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Preliminary Reliability and Validity of Asynchronous Speech Screening to Support Clinical Triage for Children With Cleft Palate and Velopharyngeal Dysfunction

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ABSTRACT

Purpose: Children with cleft and craniofacial conditions require ongoing monitoring and evaluation to manage persistent speech and resonance disorders. Regular assessment allows clinicians to detect emerging problems, evaluate intervention efficacy, and adjust treatment plans accordingly. However, socioeconomic and logistical barriers place many children at risk for sporadic or absent follow-up, leading to undiagnosed or underaddressed velopharyngeal dysfunction. This pilot study examined the reliability and use of asynchronous speech and resonance screenings to identify children who need comprehensive imaging assessment versus those suitable for continued monitoring and local speech therapy.

Method: Twenty children with repaired cleft palate and/or noncleft velopharyngeal dysfunction completed in-clinic speech evaluations, during which standardized audio-only and audio–video samples were simultaneously recorded using telephone and web-conferencing platforms. During the evaluation, speech samples were rated in real time using the Cleft Audit Protocol for Speech-Americleft Modification. Each of the 40 recording files, including 20 audio-only and 20 audio–video recordings, were blinded, randomized, and independently reviewed by two asynchronous raters, yielding 80 asynchronous rating events. Interrater agreement and reliability were evaluated using percentage agreement and unweighted kappa coefficients across modalities.

Results: Across parameters and modalities, asynchronous ratings closely approximated in-person ratings. Reliability was very good for intelligibility and acceptability (κ = .81–.83), good for resonance and cleft speech characteristics (κ = .63–.75), and moderate for audible nasal emission and weak pressure consonants (κ = .45–.57). Asynchronous raters demonstrated high agreement with in-person ratings for therapy recommendations (80%–85%; κ = .57–.69) and clinical triage decisions (70%–90%; κ = .41–.79).

Conclusions: Preliminary findings support the feasibility and reliability of asynchronous speech and resonance screening to inform clinical triage decisions. Audio-only and audio–video recordings yielded generally comparable ratings and triage recommendations, with video offering potential added value for select speech features. Future development of asynchronous monitoring platforms has promise for reducing unnecessary clinic visits, streamlining interventions, and ensuring timely follow-up for those in need of higher level care.

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Children with velopharyngeal dysfunction (VPD) secondary to cleft palate and craniofacial conditions may experience a range of speech and resonance impairments that can persist beyond or emerge after surgical repair (de Blacam et al., 2020; Hashemi Hosseinabad et al., 2024). Some common challenges include hypernasality, audible nasal air emission, and compensatory articulation errors, which require ongoing assessment to support optimal communication development (Cronin et al., 2020; Harding & Grunwell, 1996; Kummer, 2014; Lancaster et al., 2020; Lien et al., 2023). If not managed adequately, these impairments can affect academic achievement, social interaction, and overall quality of life (Bhuskute et al., 2017; Kinter, 2018; Wydick et al., 2022). Consistent clinical visits for speech and resonance evaluations are therefore critical to identify and address VPD, including the potential need for secondary surgical procedures or speech therapy (Mason et al., 2025; Snodgrass, Sitzman, et al., 2025; Woo, 2012).

Speech and resonance quality often serve as early indicators prompting follow-up evaluations (Aparna et al., 2019; Hayakawa et al., 2026). Management of VPD involves care by a multidisciplinary team including plastic/craniofacial surgeons, speech-language pathologists (SLPs), and other specialized health professionals (American Cleft Palate-Craniofacial Association [ACPA], 2024; Snodgrass, Perry, & Sitzman, 2025). In-person evaluations by these teams are considered the gold standard for comprehensive assessment and treatment planning, allowing direct perceptual judgments, instrumental assessment (e.g., nasometry), and visualization of the velopharyngeal mechanism through nasopharyngoscopy, videofluoroscopy, and/or magnetic resonance imaging (Al Awaji et al., 2025; Myers et al., 2022; Weidler & Sitzman, 2025). However, this model of care can be difficult to access for many families due to lengthy travel, time off work, and other caregiving constraints (Fairweather et al., 2016; O'Callaghan et al., 2005). These barriers are amplified for families living far from major metropolitan centers, where multidisciplinary cleft/craniofacial teams are often located, potentially leading to reduced follow-up, delayed interventions, and greater health disparities among children in underserved regions (Mason, 2024; Peck et al., 2021). Consequently, many children may be lost to follow-up, particularly for speech assessments, or receive only sporadic evaluation (Heister et al., 2025).

Consistent attendance at follow-up cleft palate/craniofacial team visits is critical because speech changes can be subtle and evolve over time. Children with mild or borderline VPD postpalatoplasty may develop more pronounced deficits as linguistic demands increase with age (Baek et al., 2017; Varagur et al., 2025) or adenoids involute during typical development (Mason, 1973; Perry et al., 2022). Regular assessments allow clinicians to detect emerging issues, evaluate intervention efficacy, and adjust treatment plans accordingly (ACPA, 2024; Pitkanen et al., 2025). Yet, socioeconomic and logistical barriers place many children at risk of incomplete or absent follow-up, potentially resulting in undiagnosed or underaddressed VPD (Dillon et al., 2026; Fujiki et al., 2024; Kong et al., 2026; Rameau et al., 2023). A recent study found that only half (50.6%) of patients adhered to follow-up appointments within the recommended timeframe (Heister et al., 2025). These trends highlight the need for innovative service delivery models that support continuous monitoring and timely intervention.

