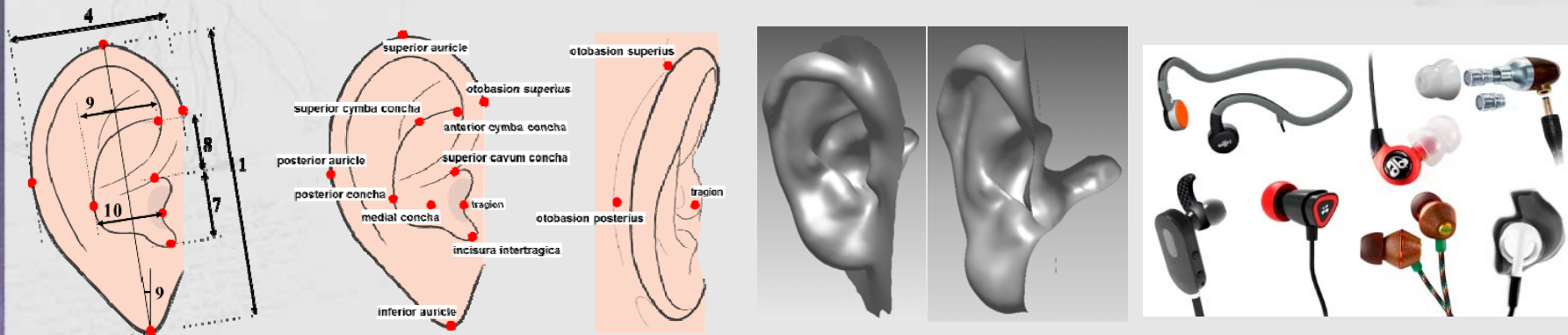# Measurement and Application of 3D Ear Scans for Earphone Design

Wonsup Lee,[1] Hayoung Jung,[2] Ilguen Bok,[3] Chulwoo Kim,[3] Ochae Kwon,[3] Teukgyu Choi,[4] and **Heecheon You**[2]

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[4] Humanopia, Co., Pohang, South Korea

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- **Introduction**
  - Background
  - Objectives of the Study
- **Collection of 3D Ear Scans**
- **Anthropometric Analysis of 3D Ear Scans**
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- **Discussion**

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Usefulness of 3D Body Scans in Product Design
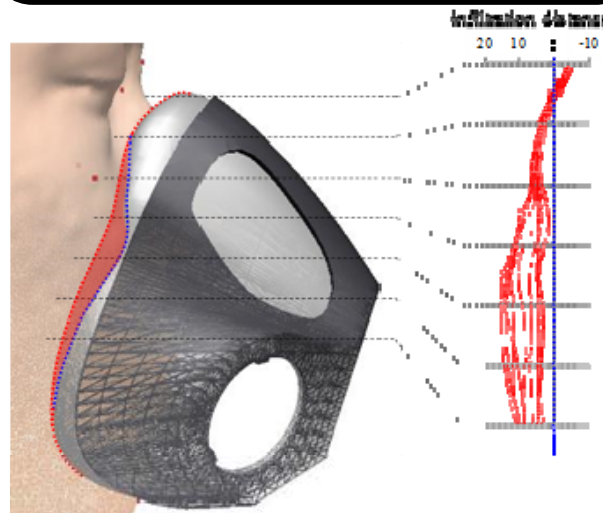
❑ **Provide detailed measurements of complex dimensions (e.g., curvature, area, and volume) of the human body applicable to various product designs**

