**Fig. S1**. Circular distribution plots for muscle length change relative to hyoid dorsoventral (left) and anteroposterior (right) hyoid movement. Colors on plots indicate different individuals. For each muscle, circles indicate that the hyoid was elevating or moving anteriorly, and triangles indicate the hyoid was depressing or moving posteriorly. The distance from the origin is represented by individual swallows. Each point indicates the vector of length change within a swallow. Values close to 270 for dorsoventral movement and 90 for anteroposterior movement indicate a 1:1 relationship between muscle shortening and hyoid movement. Values close to 90 for dorsoventral movement and 270 for anteroposterior movement indicate a 1:1 relationship between muscle lengthening and hyoid movement.

**Table S1**. Dorsoventral line of action for each muscle relative to the hyoid when the hyoid is at rest and at its estimated maximal elevation during a swallow .

|  | At rest | Elevated |
| --- | --- | --- |
| Geniohyoid | -11.9 | **-17.7** |
| Stylohyoid | 25.34 | **19.03** |
| Thyrohyoid | 3.52 | **-5.15** |
| Omohyoid | 2.78 | **-3.13** |

**Table S2.** Cross correlation and circular distribution statistics by individual (A01- A05) for muscle length changes related to anteroposterior (AP) and dorsoventral (DV) movement of the hyoid during a swallow.

*Cross correlation statistics by individual*

|  | Geniohyoid | | Stylohyoid | | Thyrohyoid | | Omohyoid | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | AP | DV | AP | DV | AP | DV | AP | DV |
| A01 |  |  |  |  | -0.90 | -0.66 | 0.75 | 0.63 |
| A02 | -0.51 | -0.38 | -0.92 | -0.93 |  |  |  |  |
| A04 | -0.74 | -0.86 |  |  |  |  | 0.61 | 0.62 |
| A05 |  |  | -0.79 | -0.78 | -0.48 | -0.49 |  |  |

*Circular distribution statistics by individual – elevation/depression of the hyoid $^{\phi}$*

|  | Geniohyoid | | Stylohyoid | | Thyrohyoid | | Omohyoid | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Elevate Mean, t (p) | Depress Mean, t (p) | Elevate Mean, t (p) | Depress Mean, t (p) | Elevate Mean, t (p) | Depress Mean, t (p) | Elevate Mean, t (p) | Depress Mean, t (p) |
| A01 |  |  |  |  | 98.7, 10.3 (<0.01) | -84.5, 6.9 (<0.01) | 88.3, 13.4 (<0.01) | -91.9, 5.9 (<0.01) |
| A02 | 91.4, 15.4 (<0.01) | -59.9, 1.2 (<0.01) | 92.1, 17.7 (<0.01) | -87.5, 4.9 (<0.01) |  |  |  |  |
| A04 | 93.6, 5.2 (<0.01) | -92.5, 1.62 (<0.01) |  |  |  |  | 87.9, 11.4 (<0.01) | -90.5, 5.8 (<0.01) |
| A05 |  |  | 92.4, 14.3 (<0.01) | -87.2, 10.1 (<0.01) | 95.8, 7.5 (<0.01) | -84.1, 14.8 (<0.01) |  |  |

*Circular distribution statistics by individual – Anterior/posterior hyoid movement $^{\phi}$*

|  | Geniohyoid | Stylohyoid | Thyrohyoid | Omohyoid |
| --- | --- | --- | --- | --- |

| | Anterior Mean, t (p) | Posterior Mean, t (p) | Anterior Mean, t (p) | Posterior Mean, t (p) | Anterior Mean, t (p) | Posterior Mean, t (p) | Anterior Mean, t (p) | Posterior Mean, t (p) |
|---|---|---|---|---|---|---|---|---|
| A01 | | | | | 94.9, 11.7 (<0.01) | -83.4, 5.8 (<0.01) | 88.4, 12.2 (<0.01) | -91.9, 4.7 (<0.01) |
| A02 | 93.1, 14.4 (<0.01) | -67.4, 3.6 (<0.01) | 94.4, 15.3 (<0.01) | -87.1, 6.8 (<0.01) | | | | |
| A04 | 95.7, 4.5 (<0.01) | -95.1, 2.4 (<0.01) | | | | | 87.2, 11.6 (<0.01) | -90.9, 6.3 (<0.01) |
| A05 | | | 98.3, (15.0 (<0.01) | -78.6, 7.1 (<0.01) | 90.6, 9.9 (<0.01) | -71.4, 6.9 (<0.01) | | |

*φ* For circular distribution statistics, values close to 90 indicate a 1:1 relationship between hyoid movement and changes in intermarker distance. For circular distribution statistics in elevation/depression, positive values indicate instances when as the hyoid is elevated, the muscle is shortening; negative values indicate instances when as the hyoid is depressed, the muscle is also lengthening. For circular distribution statistics in anterior/posterior hyoid movement positive values indicate instances when as the hyoid is moved anteriorly, the muscle is shortening; negative values indicate instances when as the hyoid is moved posteriorly, the muscle is also lengthening T = t statistic, p = p value.
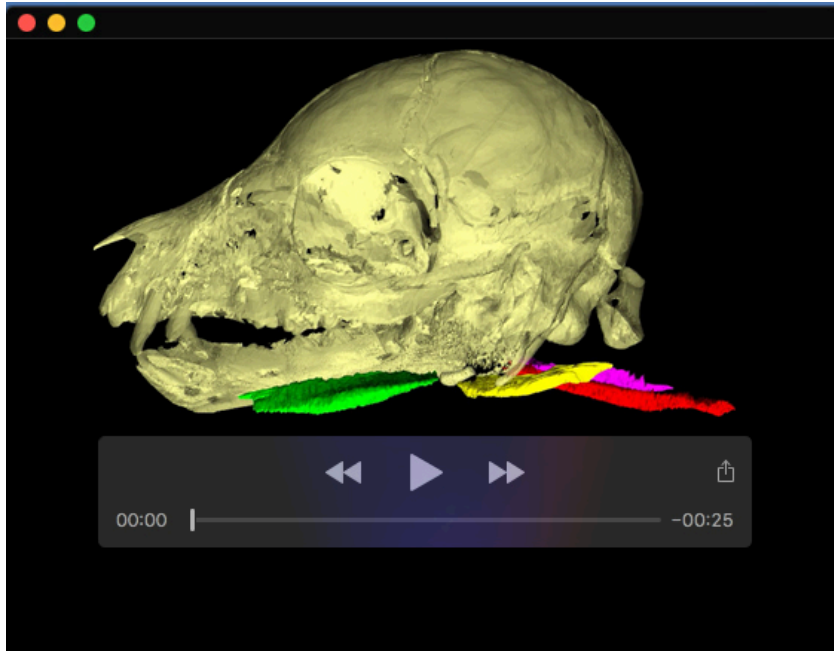
**Movie 1.** Animation of changes in the orientation of genioglossus (green), styloglossus (yellow), thyrohyoid (pink) and omohyoid (red) from at rest through maximal hyoid elevation during a swallow.