Asynchronous speech and resonance screenings offer a potential solution. By enabling remote clinical monitoring, these methods may provide a scalable approach to triaging patients, identifying those who may require comprehensive in-person imaging evaluation, and facilitating referrals to local therapy services. Although asynchronous approaches have shown promise in related areas, such as telehealth applications for voice disorders (Awan et al., 2025; Hwang et al., 2025), their validity and generalizability to craniofacial populations remain underexplored (Pamplona & Ysunza, 2020; Zarei et al., 2026).

Unlike synchronous telehealth assessments, which require real-time interaction between clinician and patient, asynchronous methods allow speech samples to be collected at times and locations convenient for patients and their families. These samples can then be reviewed later by a qualified craniofacial SLP, supporting flexible scheduling and reducing travel burdens, particularly for families in rural or resource-limited areas (Al Awaji et al., 2025; Scott et al., 2025). Moreover, asynchronous screening holds promise as a scalable tool for monitoring and triaging large patient populations, helping clinicians identify those needing in-person evaluation or advanced imaging and prioritizing care based on the severity and type of speech and resonance concerns.

The purpose of this study was to examine the validity and reliability of asynchronous speech and resonance screenings compared to synchronous in-person assessments. Specifically, it sought to evaluate whether asynchronous methods could replicate in-person perceptual ratings of speech and resonance characteristics for situations where in-person screenings are not possible and generate preliminary data to inform the design of a large-scale, multicenter investigation. Additionally, the study examined the potential of these methods to triage children who may require more comprehensive imaging or local therapy interventions.

Method

The study was approved by the Children's Healthcare of Atlanta (CHOA) Institutional Review Board (IRB#

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00001848) with collaborative institutional affiliation and data use agreements established between CHOA, the University of Virginia, and the University of Wyoming (IRB-SBS#6476; DUA#00000541). Written informed consent was obtained from caregivers, and assent was obtained from children as appropriate. All procedures adhered to established ethical guidelines for research involving human subjects.

Participants

Participants included 20 children (M_{age} = 9.7 ± 3.5 years) recruited during routine craniofacial clinic visits at a large tertiary pediatric hospital (see Table 1). A sample size of 20 participants was selected because this preliminary study prioritized methodological feasibility, pilot data generation, and reliability assessment. This preliminary sample size is aligned with prior studies assessing perceptual analysis of speech (Chapman et al., 2016; Johanson & Brooks, 2010; Whitehead et al., 2016). Children meeting inclusion criteria were recruited consecutively over the study period. Inclusion criteria consisted of being an active, established patient within the craniofacial clinic, having a documented diagnosis of VPD, speaking English as their primary language, and being scheduled for a comprehensive speech/resonance assessment during the study period. Children with both cleft- and non–cleft-related VPD were eligible for inclusion. Children with concomitant syndromic diagnoses were additionally included in the sample. Children with significant comorbid conditions, such as cognitive or neurological impairments, were excluded.

Table 1. Participant demographics.

Demographics	Category	*n* (%)
Mean age	Years (*SD*)	9.7 (3.5)
Sex	Female	6 (30)
	Male	14 (70)
Race	Asian	1 (5)
	Black	4 (20)
	White	15 (75)
Ethnicity	Non-Hispanic	13 (65)
	Hispanic	7 (35)
Primary language	English	20 (100)
Syndromic status	Nonsyndromic	17 (85)
	Syndromic	3 (15)
Cleft type	CPO	5 (20)
	BCLP	2 (10)
	UCLP	7 (35)
	SMCP	1 (5)
	Noncleft VPD	5 (20)

Note. *N* = 20. CPO = cleft palate only; BCLP = bilateral cleft lip and palate; UCLP = unilateral cleft lip and palate; SMCP = submucosal cleft palate; VPD = velopharyngeal dysfunction.

Data Collection

All participants completed a comprehensive in-person speech evaluation conducted by the craniofacial SLP in the room with the child. The SLP elicited a standardized speech sample that included sentence or phrase repetition, counting, and 2–3 min of elicited conversation as a part of the Cleft Audit Protocol for Speech-Augmented-Americleft Modification (CAPS-A-AM; Chapman et al., 2016). During the live encounter, the SLP completed real-time CAPS-A-AM ratings of intelligibility, acceptability, voice quality, hypernasality, hyponasality, audible nasal emission (ANE), weak pressure consonants, and cleft speech characteristics (CSCs) using the ordinal scales in Supplemental Material S1. The clinician also made clinical triage decisions regarding the need for comprehensive imaging assessment and/or required local speech therapy intervention. During this same in-person evaluation, these speech samples were simultaneously captured with two recording devices: (a) an audio-only system accessed via telephone and (b) an audio–video system accessed via a Health Insurance Portability and Accountability Act (HIPAA)-compliant web-conferencing platform. Both recording pathways used Voice over Internet Protocol (VoIP) audio capture. Audio-only samples were recorded through the Cisco CP-8851 institutional VoIP telephone and voicemail system (detailed below), whereas audio–video samples were recorded through an HIPAA-compliant Zoom VoIP session on an iPad. Because both recording modalities used Internet Protocol (IP)–based audio transmission, comparisons between audio-only and audio–video recordings could preliminarily evaluate the added contribution of visual information for the same standardized speech sample. Two asynchronous raters independently reviewed both recording formats for every participant and rated recordings according to the same criteria listed above.

