Teaching tool for advanced visualization of temporal bone structures by fusion of μCT and CT scan images

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Main goal

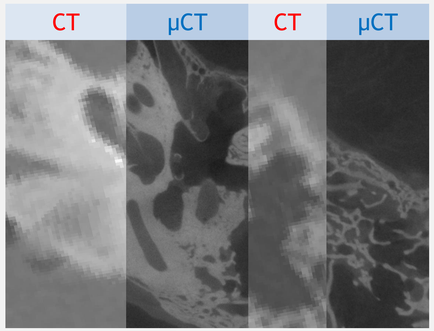
Improve the understanding of human temporal bone computed tomography (CT) scans based on semi-automatically segmented microcomputed tomography (µCT).

Introduction

The three-dimensional ear anatomy is complex and challenging to interpret in CT scans because small structures are partially visible. Histological slices provide complementary high-resolution information, but may lead to geometrical distortions of the anatomy during preparation. Conversely, µCT preserves the shape.

3D images acquisition and segmentation

- Five freshly cadaveric pairs of temporal bones
- Acquisition of CT (General Electric; Light Speed VTC 64)) and a µCT (General Electric; eXplore speCZT) images
- Seed-based segmentation of every **reliable anatomical structures** on CT or µCT



Rigid registration of µCT and CT

- First, rough point-based registration using anatomical landmarks[1]
- Second, automatic rigid registration using a block matching framework[2]

References

[1] Umeyama, S.: Least-squares estimation of transformation parameters between two point patterns. IEEE Trans. Pattern Anal. Mach. Intell. 13, 376-380 (1991).

[2] Ourselin, S., Roche, A., Prima, S., Ayache, N.: Block Matching: A General Framework to Improve Robustness of Rigid Registration of Medical Images. Med. Image Comput. Comput. Interv. 557-566 (2000).

Reliable anatomical structures

CT µCT	➢ cortical and trabecular layers of the entire temporal bone
CT µCT	➢ vestibular labyrinth with the scalae tympani and vestibuli
µCT	➢ ossicles and their ligaments
CT µCT	➢ tympanic membrane
µCT	➢ middle ear muscles and tendons
CT	➢ internal carotid artery and the sigmoide sinus
CT µCT	➢ different branches of the vestibular nerve
CT µCT	➢ facial nerve and the chorda tympani

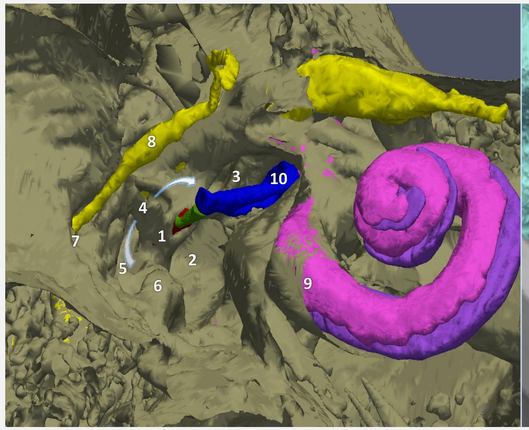
Results

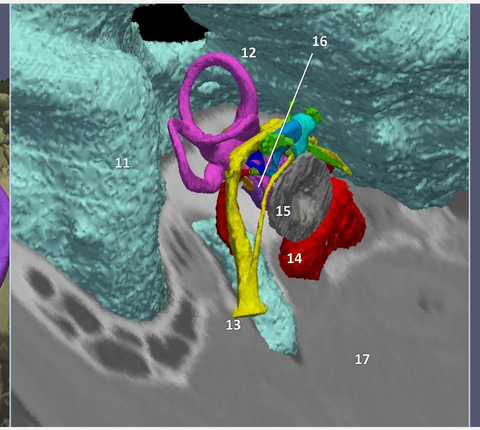
High resolution structures are fused and visualized on corresponding CT images. This experience significantly improves the visual recognition and spatial understanding of partially visible structures (e.g. tympanic scala, facial nerve and chorda tympani) in CT images.

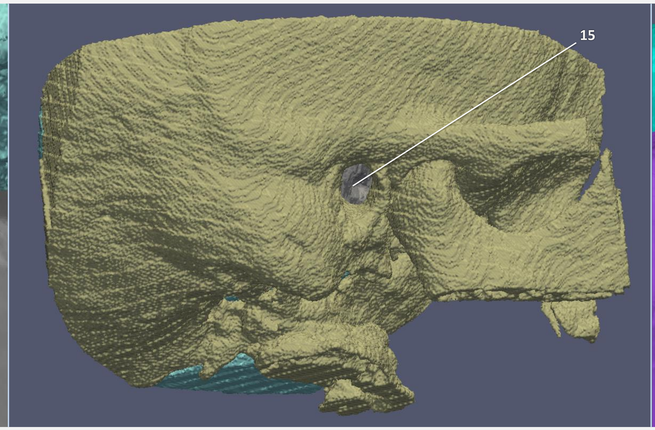
Conclusion

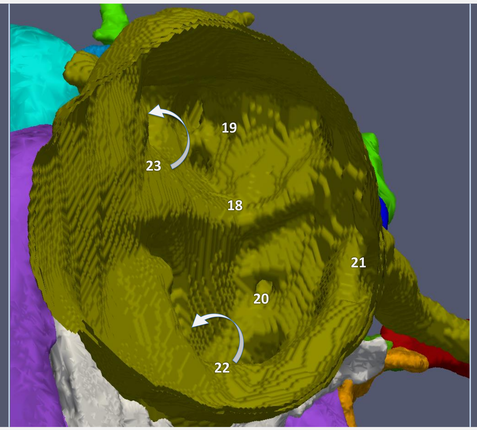
Geometrically accurate temporal bone reconstructions provide an advanced teaching tool for medical students and cochlear implant surgeons. The understanding of spatial relationship between anatomical structures as well as the virtual exploration of surgical approaches is greatly facilitated.

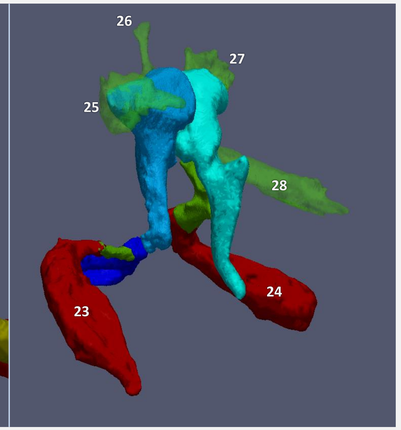
N°	Structure
1	pyramidal eminence
2	sinus tympani
3	posterior tympanic sinus
4	chordal ridge
5	excavated lateral tympanic sinus
6	styloid eminence
7	chordal eminence
8	chorda tympani
9	cochlea
10	stapes
11	lateral sinus
12	superior semi-circular canal
13	facial nerve
14	internal carotid artery
15	tympanic membrane
16	scala tympani
17	CT slice
18	sickle crest
19	superior vestibular nerve area
20	inferior vestibular nerve area
21	posterior ampullary nerve
22	cochlear nerve area
23	stapes muscle
24	tensor tympani muscle
25	posterior ligament of incus
26	superior ligament of incus
27	superior ligament of malleus
28	anterior ligament of malleus











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