Application of 3D scan images to product design
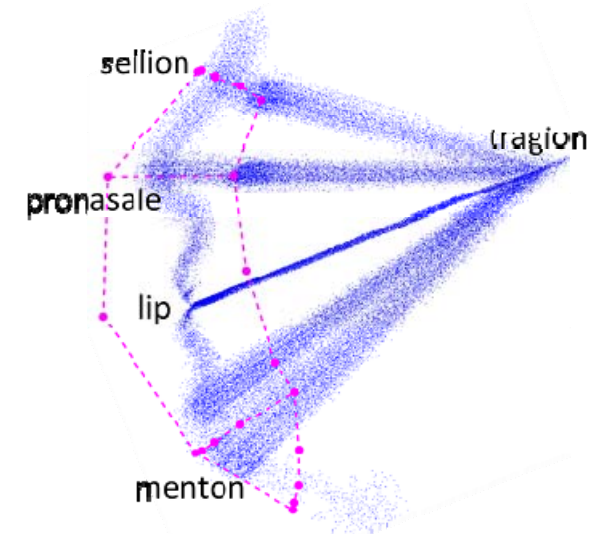
Representative head form analysis of 2,300 head images for head wearable products

Virtual fit analysis for design of pilot's oxygen mask by applying 3D facial shapes of 336 Korean pilots

**3D shape analysis of 300 Korean faces for design of dust-proof mask**

Needs of 3D Ear Anthropometry

- ❑ **Diversity & complexity** of earphone types and designs
  - ⇒ Require **detailed measurements of the ear** for **earphone design**
- ❑ **Little information of 3D ear shapes** is available

⇒ Need to identify **detailed ear dimensions** which is significantly **related to earphone design**

⇒ Need to collect **3D ear scans including the pinna and earhole**

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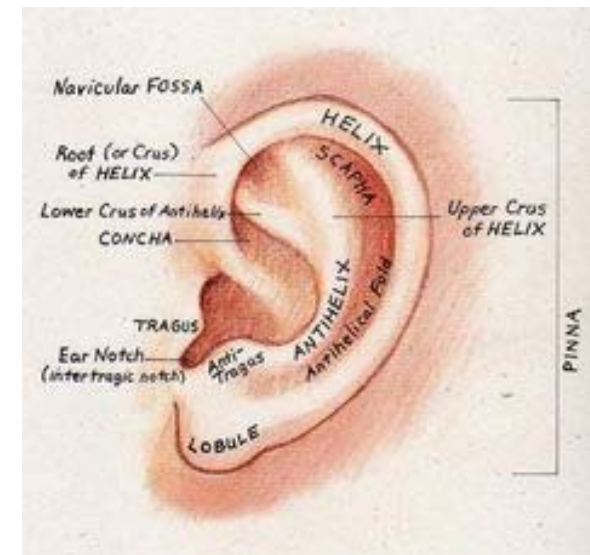
Objectives of the Study

> ### Measurement and Application of 3D Ear Scans
> ### for Earphone Design

1. **Identification of ear dimensions and landmarks related to earphone**

2. **Collection of 3D ear scans and measurements: scanning, editing, landmarking, and measurement**

3. **Analysis of the size, shape, volume of the ear**

4. **Application of 3D ear scans to design of earphone**
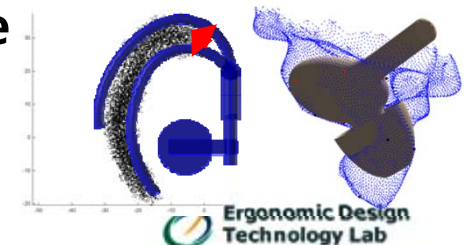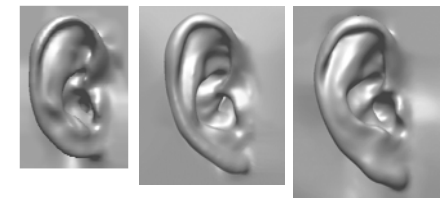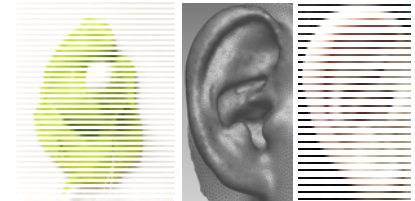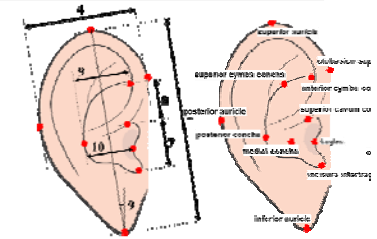
Identification of Ear Dimensions