Audio-only recording pathway: Audio-only speech samples were captured using a Cisco CP-8851 VoIP institutional telephone system (Cisco Systems, Inc.). The device was selected for feasibility within the clinical environment and was not intended to represent a typical home or personal mobile-phone recording pathway during this pilot phase of the study. This phone features audio processing technologies, including automatic gain control, comfort noise generation, silence suppression/voice activity detection, acoustic echo cancellation, and dynamic noise reduction. It supports multiple audio codecs to digitize and compress voice signals for transmission (e.g., G.711, G.722, G.729a/b, Internet Low Bitrate Codec, and Internet Speech Audio Codec, G.722.1, G.722.2, and OPUS). Participants were instructed, and assisted as

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needed, to hold the device to their ear during speech sampling, resulting in a microphone position of approximately 45° and a distance of 3–5 in. from their mouth. Audio recordings were recorded and saved to the institutional phone system voicemail, extracted as .wav format files, and stored securely for asynchronous analysis.

Audio–video recording pathway: Audio–video recordings were captured simultaneously with the audio-only recordings during the same in-person evaluation using an 11-in. iPad Pro (Apple Inc., iOS 17.2) placed 12–24 in. in front of the seated participant, consistent with the protocols outlined by Baylis et al. (2024). This device was equipped with a 12MP camera (f/1.8 aperture) and a four-microphone array with stereo sound. The device's built-in Center Stage technology automatically panned and zoomed to keep participants in view. All recordings were obtained via an HIPAA-compliant Zoom session (Zoom Video Communications, Inc.), which automatically started recording upon participant entry. Resulting .mp4 files were downloaded and stored on an institution-approved secure server for asynchronous analysis.

Rating Process

During the live clinical evaluations, the fellowship-trained craniofacial SLP with more than 5 years of VPD assessment experience conducted the standardized synchronous, in-person perceptual ratings while simultaneously capturing the audio-only and audio–video recordings. This clinician served as Rater 1 and was familiar with the participant and clinical history as part of routine craniofacial care. Accordingly, these ratings served as a pragmatic, history-informed clinical reference against which asynchronous ratings could be compared. Subsequently, a research assistant removed identifying information from speech sample recordings, assigned study codes, and randomized the audio-only and video speech samples. Two independent, craniofacial fellowship-trained SLPs with expertise in VPD assessment then completed the asynchronous ratings. These raters had no prior clinical contact with participants and were blinded to participant identity, age, diagnosis, clinical history, prior treatment, and anticipated management plan. All raters had previously completed standardized perceptual speech training consistent with the CAPS-A-AM protocol (Chapman et al., 2016). All raters used the same standardized CAPS-A-AM and clinical triage criteria outlined above to evaluate key speech characteristics and to make triage recommendations.

Asynchronous raters independently reviewed the recordings using either external desktop speakers or built-in laptop speakers in their usual professional work setting. Headphones were not used. Raters were permitted to replay recordings as needed before finalizing their judgments. Ratings were documented using the CAPS-A-AM and clinical triage rating form provided in Supplemental Material S1. No formal acoustic calibration procedure was used. This approach was selected to evaluated feasibility under typical professional listening conditions rather than laboratory-standardized conditions.

Speech Recording Quality Control

Audio and video recording quality was assessed systematically to ensure that poor recording conditions did not confound perceptual judgments of speech and resonance. After recordings were generated, each recording underwent an initial quality check in which a trained study coordinator rated audio clarity on a 5-point scale (1 = *very poor*; 5 = *excellent*) considering distortion, background noise, and microphone artifacts. The signal-to-noise ratio (SNR) was calculated using Praat software (Version 6.3.17; Boersma & Weenink, 2025) with the Phonanium plugin (Version 01.02; Maryn, 2025) to provide an objective measure of audio quality related to extraneous noise relative to the target speech signal. Only recordings with a clarity rating ≥ 3 and SNR ≥ 25 dB were included in subsequent analyses to ensure sufficient audio/video quality. All 40 speech sample recordings met these criteria. Therefore, no samples were excluded from analysis.

Statistical Analysis

Mean audio quality control ratings and SNR were calculated for all audio and audio–video recordings. Agreement between asynchronous ratings and the in-person clinical reference was evaluated using exact percentage agreement, mean directional differences, and unweighted kappa coefficients for CAPS-A-AM variables and triage decisions. Following guidelines provided by Altman (1991) and consistent with prior studies by Chapman et al. (2016), kappa values were interpreted as poor (< .20), fair (.21–.40), moderate (.41–.60), good (.61–.80), and very good (> .81). Given the small pilot sample and sparse category distributions for several speech variables, kappa estimates are presented as preliminary descriptive indices. Confidence intervals and more robust agreement analyses are planned for a larger validation study.

Results

Audio/Video Speech Sample Quality Control

A total of 40 speech samples were assessed (20 audio-only and 20 video files, each simultaneously recorded from

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every participant). Based on the 5-point audio/video clarity scale (1 = *very poor/unrateable*; 5 = *excellent*), the average rating was 4.75 (*SD* = 0.44), indicating predominantly "good" to "excellent" quality. Similarly, the mean SNR across all audio-only samples was 34.82 dB (*SD* = 2.58) and all video samples was 44.04 dB (*SD* = 5.16), suggesting sufficient separation of the target speech signal from any ambient noise for reliable perceptual judgments. Importantly, no samples were deemed "very poor/unrateable" or excluded due to microphone interference, excessive background noise, or other recording artifacts. All 40 samples met the prespecified quality criteria. These findings indicate that the pilot speech sample recording process successfully yielded clinically analyzable audio and video data in all cases.

