MotorcYcle and MOtorcyclist SAfety (MYMOSA) meeting

Finite Element neck model

TNO
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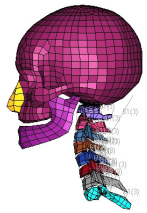
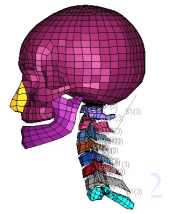
WP4 – Biomechanics

February 4th, 2010



Structure

- Objective
- Introduction
- Approach/Results
- Secondments
- Conclusion



Objective

- FE[1] human neck model for LS-DYNA analysis
  - 3D FE neck muscle model
  - Translation of existing MB[2] facet neck model to LS-DYNA
  - Coupling of FE neck muscle model and FE neck model
    - Highly dynamic test validation

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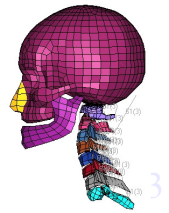
1 Finite Element

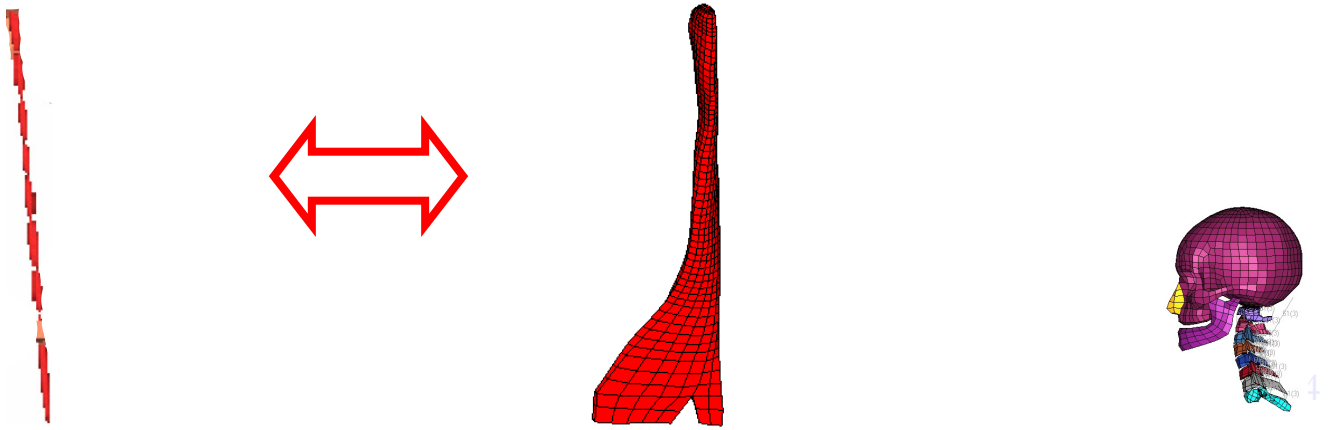
2 Multibody



Introduction

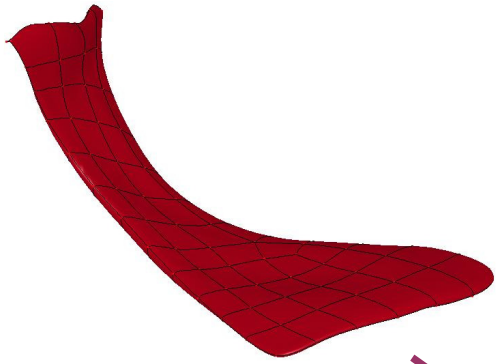
- 3D muscle model vs. line element muscle model
  - Accurate geometry and attachment points/areas
  - Contact (important – muscles stiffen each other)
  - Correct fiber direction
  - Tissue inertia

