Perceptions of Speech Before and After Orthognathic Surgery

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Introduction

- 70-90 percent of DFD patients exhibit speech-sound disorders, as opposed to 5 percent of the general US population (Vallino 1990, Vallino and Tompson 1993, Black et al. 2015)
  - /s/ (as in 'sue') and /ʃ/ (as in 'shoe') are two sounds commonly affected by malocclusion
  - Speech distortions rarely go away after speech therapy due to structural abnormalities
- Quantitative measures show speech improvements after orthognathic surgery, particularly among Class III patients (Bode et al. 2023)
- Do listeners perceive the noted acoustic changes in speech after orthognathic surgery?

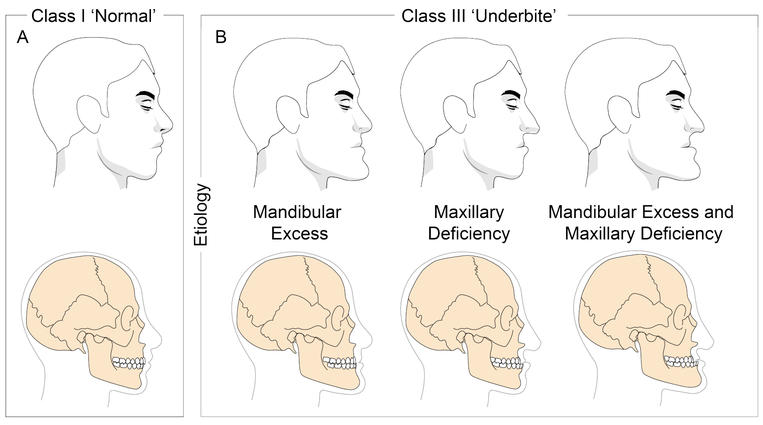


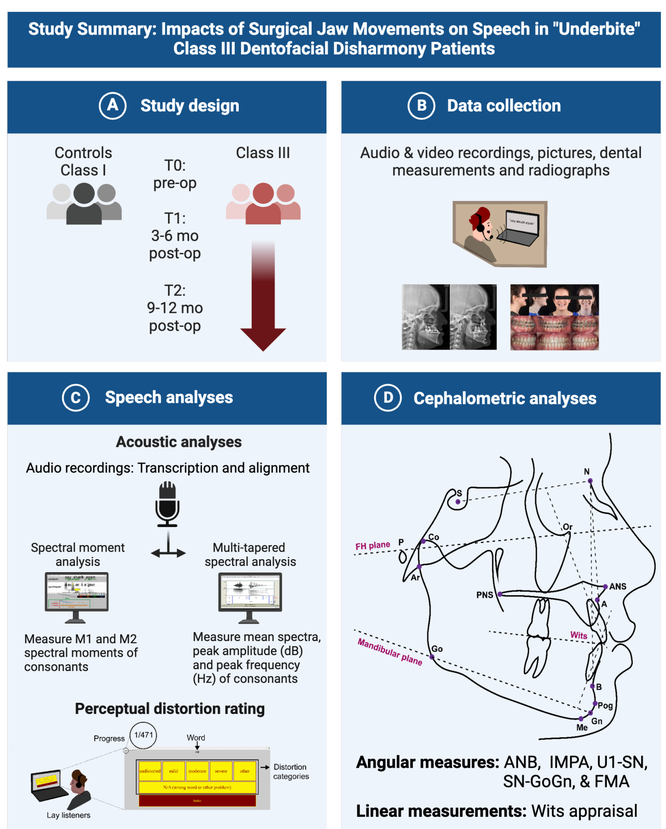
Figure 1: Skeletal Classes

Methods

- Materials:
  - 469 speech recordings
    - Patients produce each target word within the carrier phrase "Say _____ again"
  - 273 DFD patients
  - 65 Class I controls
- Listening task involving the rating of distortion for each word (18 listeners)
  - Stimuli were played for each listener in a randomized order
  - 3 repetitions of target words
  - Tasked with rating each stimuli as undistorted or mild, moderate, or severe distortion
  - Listening task was performed with *Praat* software (Boersma and Weenink 2007)
- Multitaper spectral analysis methodology described in (Tran et al. 2024)
- Data was analyzed and visualized using `tidyverse` (Wickham et al. 2019)
- Ordinal regression of over 61,000 observations was performed using the `ordinal` package in R (Christensen 2023).

