ESTIMATING NASAL TIP SUPPORT USING COMPUTER-AIDED DESIGN AND 3D-PRINTED MODELS

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Abstract

Objective: Palpation of the nasal tip is essential during the pre-operative rhinoplasty exam, however there are no studies comparing surgeons’ qualitative assessments of tip support with actual mechanical behavior. In this study, five silicone nasal models of varying stiffness (e.g., Young’s modulus) were constructed. Rhinoplasty surgeons evaluated tip support for each model and the results were compared with the actual mechanical behavior to identify the threshold stiffness for adequate and ideal tip support.

Methods: A digital nasal model was created using CT scans and CAD/CAM software. Facial skeletons were 3D-printed in ABS plastic and the cartilage and skin components were cast in silicone of varying stiffness (0.042-0.302 MPa). Thirty rhinoplasty surgeons evaluated the tip support for each model, and then selected the model that satisfied their minimum requirement for adequate and ideal tip support. Logistic regression was used to estimate the threshold for both adequate and ideal tip support.

Results: Of thirty respondents, four surgeons had practiced for 1-5 years; nine, 6-15 years; seven, 16-25 years; and ten, 26+ years. Logistic regression found the minimum threshold for Young’s modulus for adequate and ideal tip support to be 0.096 MPa and 0.154 MPa, respectively.

Conclusion: This novel study attempts to correlate nasal tip support with actual mechanical behavior. 3D printing was used to create nasal simulators that allows for changing overall mechanical behavior while preserving intrinsic form factor. This allows analysis of mechanical response independent of object shape. This information will be increasingly important as sophisticated modeling techniques continue to enhance surgical planning.

Introduction

Nasal tip support structures include the fibrous connection between the upper and lower lateral cartilages, fibromucosal and sebaceous cartilage connection between the lateral crus and the pyriform aperture, loose connective tissue between the paired domes of the lower lateral cartilages, and the attachment of the medial crural footplates with the caudal septum1,10. These structures are normally subjectively examined through palpation of the nasal tip during the pre-operative exam. This is the surgeon’s primary way of assessing a patient’s tip support; however, there are no studies comparing surgeons’ qualitative assessments of tip support with actual mechanical behavior.

Objective: In this study, five silicone nasal models of varying stiffness (e.g., Young’s modulus) were constructed. Rhinoplasty surgeons were asked to evaluate the tip support for each model and their analysis was compared with the actual mechanical behavior to identify the threshold stiffness for absolute minimum and ideal tip support.

Methods and Materials

Using a high-resolution computer tomographic (CT) scan of single patient as a template, a digital nasal model was created using CT scans and CAD/CAM software. A digital nasal model was created from individual CT scan in 3DSlicer. Using a high-resolution computer tomographic (CT) scan of single patient as a template, a digital nasal model was created using CT scans and CAD/CAM software.

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The demographic of the surgeons surveyed are shown in Table 2. The responses of the thirty surgeons are displayed in Figure 6.

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Discussion

No studies exist comparing surgeons’ qualitative assessments of tip support with actual mechanical behavior. Mechanical analysis on excised nasal cartilage samples has shown an elastic modulus of ~2 MPa for the lower lateral cartilages, and ~5 MPa for the septal cartilage.

Our model calculates a global elastic modulus for the skin, soft-tissue, and cartilaginous structures as one homogenous unit. A more complex model reflecting the heterogeneous anatomical structure of the nose is needed to provide more accurate values for the absolute minimum and the ideal elastic modulus for the various nasal tip structures.

Conclusions

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