❑ **Selected 9 ear dimensions** out of 22 dimensions found from 22 papers
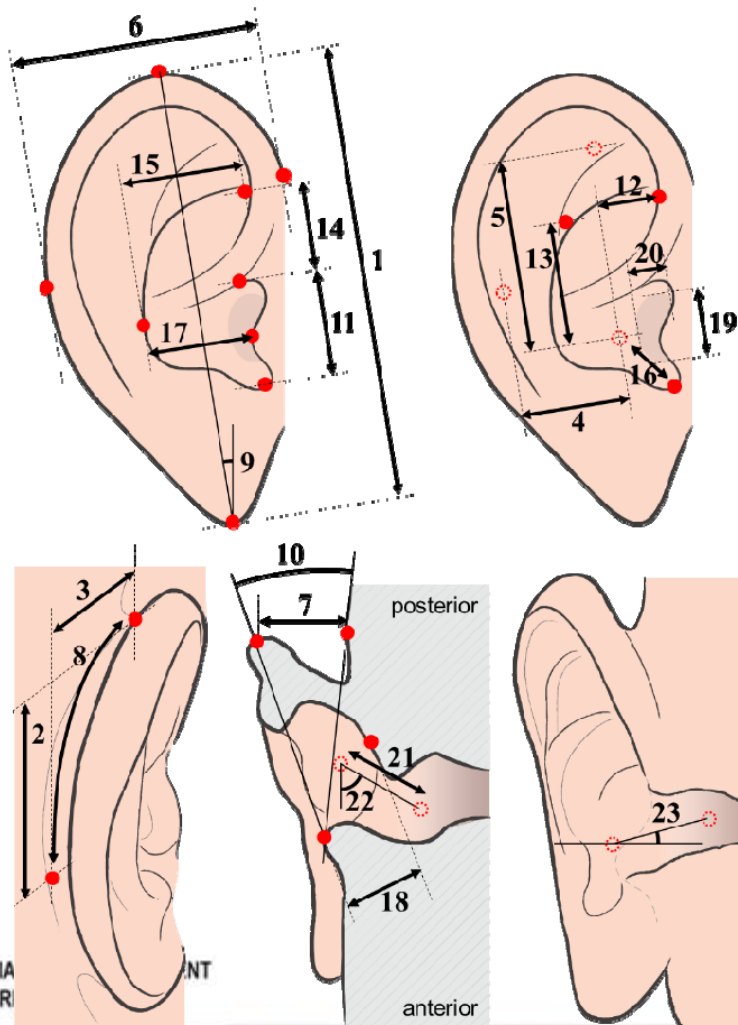❑ **Defined 14 new dimensions** which are **highly relevant to earphone design**

Category		No	Ear dimensions
Ear dimensions	Length	1	ear length
		2	otobasion superius to otobasion posterius horizontal length
		3	otobasion superius to otobasion posterius vertical length
		4	center of concha to otobasion posterius length
		5	center of concha to otobasion superius length
	Width	6	ear breadth
		7	ear protrusion
	Arc	8	upper otobasion arc
	Angle	9	ear angle
		10	pinna flare angle
Concha dimensions	Length	11	cavum concha length
		12	center of concha to anterior cymba concha length
		13	center of concha to superior cymba concha length
		14	superior cavum concha to anterior cymba concha length
		15	posterior concha to anterior cymba concha length
		16	center of concha to incisura intertragica length
	Width	17	cavum concha width
	Depth	18	cavum concha depth
Ear canal dimensions	Length	19	ear canal length
	Width	20	ear canal width
	Depth	21	ear canal depth
	Angle	22	ear canal azimuth angle
		23	ear canal elevation angle