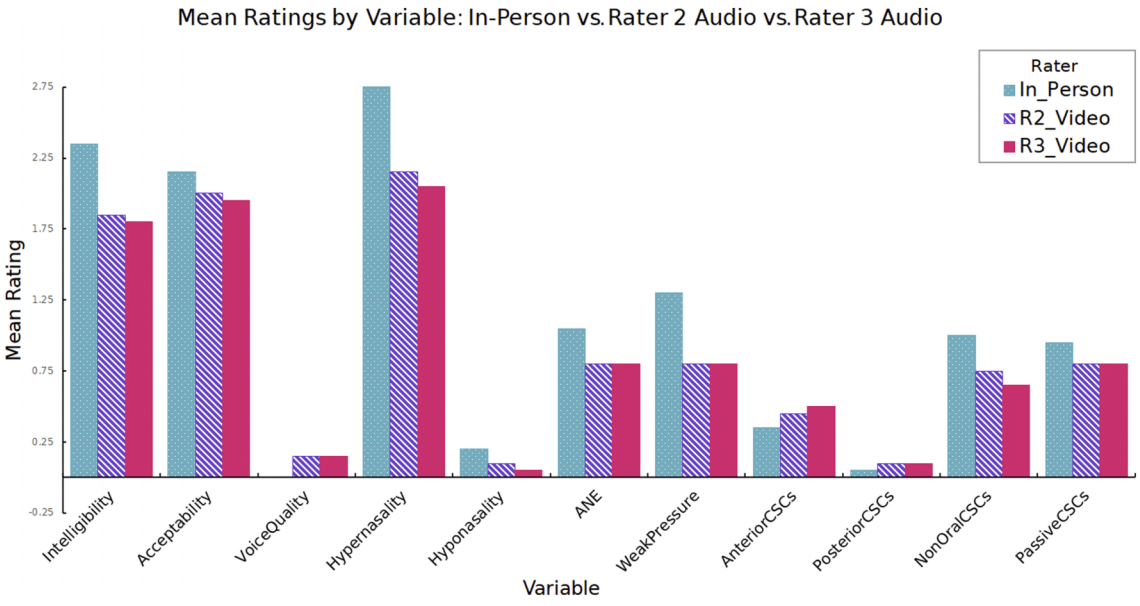
Mean Ratings Across Modalities

Mean severity ratings were generally higher (i.e., more severe) in the in-person condition compared to asynchronous ratings. For intelligibility, in-person ratings exceeded asynchronous ratings by 0.70–0.80 points in the audio condition and by 0.91–0.92 points in the video condition. Acceptability ratings were closer in magnitude, differing by 0.12–0.57 points across modalities. Hypernasality ratings differed by 0.91–1.17 points and ANE scores by 0.62–0.80 points, with both showing reduced discrepancy in the video condition. Weak pressure consonants also followed this pattern, with in-person ratings averaging 0.62–1.00 points higher than asynchronous ratings. Posterior CSCs were the only parameter for which asynchronous raters assigned slightly higher mean ratings than the in-person clinician. However, these differences were small across conditions (1.00 and 0.33 points higher for audio and video, respectively). In contrast, for non-oral and passive CSCs, asynchronous ratings were lower than in-person ratings by 0.29–1.40 points, with slightly smaller differences observed in the video condition. Figures 1 and 2 highlight mean ratings across modalities for each speech parameter. Overall, in-person ratings were slightly higher than asynchronous ratings for most variables, with differences generally ranging from 0.12 to 1.40 points across the various parameters, with many parameter ratings within or less than a single ordinal step across raters.

Percent Agreement Across Speech Parameters and Modalities

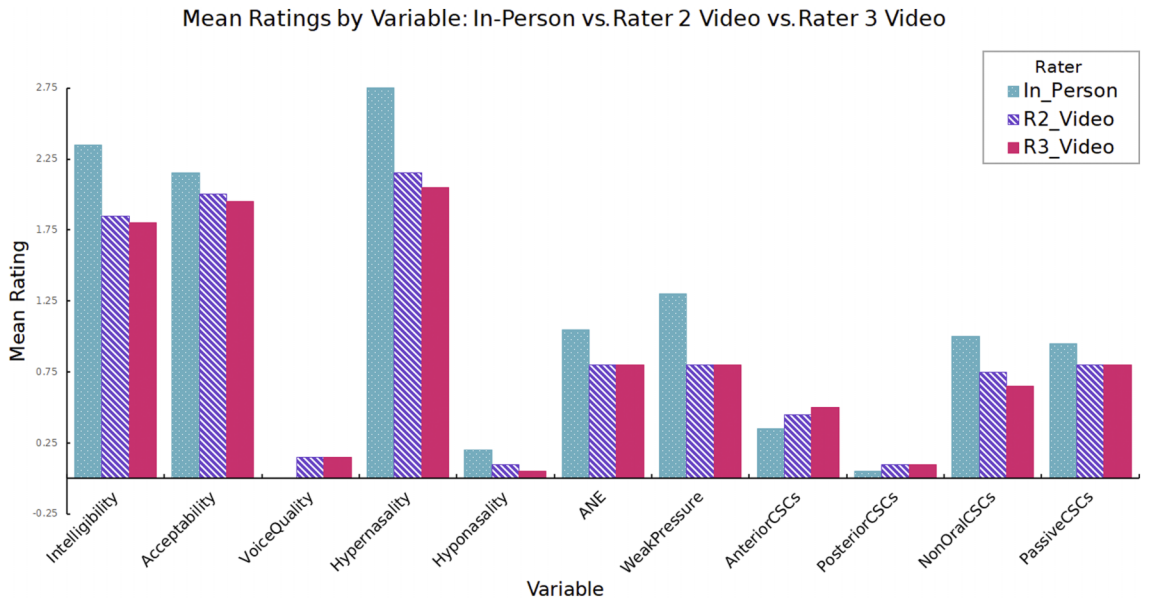
Exact agreement values were calculated across all CAPS-A-AM parameters, comparing in-person ratings with each asynchronous rater in both audio and video formats (see Table 2). Exact agreement for intelligibility and acceptability ranged from 40% to 60%, while voice quality yielded substantially higher agreement at 85% across all comparisons. Hypernasality and ANE exhibited lower agreement, ranging from 40% to 60%, although ANE agreement improved by approximately 10% in the video condition. Agreement for weak pressure consonants ranged from 50% to 60% in all comparisons. Hyponasality showed the highest reliability among resonance features, with agreement ranging from 85% to 100% across conditions. For CSCs, anterior CSCs yielded 70%–80% agreement; posterior CSCs,

