Beyond the Eye: AI-Enhanced Visual Biomarker Discovery & Tracking for ALS

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Introduction

Amyotrophic Lateral Sclerosis (ALS) is a progressive degenerative neuromuscular disorder causing muscle weakness and impaired mobility. Clinical evaluations including rating scales, such as ALS Functional Rating Scale (ALSFRS-R) and Rasch Overall ALS Disability Score (ROADS), are generally carried out at 3 month intervals. As ALS progresses, attending clinics can become increasingly difficult requiring an increased use of telemedicine. Digital biomarkers offer an innovative solution for more sensitive detection of changes between clinic visits and remote monitoring of persons with ALS (PALS) unable to attend clinic. CaptureProof (CP), a video capture application enhanced by artificial intelligence, may provide this solution through identifying visual biomarkers to remotely monitor ALS progression.

Objectives

The initial goal is to develop and validate a standardized video and photo capture protocol using a smartphone application (CaptureProof) in order to detect and monitor the progression of Amyotrophic Lateral Sclerosis (ALS).

Methods

In order to generate visual biometric markers using CP's AI-Smart Medical Camera, to detect motor involvement in PALS and monitor ALS progression, PALS were recruited from the MDA/ALS clinic at Temple University for this single-arm study. Data collection occurred at Temple University during regular clinic visits or at patients' homes for those unable to attend. Using CaptureProof's smartphone application, participants were recorded performing specific tasks involving facial movement, speech, upper and lower extremity function, balance, and gait (including the Timed Up and Go test). Participants also completed ALSFRS-R and ROADS assessments. CP's proprietary algorithms analyzed the video data, generating biometric markers for each task by evaluating symmetry, fluidity, speed, range, and rate of movements. These markers were compared between PALS and healthy controls, as well as against self-reported ALSFRS-R and ROADS scores. The study was approved by the Institutional Review Board, and informed consent was obtained from all participants.

Initial Results

Our preliminary data set includes 10 PALS (7M, 3F, 48–71 years) and an average ALSFRS-R score of 33.6 Video assessments revealed decreased function in all 9 performing PALS for TUG (9.4–24.7 sec, mean 13.62 ± 5.08 sec vs. norm 8.1 sec), with 5/9 showing normal ALSFRS-R Walking scores, and in 9/9 for 5x SST (12.36–24.5 sec, mean 16.83 ± 4.29 sec vs. norm 11.4 sec), with 6/9 having normal ROADS gait/stairs scores. Longitudinal data from 1 patient (3 visits) showed increased facial asymmetry (eye closure, lower teeth, pucker lips), reduced max left arm/leg extension, increased max right leg extension, TUG +43.6% to 21.4 sec, and 5x SST +31.5% to 16.3 sec, highlighting CP's precision in tracking progression beyond traditional scales. Audio analysis of the Bamboo Passage in 7 PALS revealed high inhale frequencies (15.0–20.9 breaths/min, mean 17.8 ± 2.2 breaths/min) and reduced words per breath (7.5–8.7, mean 7.8 ± 0.6), indicating respiratory compromise, despite ALSFRS-R scores (21–36) suggesting a milder impairment. Praat analysis confirmed dysarthria (jitter >1%, monotone pitch <50 Hz), with frequent pauses (13–15, ~17% of duration) signaling bulbar decline.

Timed-Up-and-Go: Compared to the normative reference value for 60-69 year-olds (8.1±0.9)[1], data from 10 PALS shows an increased average TUG time (13.6±5.0 sec) among the 9 patients able to perform the test. One patient was unable to complete the TUG due to an inability to walk. All 9 completing subjects had abnormal TUG times (>8.1 sec). On ALSFRS-R walking scores, four patients reported significant dysfunction (score 2, walks with assistance), three reported early ambulation difficulties (score 3), and two reported no difficulties (score 4).

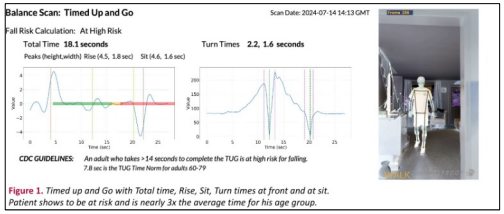
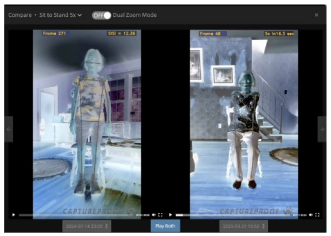


Figure 1. *Timed up and Go with Total time, Rise, Sit, Turn times at front and at sit. Patient shows to be at risk and is nearly 3x the average time for his age group.*



5-Repetition Sit to Stand: S5-Repetition Sit to Stand: Sit to Stand was performed in 9 participants. Compared to the normative reference value for 60-69 year-olds (11.4 seconds)[2], data shows increased values in PALS (12.36 - 24.5 sec). ROADS scores associated with gait ("walk around your home") and climbing stairs ("walk up 1 flight of stairs") were normal for both tasks in two participants, normal for walking but abnormal for stairs in four participants, and abnormal for both tasks in two participants, including the individual with the highest sit-to-stand time of 24.5 sec. One patient did not perform the test, due to an inability to stand safely. One patient (seen left) showed a 31.877% increase in Sit to Stand from July 2024 (12.36 seconds) to March 2025 (16.3 seconds).

