Flow measurements in a Scaled-up Vocal Folds/Glottis Model

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Measurements of the flow through a scaled-up model of the human vocal folds are presented. This study is motivated by a need to address unresolved questions regarding the aerodynamics of vocal fold vibration, in particular, the degree to which the flow is quasisteady. The focus of this investigation is on the flow during the opening phase of the glottal cycle, which previous investigations have suggested is not quasisteady..

The model was designed to facilitate spatially and temporally resolved measurements of glottal flow using Digital Particle Image Velocimetry (DPIV), which provides successive snapshots of planar slices of the velocity field. Because DPIV is limited to a 15 Hz sampling rate, the dimensions of the model were chosen to be ten times the dimensions found in an average person's vocal tract, and the model uses water as the working fluid. By making use of dynamic similarity, these two features make the model's flow velocity smaller by a factor of 150 times, and the time scales smaller by a factor of 1500. Dynamic similarity was imposed by matching the Reynold's number and the Strouhal number of glottal flow. The Reynold's number (based on maximum glottal width and maximum jet speed) used is 3000, and the Strouhal number (based on glottis length, maximum jet speed, and opening/closing time) used ranges from 0.005 to 0.1.

Measurements are presented for the flow during the opening phase of the vocal fold vibration cycle, where the vocal fold model walls are moved in a prescribed fashion. Three cases are presented, each representing a different opening time (time for the glottis to open completely). The flow in these cases is compared to the steady-state flow field obtained for different values of glottis open area. The vorticity field is used as the basis for comparison, in order to identify: (1) the location, strength, and convection speed of the starting vortex, (2) the location of the point of separation of glottal flow, (3) the nature of the glottal jet instability, and (4) the energy losses associated with the jet. The implications of these results on (1) the time for the flow to reach a steady state condition, (2) the development of the glottal jet and its relation to the quasisteadiness of glottal flow, (3) the occurrence of the Coanda effect, and (4) the degree to which these factors are affected by the opening time will be addressed.

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