Figure 1. Mean audio perceptual ratings across raters for each speech parameter. ANE = audible nasal emission; CSCs = cleft speech characteristics; R2 = Asynchronous Rater 2; R3 = Asynchronous Rater 3.



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Figure 2. Mean video perceptual ratings across raters for each speech parameter. ANE = audible nasal emission; CSCs = cleft speech characteristics; R2 = Asynchronous Rater 2; R3 = Asynchronous Rater 3.



85%–95%; non-oral CSCs, 75%–85%; and passive CSCs, 65%–75%. Asynchronous raters, when compared against each other, had higher exact agreement across parameters, often reaching 95%–100% agreement in the video modality.

Mean Directional Differences Across Modalities

To better understand the nature of disagreement between in-person and asynchronous raters, mean directional differences were analyzed (see Table 3). For nearly all variables, asynchronous raters provided slightly lower severity ratings compared to in-person judgments. This was especially notable for hypernasality, where asynchronous scores were on average 0.91–1.17 points lower. For ANE and weak pressure consonants, differences ranged from −0.62 to −1.00. Global parameters such as intelligibility and acceptability showed smaller differences, typically between −0.12 and −0.92 points. Hyponasality was also rated slightly lower by asynchronous raters, with differences of approximately −0.90 to −1.00 points. For voice quality, asynchronous ratings were consistently 1.00 point higher across all raters and conditions, likely reflecting reduced variability within this perceptual category. Posterior CSCs were the only parameter with minimally higher ratings from asynchronous raters (up to 1.00 point), while anterior, non-oral, and passive CSCs showed slightly lower ratings. Overall, the directionality of differences

Table 2. Percentage agreement across each variable and modality.

Percent agreement	In-person vs. R2_Audio	In-person vs. R3_Audio	R2_Audio vs. R3_Audio	In-person vs. R2_Video	In-person vs. R3_Video	R2_Video vs. R3_Video
Intelligibility	50%	50%	95%	45%	40%	95%
Acceptability	60%	60%	100%	70%	65%	95%
Voice quality	85%	85%	100%	85%	85%	100%
Hypernasality	50%	45%	90%	40%	40%	90%
Hyponasality	100%	85%	85%	90%	85%	95%
ANE	50%	50%	85%	60%	60%	100%
Weak pressure	60%	50%	85%	50%	50%	100%
Anterior CSCs	80%	70%	85%	80%	75%	95%
Posterior CSCs	95%	85%	90%	95%	85%	90%
Non-oral CSCs	85%	75%	80%	80%	75%	95%
Passive CSCs	75%	65%	85%	70%	70%	100%

Note. ANE = audible nasal emission; CSCs = cleft speech characteristics.

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Table 3. Mean directional differences across modalities between asynchronous ratings compared to in-person ratings.

Mean difference	Rater 2 audio vs. in-person	Rater 2 video vs. in-person	Rater 3 audio vs. in-person	Rater 3 video vs. in-person
Intelligibility	−0.70	−0.91	−0.80	−0.92
Acceptability	−0.12	−0.5	−0.12	−0.57
Voice quality	1.00	1.00	1.00	1.00
Hypernasality	−1.00	−1.00	−0.91	−1.17
Hyponasality	−0.90	−1.00	−1.00	−1.00
ANE	−0.70	−0.62	−0.80	−0.62
Weak pressure	−0.62	−1.00	−1.00	−1.00
Anterior CSCs	0.50	0.50	0.17	0.60
Posterior CSCs	1.00	1.00	0.33	0.33
Non-oral CSCs	−0.33	−1.25	−1.40	−1.40
Passive CSCs	−0.21	−0.50	−0.29	−0.50

Note. ANE = audible nasal emission; CSCs = cleft speech characteristics.

favored less severe ratings from asynchronous raters, though the magnitudes were small and generally remained within the typical range of perceptual variability (Chapman et al., 2016; Pereira et al., 2021).

Reliability of Asynchronous and In-Person Ratings

Interrater reliability was evaluated using unweighted kappa coefficients across all CAPS-A-AM variables (see Table 4). Intelligibility and acceptability demonstrated the highest reliability, with κ values ranging from .814 to .831 from audio and .824 to .827 for video, indicating very good agreement across modalities. Voice quality showed moderate reliability (κ = .439 in both audio and video), despite high percent agreement due to limited score variability for this parameter in the sample. Hypernasality and hyponasality exhibited good reliability, with κ values of .793 and .735 in audio, and .723 and .633 in video, respectively. For ANE, kappa values improved from moderate in the audio condition (κ = .454) to good in the video condition (κ = .574), suggesting a visual advantage in identifying nasal airflow distortions. Weak pressure consonants yielded moderate reliability across modalities, with κ values of .573 for audio and .552 for video.