→ Realistic behavior, information about neck injuries

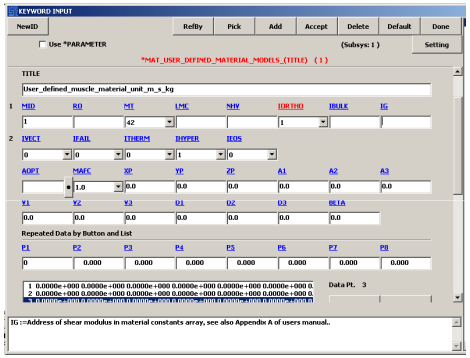


Approach

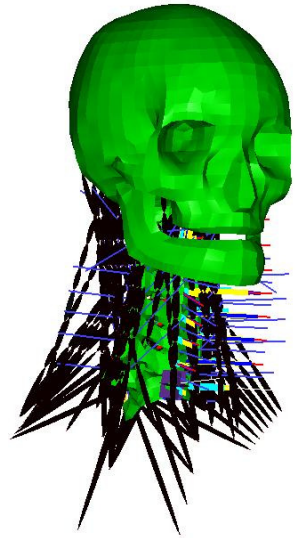
CAD muscle model



Luis' user defined muscle material



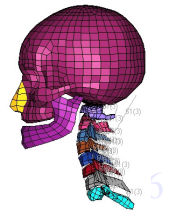
MB neck model



LS-DYNA neck model

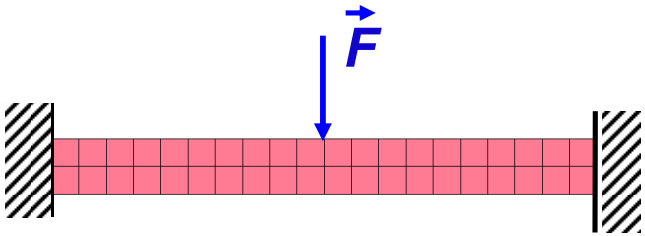
Approach

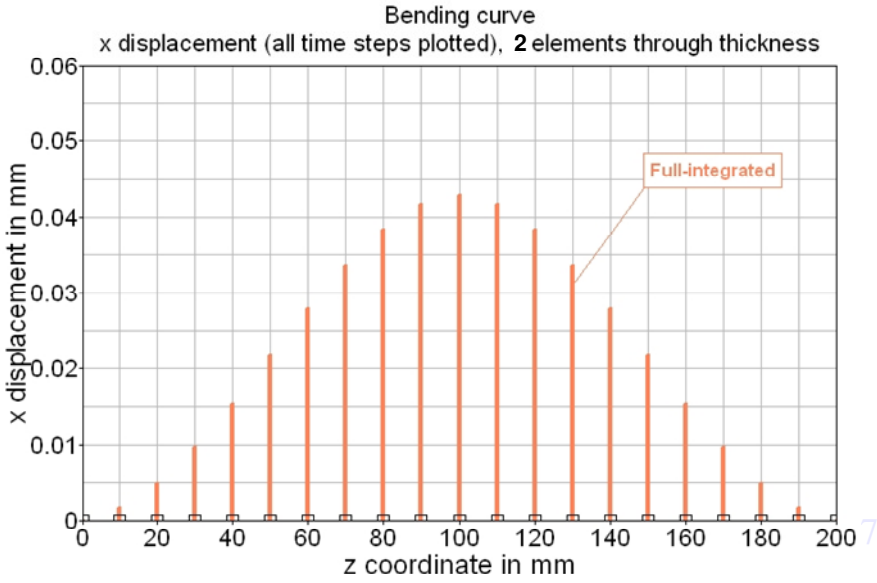
- 3D FE neck muscle model
  - Mesh attributes (size – element number, element type, hourglass control card settings etc.)
  - Simplified geometry
  - Mesh
  - Fiber direction
  - User defined material card



