effectively treat speech sound errors in children with cleft palate (Whitehead et al., 2013). The current study was consistent with previous findings that telepractice is an effective service delivery method comparable to in-person intervention (Grogan-Johnson et al., 2013; Gabel et al., 2013; Blaiser et al., 2013; Constantinescu et al., 2014; Keck and Doarn, 2014; Lee, Hall, & Sancibrian, 2017; Lee, 2018). Grogan-Johnson and colleagues examined children with functional speech and language disorders, whereas Constantinescu et al. (2014) and Lee et al. (2018) tested children with hearing loss. Similarly to these populations, telepractice was also effective for treating developmental errors in children with cleft palate. The children in the current study were seen for intervention solely via telepractice for 25 sessions and exhibited improved speech production compared to baseline.

The telepractice delivery model may have some barriers, for example, the lack of tactile cueing, which was noted by Grogan-Johnson et al. (2013). In the current study, when treating three /s/ consonant clusters, mainly auditory cues were employed via the minimal pair approach. It is not certain whether the telepractice service delivery model is also effective for children with cleft palate when the traditional motor approach is adopted to correct "compensatory articulation" in children with cleft palate. Typically, visual and tactile cues are commonly provided when treating children with cleft palate. For example, Kummer's treatment guidelines for cleft palate include three principles involving biofeedback: auditory, visual, and tactile. Children with cleft palate may require visual feedback using therapy tools such as a mirror to see nasal emission, a straw to hear hypernasality or nasal emission, or the placement of a hand under their noise to feel nasal emission (Kummer, 2020). However, in telepractice, unless assistants or caregivers are given intensive training to use forms of biofeedback during therapy, children may have limited opportunities to receive various types of biofeedback. Currently, there are no studies available that compare telepractice to in-person intervention in individuals with cleft palate. Further investigation comparing telepractice to traditional service delivery is also necessary.

4.3 Limitations of the Current Study

The present study only evaluated two children. It is difficult to generalize the findings to other children with cleft palate. However, previous studies examining consonant cluster intervention also included a smaller number of children (Baker and McLeod, 2004; Dodd and Bradford, 2000; Hoffman, Norris, and Monjure, 1990; Young, 1987). In addition, both participating children were from the same family. Frequent interaction between the two children may have positively affected their speech improvement. Since no studies have been conducted to evaluate the effect of phonological intervention in treating consonant clusters and to examine the effect of the telepractice service delivery model in children with cleft palate, the present study provided preliminary, but valuable information. However, in future studies, a larger sample of participants is necessary to determine whether using a phonological intervention approach or telepractice service delivery model is effective in children with cleft palate. Finally, the target probes used in this study were monosyllabic words, and no data were taken on generalization to multisyllabic words or connected speech. Thus, further studies are needed to examine whether a phonological approach is effective for more complex speech stimuli.

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