Finger Taps: Finger taps were recorded for 7 participants. Speed varied between 35.3–150 taps per minute, with tap durations ranging from 0.4–1.7 seconds (estimated from speed). ALSFRS-R scores for handwriting and utensil use were normal (4) for one participant, while six showed varying difficulties (scores 3–1). ROADS scores for "sign name on paper" and "use a knife and fork" were normal (2) for one participant, mixed (2, 1) for one, and abnormal (1) for both tasks in four participants, with the lowest tap speed (35.3–38.2) corresponding to abnormal ROADS scores.

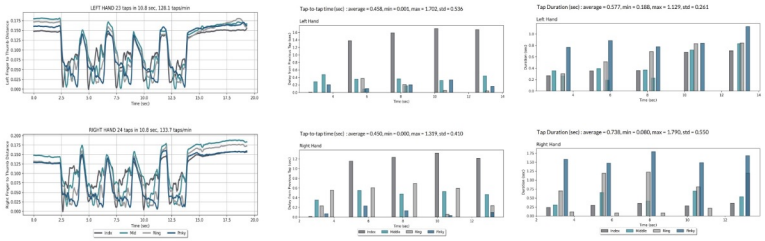


Figure 3. Finger Tap. Patients are instructed to tap each finger to thumb in a forward and reverse sequence.

References:

1.Bohannon RW. Reference values for the timed up and go test: a descriptive meta-analysis. J Geriatr Phys Ther. 2006;29(2):64-8. doi: 10.1519/00139143-200608000-00004. PMID: 16914068.
2.Bohannon RW. Reference values for the five-repetition sit-to-stand test: a descriptive meta-analysis of data from elders. Percept Mot Skills. 2006 Aug;103(1):215-22. doi: 10.2466/pms.103.1.215-222. PMID: 17037663.

Finger Spread: 7/10 PALS Net distances (0.8–41.3 px), spreads (2–19 reps). Initially-proposed metrics (distance from thumb to index finger, spread time) captured and are in development. Analysis of the best biometric and signal are under investigation. Clarity and sensitivity will increase with direct correlation to the sample size.

Figure 4. Finger Spread. Regular motion of fingers. Tremor is apparent at the start and end during the 3 second "hold still" periods.

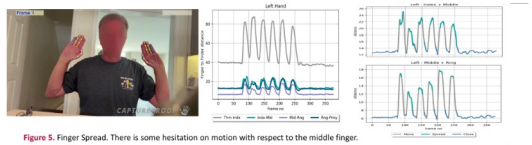
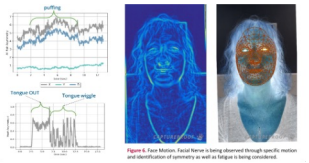


Figure 5. Finger Spread. There is some hesitation on motion with respect to the middle finger.

Facial Movements: Puff (3–16%), asymmetry (0.0004–4.1459%) in 7/10 PALS. F71: lip asymmetry -19.7% to 9.5%, puff declined (Visit 2: 0.201/0.180 to Visit 3: 0.176/0.167 px); M63: 0.0015–4.1459%. Waveform analysis ongoing.
Audio: 6/10 PALS (128–173.8 WPM, 15–20.9 inhales/min). M63 (173.8 WPM) compensatory; F71 stable (141.3 WPM) despite bulbar decline.



Discussion and Future Directions

Our data suggests that CaptureProof (CP) accurately captures features associated with ALS motor involvement, enabling detection of functional changes and disease progression. Video assessments of TUG revealed decreased function in all 9 performing subjects (mean 13.62 ± 5.08 sec vs. norm 8.1 sec), despite 5/9 having normal ALSFRS-R Walking scores, suggesting CP's increased sensitivity to motor involvement. This heightened sensitivity, particularly evident in TUG and 5x SST results, highlights the utility of AI-enabled video capture for detecting motor changes, enabling earlier intervention, and tracking ALS progression with precision beyond traditional scales. Audio analysis further supports CP's ability to detect bulbar decline, with high inhale frequencies (mean 17.8 ± 2.2 breaths/min) and dysarthria (jitter >1%) indicating respiratory compromise. Continued data collection will expand our sample size and explore additional motor tasks, biomarker metrics, correlations with ALS rating scales, and longitudinal monitoring of disease progression. The initial set of assessments will be comprehensive, aiming to identify the most sensitive movements for a streamlined test battery, completable in under 10 minutes, to enhance clinical utility.
In conclusion, AI-enhanced video assessments provide valuable digital biomarkers for ALS progression, detecting subtle motor and bulbar changes with greater sensitivity than ALSFRS-R and ROADS. From TUG and 5x SST outperforming self-reported scores to longitudinal data showing increased facial asymmetry and motor decline (e.g., TUG +43.6% to 21.4 sec over 3 visits), CP offers a robust tool for early intervention, longitudinal tracking, and personalized care strategies. These findings could inform predictive models and enhance access to specialized ALS care through remote monitoring, with potential applications for other neurodegenerative conditions.