Approach/Results

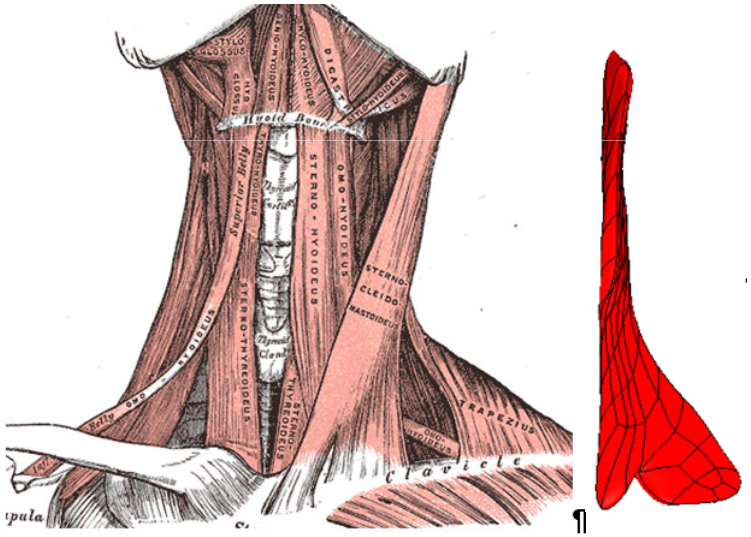
- 3D FE neck muscle model: mesh attributes
  - Small test models
  - 3 elements through thickness (realistic behavior)
  - Element size: ca. 1 mm minimum; average 3 to 6 mm
  - Under-integrated elements with hourglass control
  - Hexa and wedge elements



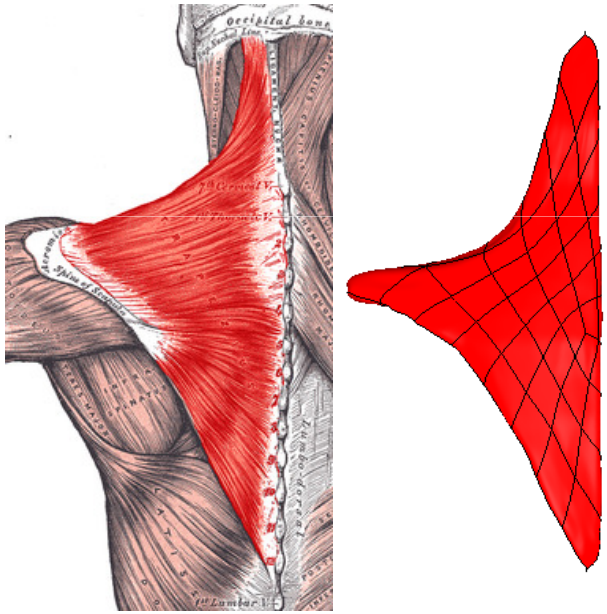


Approach/Results

- 3D FE neck muscle model: geometry
  - Left Sternocleidomastoideus, left Trapezius