	/s/	/ʃ/
/i/	see	she
/u/	sue	shoe
/æ/	sack	shack
/a/	sock	shock

Table 1: Words by target consonant and following vowel



	Class III	Class III AOB	TOTAL
T0	34	22	56
T1	27	17	44
T2	12	11	23
TOTAL	73	50	123

Table 2: Number of recordings per patient group and surgical timepoint

Results

- Class III and Class III AOB patients before surgery are 5.37 and 3.61 times more likely, respectively, to be evaluated as having speech distortions relative to Class I controls ($p<0.001$)
- Both patient groups show less distortion after surgery (figure 2)
- Decreased distortion ratings correlate with changes in acoustics after surgery in the direction of Class I controls (figure 3)

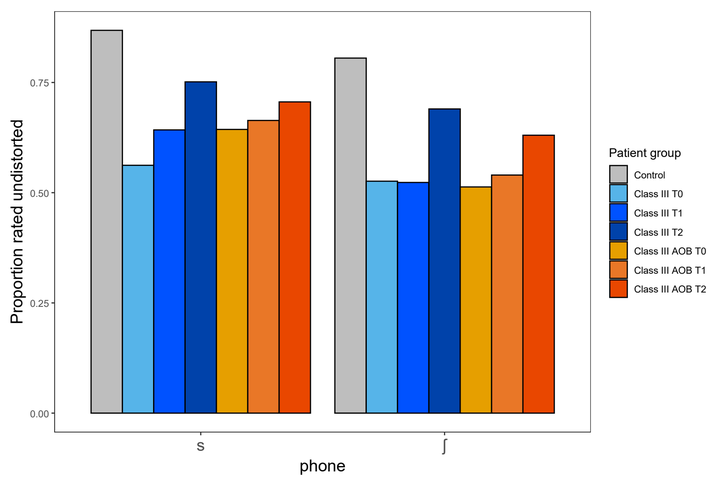


Figure 2: Proportion of undistorted ratings across patient groups and surgical status. Both patient groups are evaluated as less distorted after surgery.

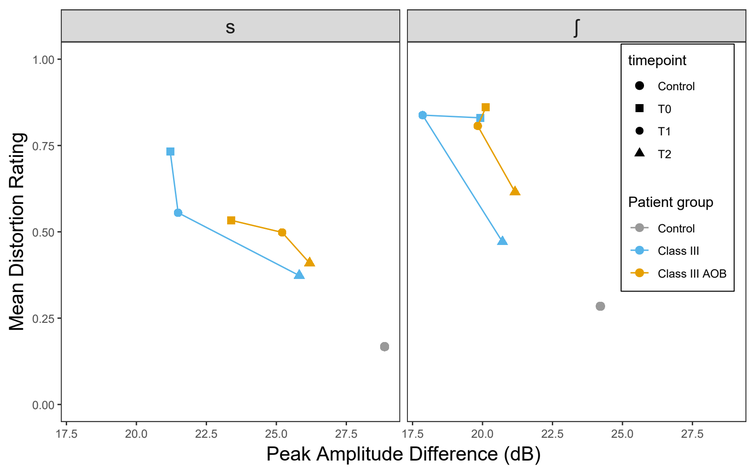


Figure 3: Average distortion rating across peak amplitude difference (dB). After surgery, peak amplitude difference for both patient groups approaches controls and distortion rating goes down.

