Prediction of Outcome with Oral Appliance Therapy for Obstructive Sleep Apnea Using In-Home Mandibular Titration

J.E. Remmers, MD[1,2], A. Zareian, PhD[1,2], Z. Topor, PhD[1,2], J. Grosse, MMath[2], N. Vranjes, DDS[2], S. Bruehlmann, PhD[2], S. Charkhandeh, DDS[2]

[1]University of Calgary and [2]Zephyr Sleep Technologies, Calgary, Alberta, Canada

ABSTRACT

Rationale: Oral appliance therapy (OAT) resolves sleep apnea in only 50-60% of cases, pointing to the need to prospectively identify therapeutic responders. We sought to assess the accuracy of an auto-titrating mandibular positioner (AMP) with machine learning to predict therapeutic outcome and an efficacious mandibular positioner.

Methods: Two independent populations (Phase 1: n=149; Phase 2: n=53) of participants with obstructive sleep apnea (OSA) participated in a prospective, blinded clinical trial. Data from Phase 1 were used to develop the predictive method, and data from Phase 2 were used to evaluate its accuracy. Each participant underwent two full-night AMP studies in the home while using a temporary dental appliance, and each was treated with a custom oral appliance. Therapeutic outcome sleep tests were performed after full clinical adjustment. Prediction of therapeutic outcome was derived from the analysis of a machine learning method (Random Forest).

Results: Using oxygen desaturation index (ODI) of less than 10 hr^{-1} at outcome as the criterion of therapeutic success, predictive accuracy was as follows for Phase 2: sensitivity: 85%; specificity: 93%; positive predictive value: 97%; negative predictive value: 72%; and accuracy: 88%. Of participants correctly predicted to respond to OAT, the target protrusive position proved to be an efficacious position in 86% of cases.

Conclusions: Data from an unattended, in-home sleep study with an auto-titrating mandibular positioner, analyzed by a machine learning method, accurately identifies OSA patients who will respond to OAT. The study also provides a therapeutic target protrusive position that is efficacious in the majority of OAT responders.

CONTACT: jremmers@zephyrsleep.com

INTRODUCTION

We have developed an auto-titrating mandibular positioner (AMP) home test for predicting outcome with oral appliance therapy (OAT) in individuals with obstructive sleep apnea (OSA). The AMP home test is comprised of 2 unattended nights of study during which apneas and hypopneas are detected in real time via oxyhemoglobin saturation and respiratory airflow feedback signals.

METHODS

- Prospective, blinded (physician and dentist), controlled study involving two sequential, independent populations (Phase 1: n=149; Phase 2: n=53)
- Between the two study phases, 8 (4%) participants were unable to collect sufficient AMP data (inconclusive) and 15 were lost to follow-up, leaving a final study population of 179 participants (n=131 for Phase 1; n=48 for Phase 2)
- Broad inclusion criteria (ODI > 10 hr^{-1}, BMI < 45 kg/m^2)
- 2-3 full night tests with an AMP in the home with automated prediction of therapeutic outcome and efficacious mandibular position
- All participants received an oral appliance (Phase 1: SomnoMed; Phase 2: MicrO_2) set to target protrusion (default position of 70% for predicted non-responders)
- Participants were tested at target, then further protruded in 1-2mm increments until therapeutic success (ODI <10 hr^{-1}) or until clinical limits of protrusion were reached
- Machine learning (Random Forest) was used to predict accuracy
  - Phase 1 data were used to train the Random Forest; Phase 2 data were used to evaluate the Random Forest machine accuracy

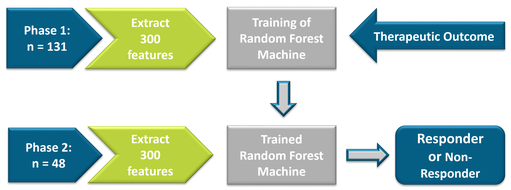

Figure 1. The two-phase approach used to first train and then validate the predictive model.

Participant Baseline Characteristics

	Phase 1 (n=131)	Phase 2 (n=48)
Age (yrs)	49.8±10.6	48.4±10.7
Females/Males	21/110	8/40
BMI ($kg.m^2$)	30.3±4.2	33.3±5.4
ODI (events.hr^{-1})	25.4±13.3	31.1±17.4
SaO_2 (%)	92.1±1.5	91.9±1.5

RESULTS

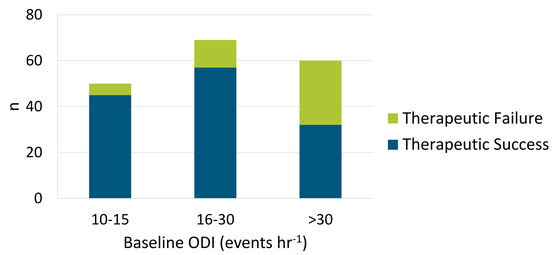

Figure 2. Baseline OSA severity and therapeutic outcome of study participants (Phases 1 and 2 combined; n=179).