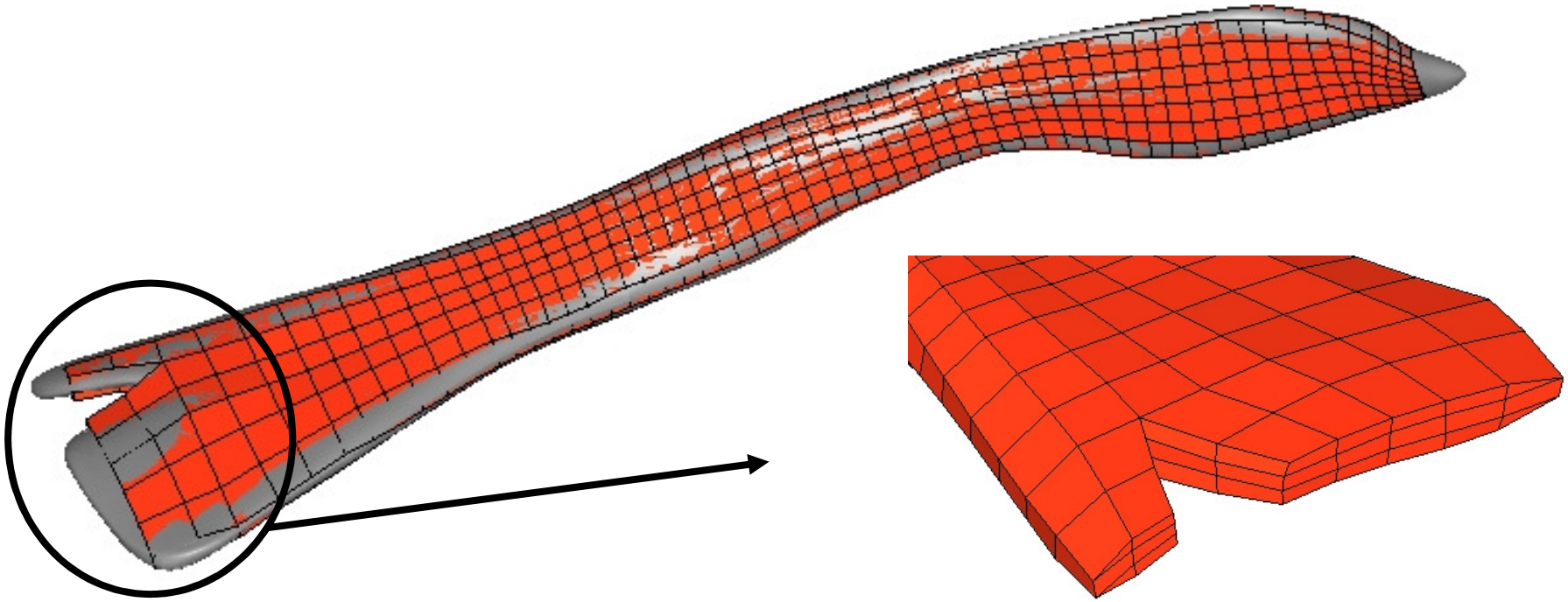
Muscles of the neck, anterior view



Muscles connecting the upper extremity to the vertebral column

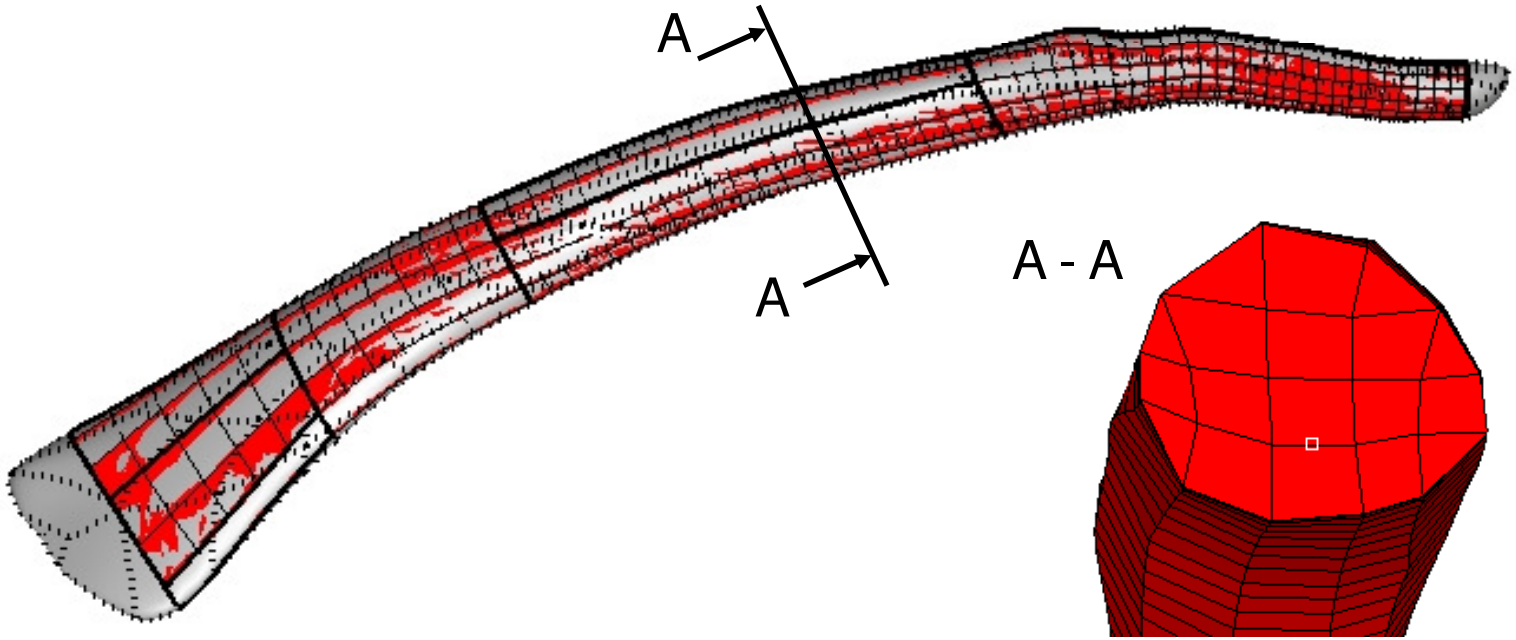
Approach/Results

- 3D FE neck muscle model: mesh
  - Left Sternocleidomastoideus
    - 3 elements through thickness; ca. 1200 elements; minimum edge length ca. 1,1 mm



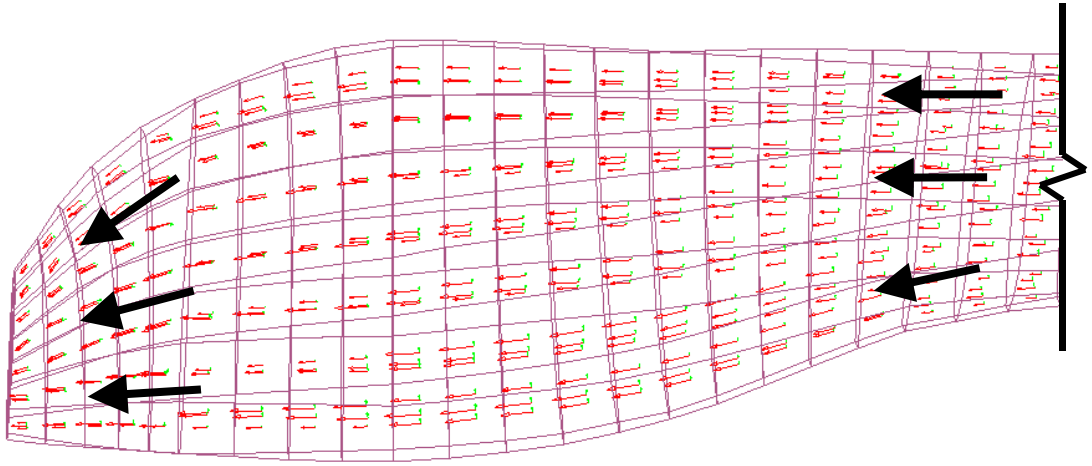
Approach/Results

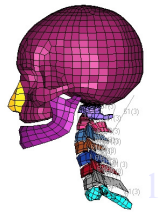
- 3D FE neck muscle model: mesh
  - Left Levator scapulae
    - 4 elements through thickness; ca. 1100 elements; minimum edge length ca. 0,9 mm



Approach/Results

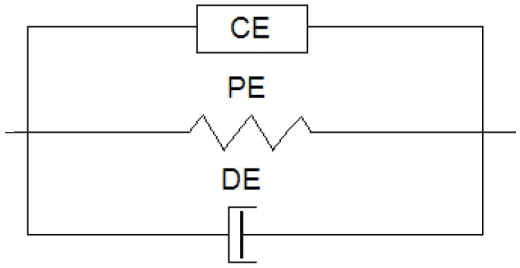
- 3D FE neck muscle model: fiber direction
  - For almost all neck muscles the angle between fiber direction and the line of action (pennation angle) is very small (negligible)
  - Vectors define the fiber direction for every element



