Supporting Information

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SI Text

SI Results. Here a number of additional simulation results are provided with variations in loadings, support constraints, placement of cavities, and loading factors using the multiresolution topological optimization (1). Eight different cases are simulated for the two-dimensional topological optimization example to determine how the individual loads, load combinations, compliance combinations (2) and cavities inside the domain affect the optimized topology.

Case a. Only the external load F1 is applied and no sinus cavities embedded.

Case b. Same loading as Case *a* with sinus cavities embedded.

Case c. Only the masticatory load F2 is applied and no sinus cavities embedded.

Case d. Same loading Case *c* with sinus cavities embedded.

Case e. Both load F1 and F2 are applied and no sinus cavities embedded.

Case f. Same loading Case *e* with sinus cavities embedded.

Case g. Used the weighted method (2) with multiple loads as a compliance combination and no sinus cavities embedded.

Case h. Same as Case *g* with sinus cavity embedded.

For this problem, the nasal cavity is formed automatically in the topological optimization process, as a result no nasal cavity is preimposed in the simulation. The optimized topologies from all the 8 cases are illustrated in Fig. S1.

It is important to note that we are using linear elastic finite element analysis. For the three-dimensional example, additional simulations are performed by changing the relative ratio of the upper applied load F1 (See Fig. 5*A* in the main paper) and the masticatory force F2. Keeping the volume fraction at 17.5%, we vary the load ratio F1/F2 from 1.0 to 3.0. The isosurfaces of the density distribution depicting the optimized topology is shown in Fig. S2 *A* and *B*. Another simulation with load ratio $F1/F2 = 3.0$ but without the nasal cavity is presented in Fig. S2*C*. These results provide a better knowledge to tailor patient-specific and location-specific (including prosthetics) optimized solution.

1. Nguyen TH, Paulino GH, Song J, Le CH (2010) A computational paradigm for multiresolution topological optimization (MTOP). *Struct Multidiscip O* 41:525–539.
2. Sigmund O (2000) Topology optimization: A tool for the tailoring of structures and materials. *Philos T Roy Soc A* 358:211–288.

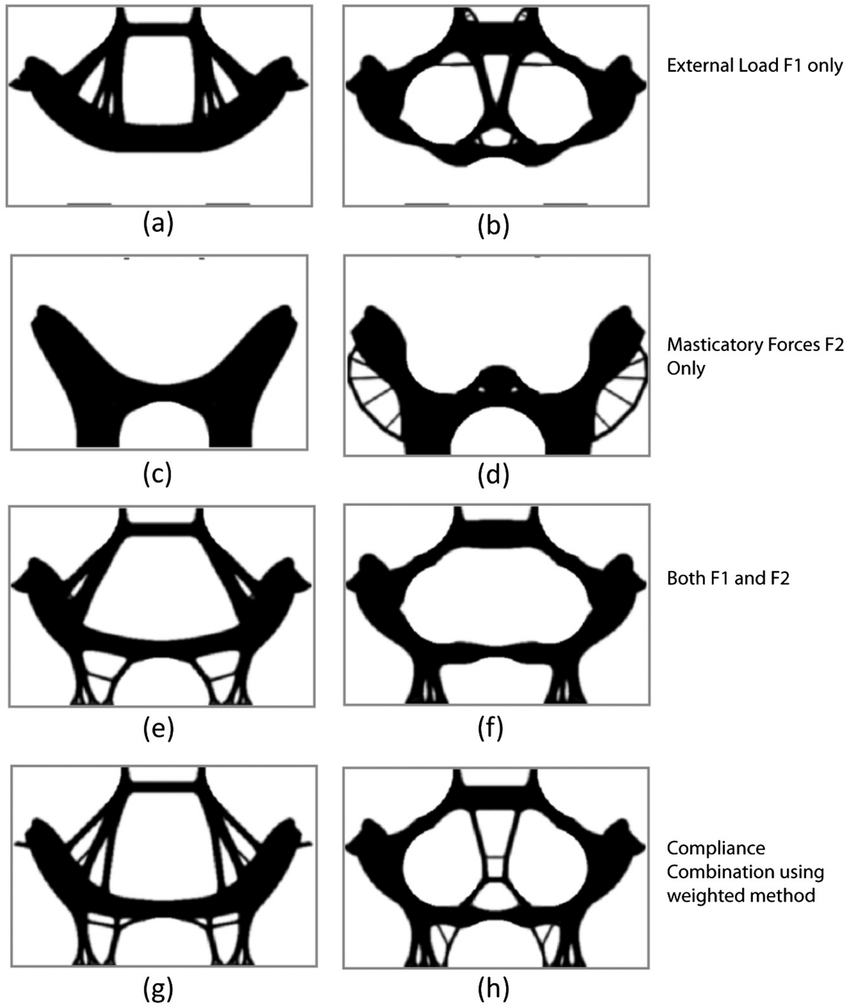


Fig. S1. Optimized solution for two-dimensional topological optimization problem for 8 different cases (*A*)–(*H*).

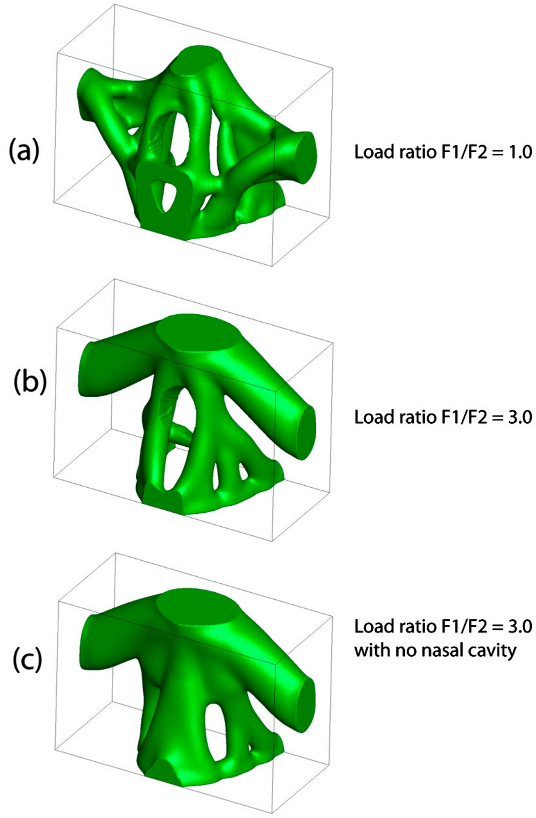
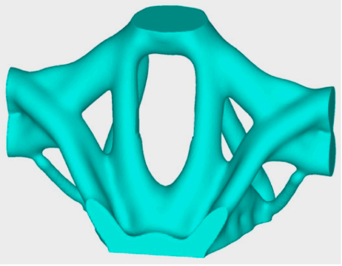


Fig. S2. Optimized solution for different cases with different value of load ratio F1/F2. (*A*) Topology when F1/F2 = 1.0, (*B*) topology when F1/F2 = 3.0, and (*C*) topology when F1/F2 = 3.0 with no nasal cavity.



Movie S1. An animation showing the evolution of the optimized topology during the numerical simulation is shown.
Movie S1 (MOV)

Movie S2. A movie depicts an artist's rendition of the overall design process starting from design domain selection, topological optimization, and insertion of the replacement bone into the region of the defect of the patient.
Movie S2 (MOV)