Among CSCs, anterior CSCs were rated with good reliability across both audio and video samples (κ = .716). Posterior CSCs demonstrated the lowest reliability, with κ values of .372 in both conditions, indicating fair agreement. Non-oral and passive CSCs showed good reliability, with κ values ranging from .693 to .753 across modalities. In general, kappa values indicated moderate to very good reliability across most speech parameters, with some variability observed for specific features such as posterior CSCs.

Clinical Triage for Imaging and Speech Therapy Recommendations

To assess reliability of clinical decision making based on asynchronous ratings of speech samples, raters' judgments

Table 4. Analysis of asynchronous and in-person ratings.

Variable	Audio-only ratings		Video ratings	
Parameter	**κ**	**Strength**	**κ**	**Strength**
Intelligibility	.831	Very good	.824	Very good
Acceptability	.814	Very good	.827	Very good
Voice quality	.439	Moderate	.439	Moderate
Hypernasality	.793	Good	.723	Good
Hyponasality	.735	Good	.633	Good
Audible nasal emission	.454	Moderate	.574	Good
Weak pressure	.573	Moderate	.552	Moderate
Anterior CSCs	.716	Good	.716	Good
Posterior CSCs	.372	Fair	.372	Fair
Non-oral CSCs	.721	Good	.693	Good
Passive CSCs	.753	Good	.736	Good

Note. Interpretation for the strength of kappa values followed Altman's (1991) guidelines: < .20 = poor, .21–.40 = fair, .41–.60 = moderate, .61–.80 = good, and > .81 = very good. CSCs = cleft speech characteristics.

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were compared for two primary outcomes: (a) the need for comprehensive velopharyngeal imaging assessment and (b) the need for speech therapy referral. Agreement between in-person and asynchronous raters for clinical triage decisions ranged from 70% to 90%, with corresponding κ values between .41 and .79, indicating moderate to good reliability across both audio and video conditions (see Table 5). Agreement for speech therapy recommendations ranged from 80% to 85%, with corresponding κ values between .57 and .69, also indicating moderate to good reliability across both audio and video conditions (see Table 6).

Discussion

Preliminary findings from this pilot study support the feasibility and reliability of asynchronous speech screenings for clinical monitoring of children with VPD. High levels of agreement between asynchronous and in-person ratings for key speech parameters suggest that asynchronous perceptual ratings of recorded screenings can approximate the perceptual ratings achieved during traditional, in-person screenings. Furthermore, clinical triage decisions, such as need for comprehensive imaging assessment and/or speech therapy services, demonstrated moderate-to-good agreement. Results support feasibility for developing asynchronous screening tools to support clinical triage recommendations and ongoing care.

Modality Considerations

Perceptual ratings were generally similar across modalities, with reliability comparable for most speech parameters, consistent with prior evidence that technology-mediated transmission can support reliable auditory-perceptual evaluation (Dahl et al., 2021). An exception was observed for ANE, where exact agreement improved by approximately ~10% in the video condition. This slight improvement may reflect the added visual cues, including articulatory movements, nasal grimace, or other observable correlates of nasal airflow, consistent with evidence that visual information can enhance interrater consistency for selected communicative behaviors (Whitehead et al., 2012). Because both recording modalities used IP-based audio transmission, the comparison evaluated the added contribution of visual information rather than a conventional telephone-versus-internet audio contrast. The audio-only and audio–video pathways nonetheless used different devices and recording platforms, which may have influenced audio capture quality. Video recordings had higher SNRs despite greater microphone distance, suggesting that microphone configuration and device-level processing, rather than distance alone, may have contributed to this difference; these mechanisms were not directly tested.

These findings are consistent with emerging evidence that the validity of remotely obtained speech information is measure specific rather than uniform across all speech domains. Hwang et al. (2025) found that several acoustic measures derived from Zoom recordings of children with dysarthria demonstrated acceptable validity relative to simultaneously obtained offline recordings, whereas noise- and perturbation-sensitive measures, including SNR and cepstral peak prominence, did not. Although the present study evaluated perceptual rather than acoustic outcomes, a similar principle may explain the variable agreement observed across speech characteristics. Features such as intelligibility and acceptability require global severity judgments, for which a one-category difference was classified as disagreement despite potentially similar overall clinical impressions. ANE may be particularly sensitive to brief, intermittent events and phonetic context, although the modestly greater agreement observed in the video condition suggests that visual information may assist detection of subtle airflow-related cues. Importantly, the high agreement between asynchronous raters within both modalities, together with their similar directional differences relative to the in-person clinician, indicates that lower in-person versus asynchronous exact agreement was not primarily attributable to unstable asynchronous ratings. Rather, these patterns likely reflect systematic differences in rating threshold or contextual information between live synchronous clinical assessment and asynchronous review of standardized recordings.

Despite posterior CSCs demonstrating the lowest interrater reliability across CSCs, the magnitude and direction of disagreement were small and differed by recording modality. In the audio-only condition, asynchronous raters

Table 5. Interrater agreement for clinical triage decision: imaging assessment needed.

Variable	Agreement (audio)	α (audio)	Agreement (video)	α (video)	Interpretation
R1 vs. R2	90%	.79	90%	.79	Good
R1 vs. R3	75%	.49	70%	.41	Moderate
R2 vs. R3	85%	.69	80%	.60	Good

Note. R1 = Rater 1 (in person); R2 = Asynchronous Rater 2; R3 = Asynchronous Rater 3.