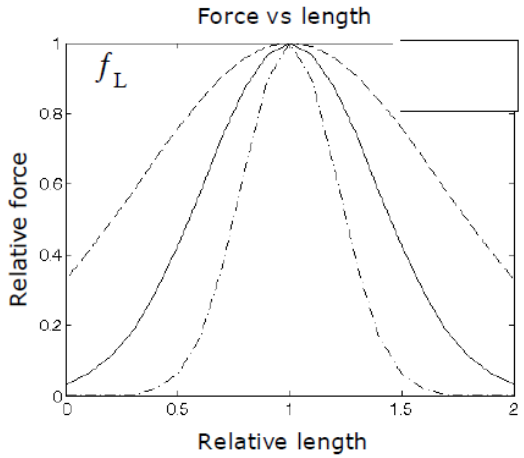


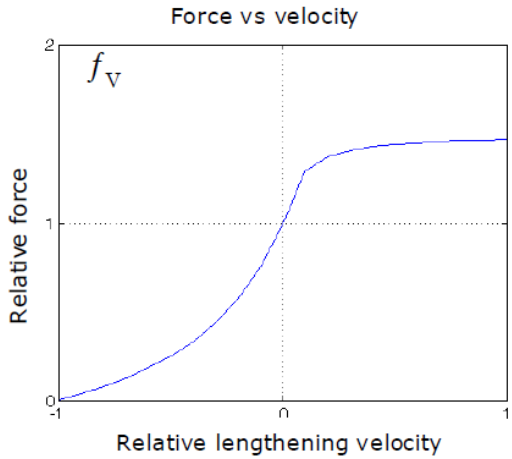
Approach/Results

- 3D FE neck muscle model: muscle material
  - Luis' user defined material card for LS-DYNA
    - Programmed by Early Stage Researcher (ESR) L. G. Matos in Fortran
    - Based on Hill-type model
    - Continuum models



