Abstract

With our team’s previous development of a custom middle ear prosthesis, a prosthesis can be sized to the middle ear anatomy of a patient for ossiculoplasty. Proper sizing of our device requires knowledge of a patient’s ossicular morphology. Although clinical CT imaging resolution has advanced, the resolution is not sufficient for the precise measurement of the ossicular chain. We believe there may be anatomical correlations between temporal bone anatomy and the geometric morphology of the ossicular chain which would provide further insight for accurate preoperative prosthetic sizing. The literature was reviewed to define major landmarks identifiable on CT imaging. These landmarks were then identified and assigned to those whose position may be identified with limited variability between subjects. 5 cadaveric temporal bones were isolated, and both clinical high-resolution spiral CT and micro-CT scans were taken. Measurements were made between all landmarks using the spiral CT, leading to over 155 total measurements per bone. These measurements were then compared to the ossicular chain anatomy of each temporal bone as measured by micro-CT. Statistical analysis was then performed to observe any correlation between these measurements. This study has provided preliminary evidence of the predictive quality of temporal bone anatomy in reference to ossicular chain anatomy.

Introduction

Ossiculoplasty is a technically demanding procedure involving the repair of a disrupted ossicular chain. In cases with damage isolated to the incus and a preserved stapes superstructure, a partial ossicular reconstruction prosthesis (PORP) is commonly utilized for repair. Prosthesis sizing dependent on the judgement of the surgical team at the time of the procedure. Improper determination of PORP length can lead to poor surgical outcomes1,2. Our team has developed a novel incus prosthesis which recreates the normal anatomy of ossicular chain with hopes of reproducing sound conduction better than conventional prostheses. We would like to assess if the morphology of the incus correlates with temporal bone anatomy as measured on HRCT, providing an opportunity to predict the incus’s anatomy through indirect measurements.

Methods and Materials

- 5 left cadaveric temporal bones were isolated and scanned with microCT and HRCT
- MicroCT at 25 micron resolution and HRCT at 670 micron
- 3D reconstruction of the ossicular chain created from microCT scans. Anatomical measurements were taken from these reconstructions (Figure 1)
- HRCT scans were used to mark 18 critical landmarks and take 2 measurements from each bone (Table 1). The distance between each landmark was calculated, providing 155 total measurements.
- The linear correlation between each landmark measurement and each morphological length of the incus was calculated. Coefficient of determination (R2) was determined for each value.
- R2 were analyzed to find most correlated measurements and compare landmark measurements correlating to multiple incus morphologies.

Results

The R2 between incus morphology and temporal bone measurements was found, and for this study we limited our search to those greater than or equal to 0.9. These values can be found in Table 2. Articular surface height provided 12 R2 values greater than 0.80, 7 of which were greater than 0.90. Short process length provided 17 R2 values greater than 0.80, 6 of which were greater than 0.90. Long process length provided 30 R2 values greater than 0.80, 9 of which were greater than 0.90. Lenticular process length provided 6 R2 values greater than 0.80, 3 of which were greater than 0.90. Functional length provided 20 R2 values greater than 0.80, 4 of which were greater than 0.90. Lenticular process angle provided 20 R2 values greater than 0.80, 5 of which were greater than 0.90.

Of the 34 R2 greater than 0.80, 6 measurements were highly correlated to more than one anatomical length of the incus (Table 3). The remaining 149 measurements taken from temporal bones did not correlate with multiple aspects of the incus. 5 out of these 6 measurements were highly correlated to 2 measurements of the incus. The measurement from the common crus to the posterior semicircular canal was highly correlated with three incus measurements.

Conclusions

Our team has developed a custom middle ear prosthesis requiring preoperative knowledge of incus morphology for proper implementation. Indirect measurement of the incus through use of landmarks in the temporal bone may provide an alternative solution to measuring incus morphology; however, more data is needed to clarify this possibility.

Table 1: Landmark and Measurements Captured from Temporal Bone. 18 discrete and readily identifiable landmarks located in each temporal bone. In addition to these 18 landmarks, two measurements were made from the ossicular chain base of the cochlea were found, one from the round window to the opposing end of the cochlea base and the other length perpendicular to the prior measurement.

Table 2: Comparison of Measurements Correlating with Multiple Incus Measurements. Multiple measurements found between landmarks of the temporal bone had a coefficient of determination (R2) greater than 0.9 in a linear correlation with incus measurements. Those which had a R2 greater than 0.9 for multiple incus measurements are listed below. The first two columns list the landmarks, which measurements were taken between. An x indicates which incus measurements the landmark measurement had an R2 greater than 0.9.