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Table 6. Interrater agreement for clinical triage decision: speech therapy recommended.

Variable	Agreement (audio)	α (audio)	Agreement (video)	α (video)	Interpretation
R1 vs. R2	80%	.61	85%	.69	Good
R1 vs. R3	80%	.57	85%	.66	Moderate–good
R2 vs. R3	90%	.80	90%	.80	Good

Note. R1 = Rater 1 (in person); R2 = Asynchronous Rater 2; R3 = Asynchronous Rater 3.

assigned posterior CSC ratings that were, on average, 1.00 severity category higher than the in-person clinician, which corresponded to a shift from fewer than three affected consonants to three or more affected consonants on the CAPS-A-AM scale. In contrast, the mean difference in the audio–video condition was only 0.33 categories. Similar to ANE, this pattern suggests that visual information may help raters distinguish posterior oral errors from non-oral articulatory behaviors or other atypical productions, thereby reducing overclassification of posterior CSC severity.

Across modalities, clinical triage recommendations remained highly similar between raters, supporting the use of either audio-only or audio–video recordings for asynchronous screening and triage. The observed modality-related differences may be most relevant when a more granular characterization of specific speech errors is needed, particularly when distinguishing posterior oral errors from non-oral or other atypical productions.

Taken together, the high agreement between the two asynchronous raters within each recording modality, along with their similar directional differences relative to the in-person clinician, supports the consistency of asynchronous review. In contrast, comparisons of each asynchronous rater's audio-only and audio–video ratings of the same standardized speech sample provide the most direct assessment of the added contribution of video. These within-rater comparisons were generally similar across speech parameters, with potential advantages of video most apparent for ANE and posterior CSC classification. Thus, audio-only and audio–video recordings appear comparably suitable for asynchronous screening and triage, while video may provide added value when clinicians require more detailed characterization of speech errors or when visual cues could help resolve uncertainty.

The generally high reliability observed across asynchronous modalities supports the potential for a hybrid, multitiered screening model for individualized, patient-specific care. Such a model could use standardized asynchronous speech samples to support routine monitoring and prioritize patients who require comprehensive in-person evaluation, imaging, or targeted speech intervention. Similar approaches have been shown to be effective across clinical contexts, including remote hearing screening in rural schools (Govender & Mars, 2018), asynchronous telerehabilitation for speech-language therapy (Hill & Breslin, 2016), and pediatric speech sound assessments delivered via telehealth (Campbell et al., 2024). This approach may be particularly beneficial in settings where regular in-person assessments are logistically challenging, such as geographically remote areas or resource-limited clinics. Broader reviews of asynchronous telehealth suggest that such methods can reduce unnecessary in-person visits, improve access to care, and maintain diagnostic accuracy (Deshpande et al., 2009). Together, these results indicate that both asynchronous audio and audio–video assessments are generally comparable for screening and triages, with video providing modest additional value when more detailed characterization of specific speech features is needed.

Clinical Utility of Asynchronous Screenings

The high levels of agreement across most rating categories suggest that asynchronous screenings, both audio-only and video based, appear to be valuable adjuncts to in-person speech and resonance screenings, rather than a replacement for comprehensive evaluation, particularly when findings are borderline, inconsistent, or likely to alter treatment decisions. Asynchronous screenings may be used to screen, monitor, and triage patients, reserving in-person evaluations for those who require more detailed, comprehensive assessment. In practice, caregivers could access a secure web-based platform to record speech samples on personal phones or computers. Specific instructions, provided online or directly by the craniofacial team, could ensure recordings are of sufficient quality. Additionally, school- and community-based SLPs could potentially use an asynchronous recording system for initial screenings, allowing craniofacial SLPs to review samples and provide timely recommendations. Importantly, these services may align with existing communication technology-based service pathways (e.g., remote evaluation and interpretation of recorded video/audio), suggesting a potential avenue for Current Procedural Terminology coding and reimbursement within current billing frameworks (American Speech-Language-Hearing Association, n.d.).

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Despite the critical role of school- and community-based SLPs in managing cleft-related speech disorders, many clinicians report limited preparation in this area (Bedwinek et al., 2010; Mason, 2025; Mason et al., 2020). SLPs infrequently encounter children with cleft lip/palate in routine practice and identify a strong need for accessible continuing education, practical clinical guidance, and direct communication with specialized cleft/craniofacial teams. Training in articulatory and resonance disorders related to VPD, combined with opportunities to collaborate with experienced team members, is particularly valued (Kotlarek et al., 2024). Structured educational resources, such as online self-study modules (Baigorri et al., 2020), Cleft Palate Video Modules from the Leaders Project (Crowley, 2016), and step-by-step treatment tutorials for speech-language pathology assistants (Kotlarek & Krueger, 2023), can help bridge these gaps and provide clinicians with the guidance needed to deliver effective, evidence-based interventions (Rogers et al., 2026). These efforts align with national standards for team management and responsibilities outlined in the ACPA Standards (2022), which emphasize mechanisms for referral, communication, and collaboration with external professionals to ensure comprehensive, patient-centered care.

This approach could also feasibly improve communication between craniofacial teams and local providers as well as streamline new patient referrals for comprehensive velopharyngeal assessment or guide local SLPs in implementing targeted therapeutic interventions (Baylis et al., 2019; Bow et al., 2024; Karnell et al., 2005). It may additionally enhance communication and coordination between local providers and multidisciplinary cleft/craniofacial teams, consistent with collaborative care models described by Grames (2025). Such models emphasize the importance of integrating SLP input, supporting local providers, and streamlining referrals for comprehensive assessment of velopharyngeal function or targeted therapeutic interventions. Together, these strategies could improve access to care, optimize resource utilization, and ensure patients receive timely, appropriate interventions.