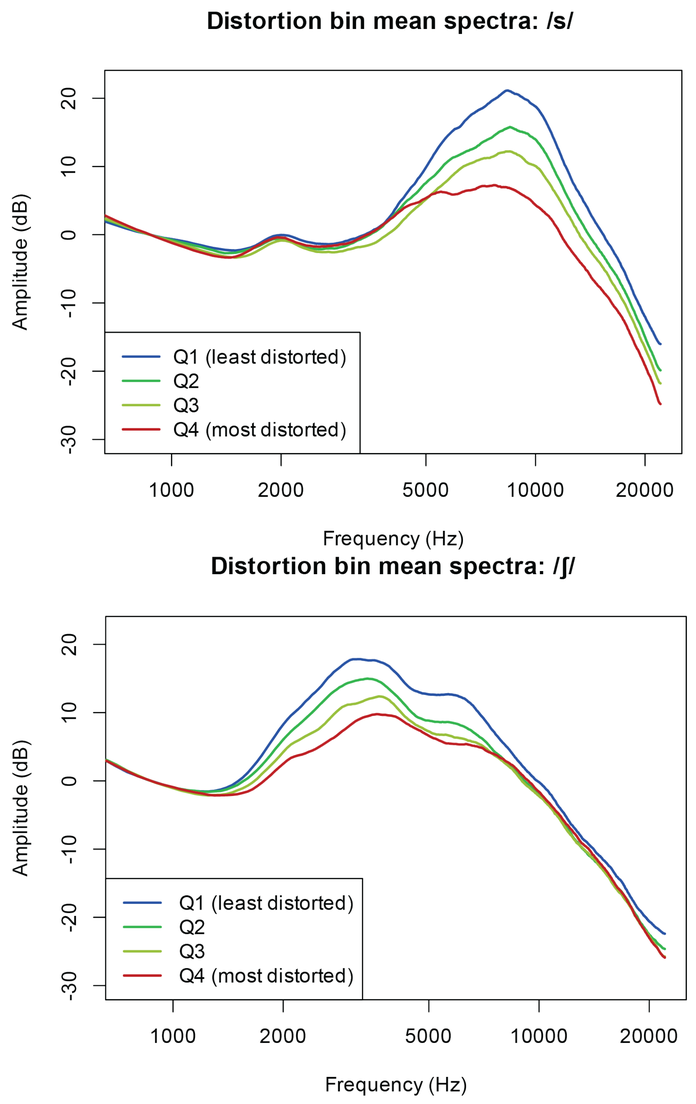


Figure 4: Averaged multitaper spectra of /s/ (top) and /ʃ/ (bottom) by perceptual response (Q1=undistorted, Q4=severe)

Results (Continued)

- Power spectra (figure 4) for most distorted tokens are flatter, which correlate to "lisping" or interdentalization
- Patients are significantly more likely to be evaluated as undistorted by T2 (figure 6)

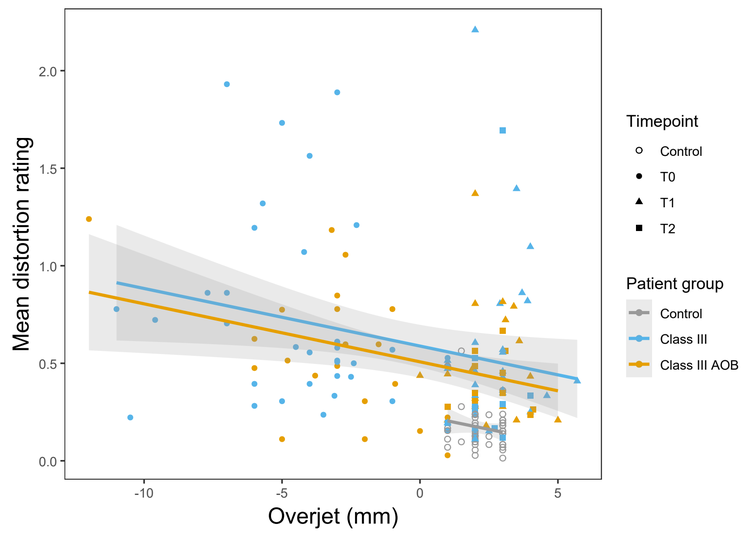


Figure 5: Average /s/ distortion rating across overjet values. As overjet goes from negative to positive after surgery, perceptual distortion overall goes down for both patient groups

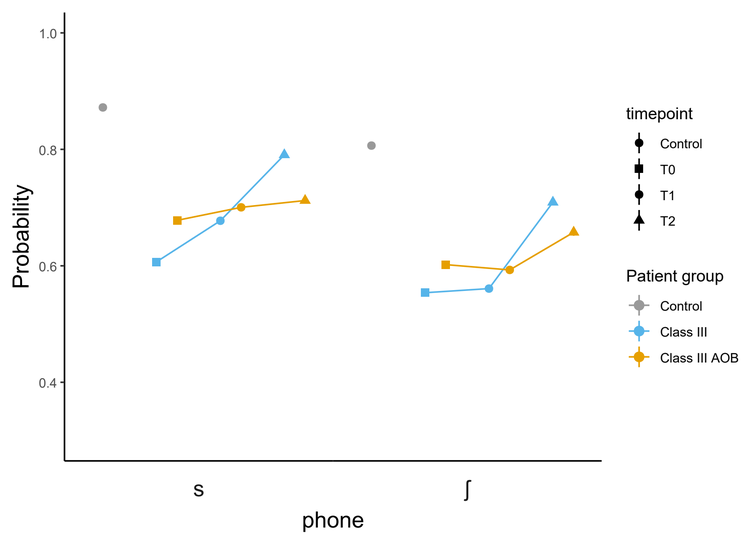


Figure 6: Probability of being rated undistorted according to ordinal regression model. Probability of being undistorted goes up for both patient groups after surgery to a significant degree ($p<0.001$)

Conclusions

- Perceptual and acoustic results indicate speech improvements after orthognathic surgery among Class III patients
  - Changes in acoustics are correlated with changes in perception
- Listeners can perceive subtle acoustic cues in a systematic way (see figure 4)
- Perceptual studies help health-care providers understand how the speech of their patients is evaluated by the outside world

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