COMPARING THE STIFFNESS OF THE SKIN TO THAT OF COMMONLY USED SKIN-CONTACTING MEDICAL DEVICES IN CONTEXT OF MDRPU

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Introduction

Medical device-related pressure ulcers (MDRPUs) are relatively common and account for a large and growing proportion of hospital-acquired pressure ulcers. Devices associated with MDRPUs are often used to perform essential, life-saving functions. They include continuous positive airway pressure masks, endotracheal tubes, nasogastric tubes (NT) and tube holders (THs), to mention a few. During the coronavirus pandemic, many forms of skin damage resulted from the prolonged use of respiration equipment [1].

Alleviation of the sustained mechanical loads in the skin at the skin-device contact sites is a key performance aspect in the prevention of MDRPUs. In particular, the risk of developing MDRPUs can be reduced by calculating the extents of matching between the material stiffness (i.e., the elastic modulus) of the skin-contacting materials in the given medical device and the stiffness of the native skin, which is a predictor of the skin and soft tissue stress concentrations that develop at and near the device interfaces [2]. The poorer the stiffness matching (i.e., the device stiffness over the skin stiffness ratio being farther than unity), the more intensified tissue stress concentrations are to be expected.

Methods

Using an integrated experimental-computational approach, we compared the biomechanical performance of commonly used skin-contacting medical devices and materials for pressure ulcer prevention with the corresponding properties of native skin [2].

We specifically measured the compressive stiffness properties of NTs and THs that are contacting the skin using a modified ASTM D3574-11 test standard. These empirical measurements were then compared to corresponding finite element simulations of the experiments to determine the mechanical properties via a 'reverse engineering' approach, in order to extract the elastic moduli of the skin-contacting material components per each tested medical device.

Results

The stiffness of hydrogel-based and foam-based dressing materials is within the 30-100 kPa range, which falls within the range of stiffnesses of adult skin, so in terms of modulus matching, there is a good fit [2][3][4]. In contrast, tubing devices demonstrated stiffness within the 30-400 MPa range, which is distant by two to three orders of magnitude from the stiffness of skin, i.e., all the tested tubes had poor modulus matching (Figure 1).

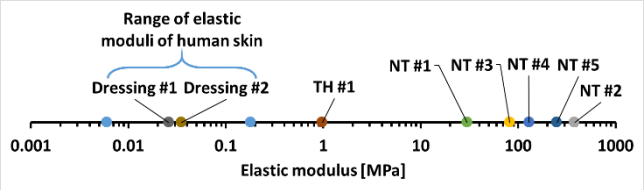

Figure 1: Mapping of the stiffness properties of prophylactic dressings and skin-contacting materials in medical devices with respect to the stiffness of an adult skin (NT – nasogastric tube; TH – tube holder).

Discussion

We report here a practical approach and metrics for quantitative evaluations and rating of materials for pressure ulcer prevention or for assessing the biomechanical risk involved in selection of certain skin-contacting materials for inclusion in the design of skin-interfacing medical devices, in the context of MDRPUs.

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