Implications for Resource Allocation and Accessibility

The ability to screen and triage patients asynchronously has important implications for craniofacial workflows and patient engagement in team care, particularly in settings with limited access to specialized teams (Fujiki et al., 2024; Strauss, 1995). Regular asynchronous monitoring can help maintain patient contact, reduce potentially unnecessary in-person clinic visits, and support continuous care. Telemedicine and asynchronous evaluations can further extend the reach of craniofacial teams to underserved populations, providing reliable speech assessments and interventions when in-person visits are impractical (Pamplona & Ysunza, 2020; Shahrul & Abd Rahman, 2021; E. Whitehead et al., 2012). These approaches also support continuity of care during periods when travel or clinic attendance is restricted, such as public health crises. An asynchronous, multitiered screening model would not only reduce the burden of care for children with cleft palate and their families but also prioritize clinic time and streamline clinical care. More efficient care delivery has the potential to benefit all patients, as clinic waitlists are reduced.

Despite these advantages, challenges remain in refining asynchronous protocols to ensure accurate assessment across all speech parameters. Certain features, such as ANE and weak pressure consonants, may require modifications to rating protocols or the inclusion of video-based speech samples to improve interrater reliability, particularly for clinicians developing skills remotely (Crowley et al., 2024). Practical constraints, such as voicemail system limitations that necessitate separate calls to capture both sentence-level and conversational speech samples, further highlight the need for video-based modalities. However, for individuals without access to tablet- or computer-based resources, phone-based options remain a viable alternative. Although these methods provide lower audio quality and reduced visual information, preliminary findings indicate that triage recommendations were highly consistent across all recording modalities, supporting their use for remote monitoring and clinical triage. Asynchronous assessment and intervention approaches can also improve speech outcomes, including compensatory articulation, and maintain caregiver-mediated continuity of care (Al Awaji et al., 2025; Pamplona & Ysunza, 2020).

Limitations and Future Directions

While these preliminary findings support the feasibility and reliability of asynchronous speech and resonance screenings, the sample size, limited number of raters, and single-center design limit generalizability. The study included one in-person rater and two independent asynchronous raters. Larger studies should include broader rater panels and additional evaluation of inter- and intrarater reliability. Recordings were obtained under controlled, clinician-guided conditions using standardized speech samples, which may not fully reflect the quality or consistency of recordings obtained in real-world settings, such as home and school environments or lower resource settings. Ongoing work is evaluating remotely acquired, smartphone-based, caregiver-led speech samples and the guidance, quality-control procedures, and technical specifications needed to support routine implementation.

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Although both recording modalities used IP-based audio transmission and allowed evaluation of the added contribution of visual information, the audio-only and audio–video pathways used different devices and recording platforms. The present study was therefore not designed to isolate the independent effects of hardware and signal processing differences. In addition, asynchronous raters used pragmatic playback conditions, including external desktop speakers or internal laptop speakers, without formal acoustic calibration. Future studies should evaluate whether playback equipment, listening environment, and standardized recording specifications influence perceptual agreement or triage decisions for this population of patients.

Methodological constraints also included limited score variability across several speech parameters, particularly voice quality, which necessitated the study's use of unweighted kappa statistics. Exact agreement and unweighted kappa offered a conservative and clinically meaningful representation of rater concordance, consistent with prior work using exact-match metrics for sparsely distributed ordinal data (Chapman et al., 2016). Complementary analyses of mean directional differences provided additional insight into the magnitude and direction of discrepancies, offering a nuanced understanding of rating patterns under conditions of limited variability. Larger samples are needed to confirm these patterns and estimate agreement with greater precision.

Although all recordings were blinded and randomized for asynchronous review, the in-person ratings, which served as the reference standard for comparison, were conducted by a clinician familiar with the participants' clinical history, which may have influenced synchronous ratings, particularly regarding triage decisions and speech recommendations. Nonetheless, high agreement between asynchronous raters (who had no prior contact with participants and no knowledge of their clinical history), as well as the high level of agreement between asynchronous and in-person raters, supports the robustness of asynchronous screenings and suggests that familiarity with the child is not essential for reliable decision making. Future studies should assess whether access to clinical history changes perceptual ratings or clinical decision making.

Conclusions

Findings from this pilot study support the feasibility and preliminary reliability of asynchronous speech and resonance screenings to inform clinical triage. Asynchronous rating for both audio-only and video recording modalities yielded generally comparable ratings and triage recommendations, suggesting that either modality may support structured monitoring and referral decisions when comprehensive in-person assessment is not immediately available. Video may provide added value when more detailed characterization of specific speech features is needed, particularly for ANE and posterior CSCs. These approaches show promise for improving monitoring, streamlining decision making, and expanding access to specialized care for children with cleft and craniofacial conditions. Larger studies using broader rater panels and remotely acquired caregiver-led recordings are ongoing and necessary before widespread implementation.

Ethics Statement

This study was approved by the Children's Healthcare of Atlanta Institutional Review Board (IRB #00001848), and institutional affiliation agreements were established with the University of Virginia and the University of Wyoming.

Data Availability Statement

The data sets generated and analyzed during the current study are not publicly available due to participant confidentiality and institutional privacy policies. However, de-identified data may be made available from the corresponding author upon reasonable request and contingent upon the establishment of an approved data sharing agreement.

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