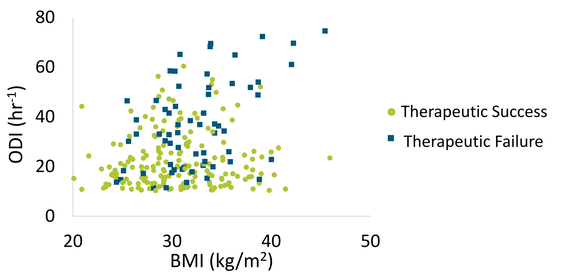

Figure 3. Distribution of baseline ODI and BMI for Phase 1 and Phase 2 study participants (n=179).

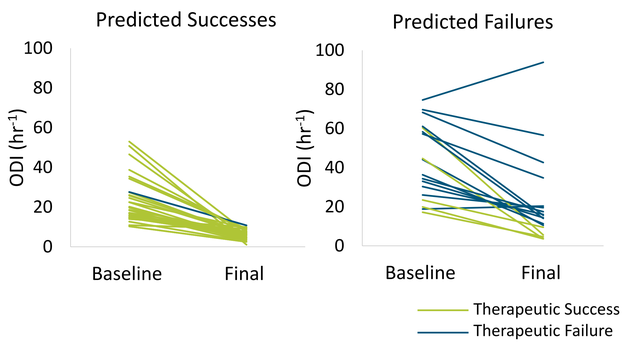

Figure 4. ODI at baseline and final therapeutic position for predicted successes (left panel) and predicted failures (right panel) for Phase 2 study participants (n=48).

	Predicted Success	Predicted Failure		
Therapeutic Success	29	5	Sensitivity	85%
Therapeutic Failure	1	13	Specificity	93%
	PPV	NPV		
	97%	72%		

Figure 5. Positive and negative predictive values, sensitivity, and specificity of Phase 2 data (n=48). Overall accuracy was 88%.

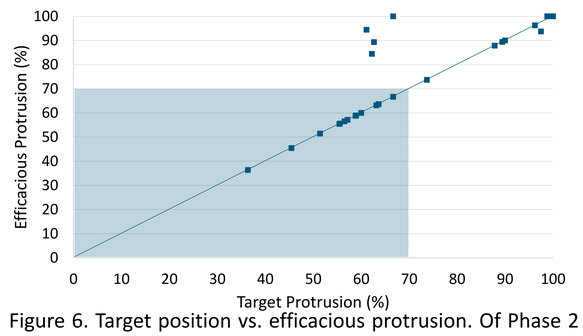

Figure 6. Target position vs. efficacious protrusion. Of Phase 2 participants predicted to be therapeutic successes, overall target accuracy was 86%.

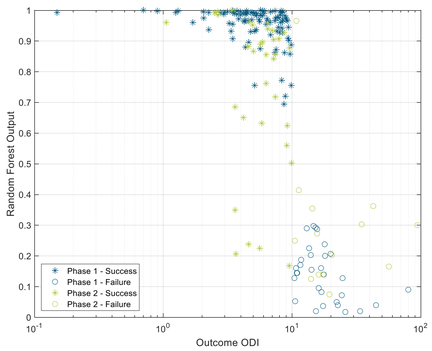

Figure 7. Random Forest output versus outcome ODI. The Random Forest (400 trees) was trained on Phase 1 data (blue data points) then applied to Phase 2 data (red data points). In this figure, Random Forest output is the proportion of trees that predicted success for a given participant.

DISCUSSION

Our results show that an AMP can be used in unattended studies to predict OAT outcome and an efficacious mandibular position. Data from 179 participants (2-3 study nights per participant) showed that the AMP home studies were feasible, well-tolerated, and safe. Random Forest machine learning analysis trained on Phase 1 data and applied to Phase 2 data resulted in a predictive accuracy of 88% and a positive predictive value of 97%. 86% of Phase 2 study participants were successfully treated at target.

CONCLUSIONS

- We have developed an AMP system suitable for unattended sleep studies
- Data from 179 study participants using 2 different oral appliances shows good accuracy in identifying favorable candidates for OAT and determining an efficacious mandibular position

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