HUMAN EAR CANAL DYNAMIC MOTION: A discrete approach to study the size and shape variations with head, face and jaw movements

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CONTEXT

Several studies proved that a significant amount of energy can be harvested from movement. Although they have already evaluated the power capability of ear canal dynamic motion, none of these studies aimed at predicting the precise locations where the energy capability of the ear canal is maximum.

Objective:
To assess size and shape variations of the ear canal with different activities to identify the in-ear region that could provide the highest amount of mechanical deformation energy.

METHODS

1. Healthy subjects
- 18
- 33% Women
- 33.5 [31;39] years Median age
- 5 activities
  - CM: Closed mouth
  - MD: Mouth opening
  - TRL: Turning head left
  - RE: Raising eyebrows
  - SM: Smiling

(1) Area
(2) Circularity
(3) Tortuosity

1st band
2nd band

3. Entry (CS1)
- Centroid set
- PoC, Med., Ant.

2nd band (CS3)

Fig. 2: Ear canal discretization with 11 cross-sections (CS) and centroid axis.

CONCLUSIONS

MO and SM show the highest differences in size and shape. The transition between first and second bend looks like a turning point as deviations change sign. By placing an energy harvester at this location, MO and SM should provide a significant amount of energy resulting from contraction and expansion of the ear canal.

RESULTS

- MO and SM contracts ear canal (EC) at the entry but then only MO tends to expand EC from first bend.
- Only MO contracts EC significantly (%ΔAmin = -1.75% [-3.21;-0.48] at CS2, p<0.001), while MO (%ΔAmax = 2.93% [-0.25;4.31] at CS6, p<0.005), TRL (%ΔAmax = 1.75% [-1.80;6.79] at CS10, p<0.05) and SM (%ΔAmax = 7.07% [1.77;13.23] at CS8, p<0.001) expand EC significantly.
- RE tends to expand EC from entry to 2nd bend (%ΔAmax = 1.86% [-2.50;10.28] at CS9, p<0.05).
- TRL and RE don’t change CS shape much until first bend, while MO (%ΔCmin = 0.61% [-2.14;3.38] at CS2, p<0.05) and SM (%ΔCmin = -3.63% [-9.97;1.34] at CS3, p<0.001) makes CS significantly more elliptical.
- MO makes CS more circular until the second bend but only significantly at the transition between the two bends (%ΔCmax = 1.34% [0.20;2.38] at CS8, p<0.001), while RE (%ΔCmin = -1.33% [-2.68;0.36] at CS7, p<0.001) and SM make CS significantly more elliptical in this period.
- Only SM makes CS significantly more circular close to the second bend (%ΔCmax = 1.62% [0.22;3.16] at CS9, p<0.005).
- MO (%ΔT = -1.15% [-1.98;0.01], p<0.001) RE (%ΔT = -0.91% [-3.36;0.45], p<0.005) and SM (%ΔT = -1.18% [-2.64;0.21], p<0.005) make EC significantly more tortuous.
- Only TRL makes EC straighter (%ΔT = 0.39% [-0.74;1.41], p<0.05) but not significantly.

Fig. 4: Distributions of Area (top), Circularity (middle) and Tortuosity (bottom) deviations for MO (blue), TRL (light blue), RE (yellow) and SM (red) with respect to CM.

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