Determination of Ear Landmarks

❑ **Identified 18 landmarks for measurement of the 23 ear dimensions selected in the study for ear phone design**

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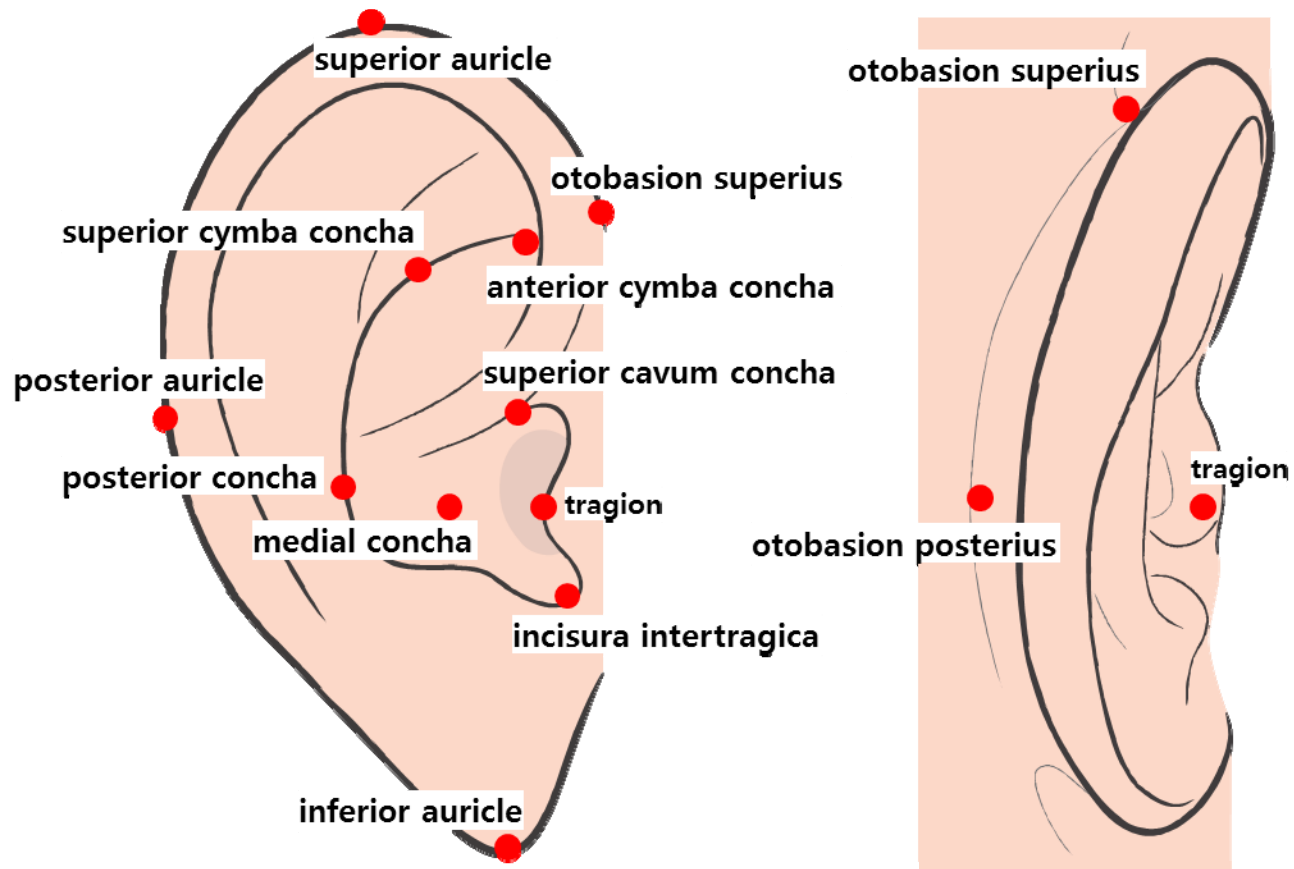
3D Scanning of the Outside Ear (Pinna)