Hill-type element



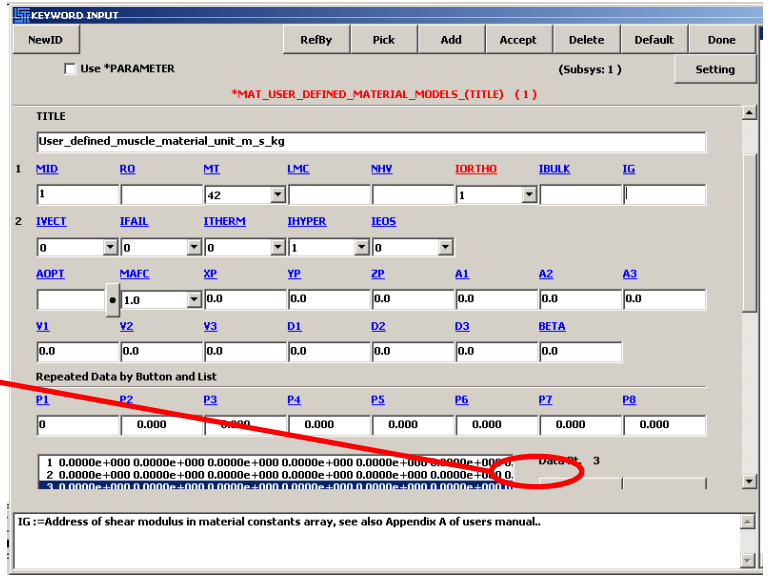


Hill-type model: Relative muscle force

Approach/Results

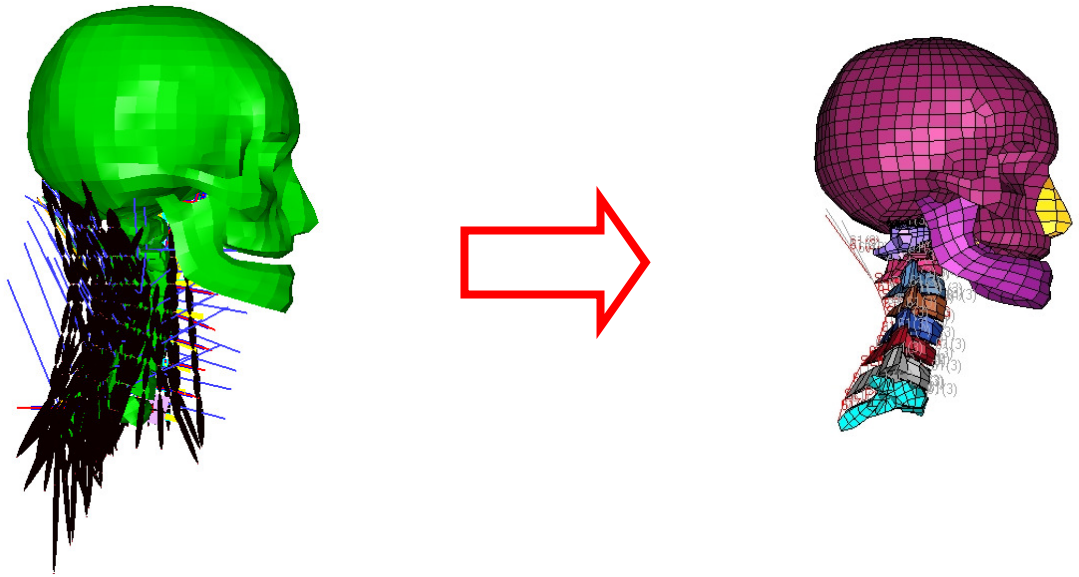
- 3D FE neck muscle model: muscle material
  - Luis' user defined material card for LS-DYNA
    - Muscle parameter input in the material card (based on existing MB neck model and other studies)

Muscle activation state (between 0 and 1)



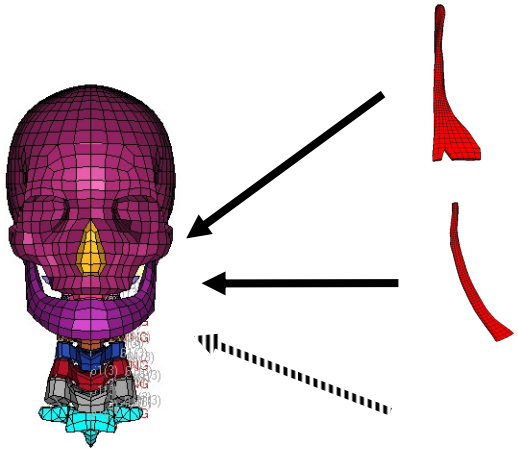
Approach/(Results)

- Translation of MB neck model to LS-DYNA
  - Elements translated: rigid bones
  - Joints and ligaments connect the rigid bones (have to be done)



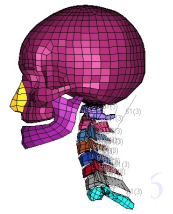
Approach

- Coupling of muscle and neck model
  - Muscle positioning (muscle scaling):
    - Anatomical books
    - Geometry data from the insertion and origin points of the neck muscles
  - Connection of the muscles with neck (tendons between or direct connection)



Secondments

- Completed
  - Altair: Antony, France, November 2009
    - Contact person: Franck Njilie
    - Duration: 3 weeks
    - Introduction course in HyperMesh, assistance in solid meshing and other issues
- Hoping
  - Secondment for FE neck model validation/comparison



Conclusion

- 3D FE neck muscle model
  - Exact geometry, fiber direction, contact
  - User defined muscle material based on Hill type model
- FE neck model
  - Rigid bones connected with joints and ligaments
  - Implement 3D FE neck muscle model

→ **Realistic behavior, information about neck injuries**

- Secondments
  - Completed: Altair
  - Hoping: Secondment for FE neck model validation/comparison