Variations in the morphology of the human mandible in the Indian population

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Summary

Variations in mandible morphology for the Indian population have hardly been investigated. In this study, a statistical shape model (SSM) of the human mandible was developed using principal component analysis (PCA) on a dataset of fifteen mandibles from India. Ten principal components (PC) sufficed to describe the 95% variation present in the training dataset.

Introduction

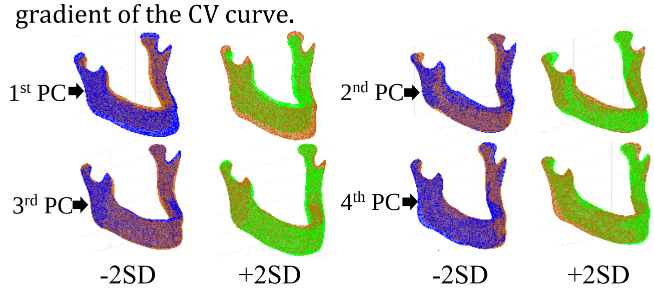
Studies on shape and size variations in the mandible are necessary to understand its morphological variation in the Indian population. Such an understanding would also be useful in conceptualizing India-specific mandibular implants [1]. The present study aims to develop an SSM of healthy mandibles to understand the morphological variability in the Indian population. Due to the availability of a limited number of mandibles, this research aims to provide preliminary results on statistical shape modeling of mandibles.

Methods

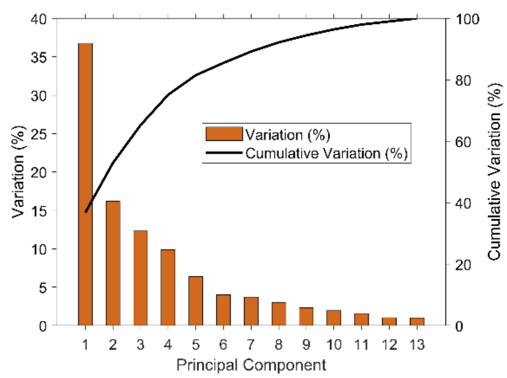
Fifteen computed tomography (CT) scans of adult skulls were collected from AIIMS Delhi. 3D mandible models were reconstructed from CT scans with Mimics, and post-processing was performed using Hypermesh software. The correspondence between all the shapes in the dataset was obtained by implementing the mesh morphing technique using the Radial Basis Function method in MATLAB [2]. In this approach, the mesh of a reference mandible (standard mesh) was adapted to all the other mandible geometries (target meshes) by choosing specific control points over the standard and target meshes. Then, the morphed mesh nodes were perpendicularly projected to the closest triangle of the target mesh, and a smoothing algorithm was applied to improve the shape reproduction of target geometries. These steps were repeated iteratively until the maximum deviations between the morphed mesh and the target geometry were below 2.5 mm. The morphed meshes were imported into ScalismoLab software to build the SSM [3]. As a first step in SSM, the rigid alignment was performed by taking one mandible as a reference, and the remaining mandibles were rigidly aligned to the reference by selecting a set of landmark points. PCA was performed to compute the Discrete Low-Rank Gaussian Process. The Statistical Mesh Model was built using the Statistical Mesh Model function in Scalismolab.

Results and Discussion

The first four PCs from the average shape along -2 standard deviations (SD) and +2 SDs are shown in (Figure 1a). These PCs describe the main shape variations with reference to the average shape. The percentage geometric variation and cumulative variance (CV) captured by the PCs are displayed in (Figure 1b). 95% of the variation was captured in the first 10 PCs. The first four significant PCs captured 75.2% of the variation present in the training set. Subsequent PCs were not considered important due to the slight change in the gradient of the CV curve.



a



b

Figure 1: (a) -2SD (blue) and +2SD (green) of first 4 PCs superimposed on the mean mandible (brown); (b) Geometric variation and CVs captured by the PCs

Conclusions

The present study employed PCA-based SSM to characterize morphological variations across mandibles. 10 PCs covered 90% of the variability identified in the training database. The modeling techniques may be useful in the diagnosis and treatment of TMJ disorders, implant design, and pre-operative planning for reconstruction and implantation.

References

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