❑ Scanned **the outside of the ear (pinna)** using an **Artec Eva 3D scanner** for **296 participants in 20s to 50s**

- – **200 Koreans: 100 males and 100 females**
- – **96 Caucasians: 50 males and 46 females**

editing

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Scanning of the Concha & Earhole

❑ Applied **casting materials** to obtain the shape of the **concha and ear hole**
❑ Scanned the cast using the Artec Eva 3D scanner
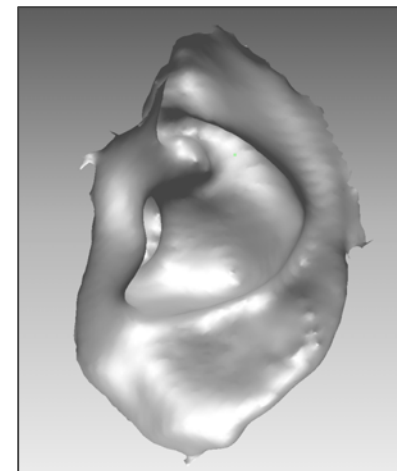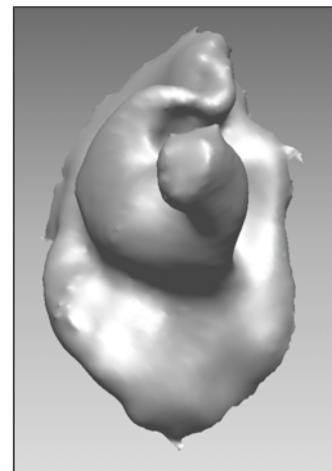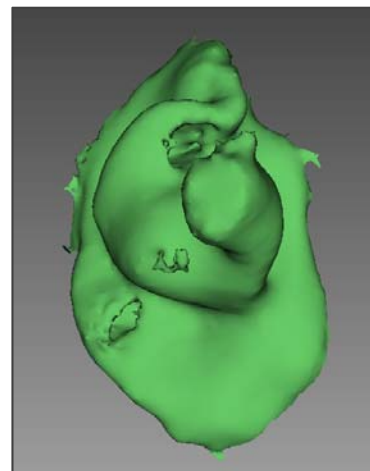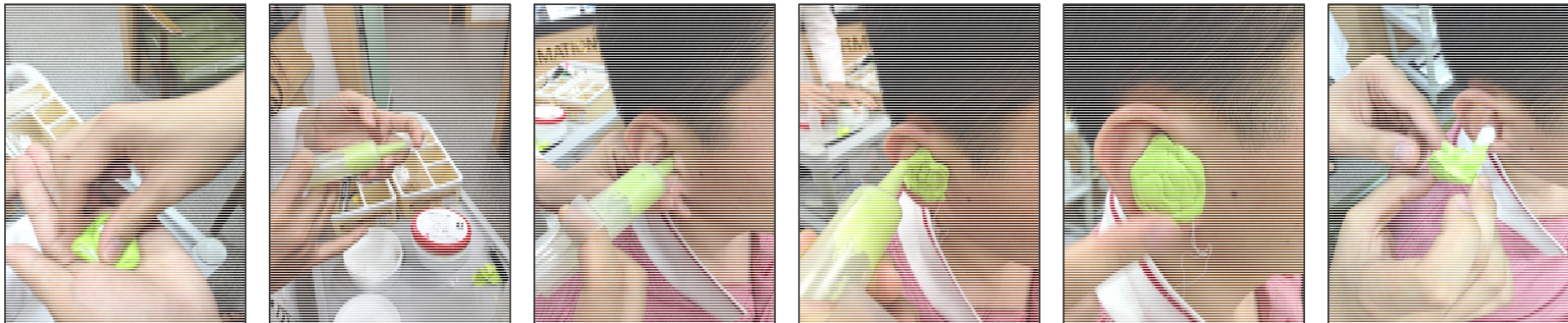
Merging Outside and Inside Ear Scans

