USE OF FINITE ELEMENT ANALYSIS MODELING TO ASSESS TISSUE STRAINS ASSOCIATED WITH TWO DIFFERENT NASOGASTRIC TUBE SECUREMENT DEVICES

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Background

Medical device–related pressure injuries are recognized as a significant clinical problem and have been described by Pitman and Gillespie in 2020.[1] Nasogastric (NG) tube usage can lead to significant pressure injury. Some NG tube securement (NGTS) devices on the market are bulky and composed of hard plastic components. Recently, a new device without hard components believed to reduce the risk of pressure injury became available. The current study assessed the differences in strain profiles for two NGTS devices using a finite element analysis (FEA) to measure strain and deformation occurring at the NG tube - tissue interface.

Purpose

To more fully understand how the use of NGTS devices may cause stresses to the nares of the nose.

Methods

An in silico face model was created from an anonymized male human head CT scan. The model was imported into Abaqus. Two different NGTS with hard components,* or without hard components,† were modeled and run in Abaqus/Explicit as a dynamic simulation whereby the NG tube was inserted in the left nostril and then the securement devices were applied to the nose. To simulate patient movement, a 4lb force was applied to the distal end of the tube. FEA models of the devices were based on device mechanical test data as well as clinically relevant placements and wear of the devices. Peak strain values were determined by modeling of different scenarios whereby the tubing was either stationary or moved during normal wear.

Results

The FEA modeling showed that the maximum principal strain associated with the use of the NGTS device without hard components was between 52 – 79% depending on whether there was no load applied to the tube or the tube was being pulled forward. The maximum principal strain associated with the NGTS device with hard components was between 404 and 434% depending on whether there was no load applied to the tube or the tube was being pulled to the left. The tissue strain energy (TSE) density that measures the strain over the area under the NGTS devices also differed between the 2 devices. For the NGTS device without hard components, the TSE ranged between 133.8 and 143.3 mJ, whereas for the NGTS device with hard components the TSE ranged between 311.1 and 311.6 mJ.

Results Cont'd

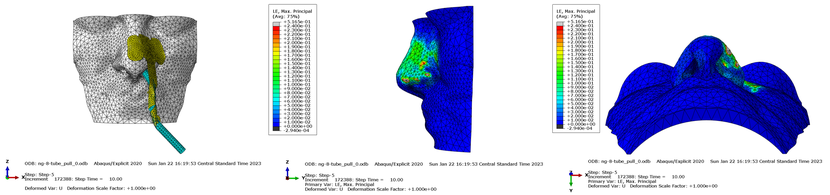

Figure 1. FEA model for the NGTS device without hard components with no load applied. Left picture shows the positioning of the NGTS device and tube and the middle and right picture shows the maximum principal strain imparted to the tissues. The max strain is 52% and is represented by the darker red areas.

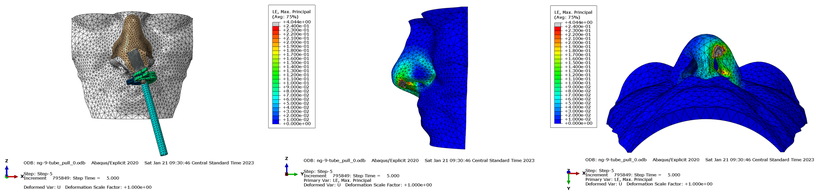

Figure 2. FEA model for the NGTS device with hard components with no load applied. Left picture shows the positioning of the NGTS device and tube and the middle and right picture shows the maximum principal strain imparted to the tissues. The max strain is 404% and is represented by the darker red areas. Note the increased area of the nares with higher strain values represented by the red and green colors versus Fig 1.

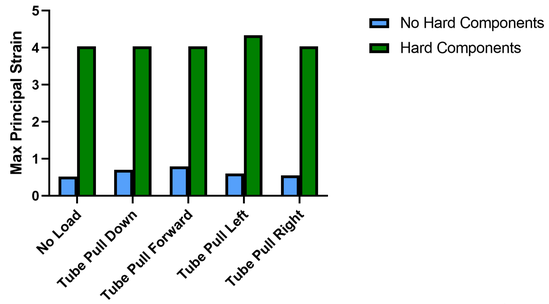

Figure 3. Maximum principal strain values for the NGTS devices with (green bars) or without (blue bars) hard components. The conditions modeled were the tube hanging from the nose with no load or with the tube being tugged in various directions with 4lb of force.

Results Cont'd

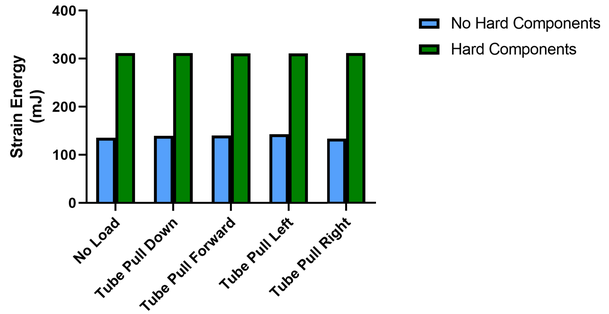

Figure 4. Strain energy density values for the NGTS devices with (green bars) or without (blue bars) hard components. The conditions modeled were the tube hanging from the nose with no load or with the tube being tugged in various directions with 4lb of force.

Conclusions

FEA model results shown in all figures visually demonstrate that the maximum principal strain values are a minimum of 5 fold less when the NGTS device without hard components is used.

Results also show that the strain energy density is over 2 fold less when the NGTS device without hard components is used.

Clinically, high strains could be more damaging to skin, especially friable skin or in the delicate skin of the nares.

This new NGTS device without hard components modeled herein may provide clinicians an option for NG tube securement that is less damaging.

References

1. Pitman J, Gillespie C. Medical device-related pressure injuries. Crit Care Nurs Clin North Am. 2020;32(4);533-542.

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*Hollister Feeding Tube Attachment Device (Hollister Incorporated, Libertyville, Illinois), †3M™ Nasogastric Securement Device (3M, St. Paul, MN)

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