❑ Acquired an **complete 3D ear scan** by **merging outside and inside ear scans**

Outside scan + Inside scan → complete 3D ear scan

(*n* = 296)

❑ **Acquired 3D ear scans including the ear-hole part**

Measurements: Koreans (illustrated)

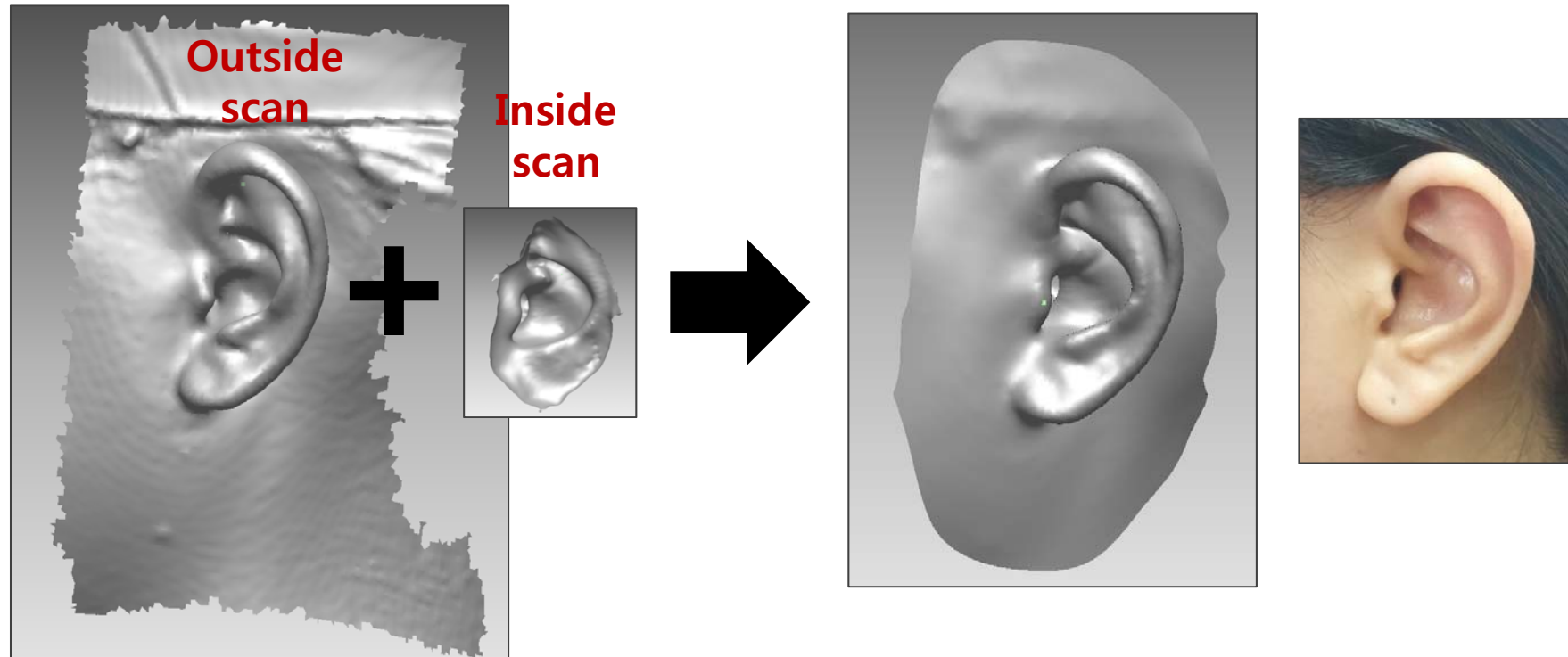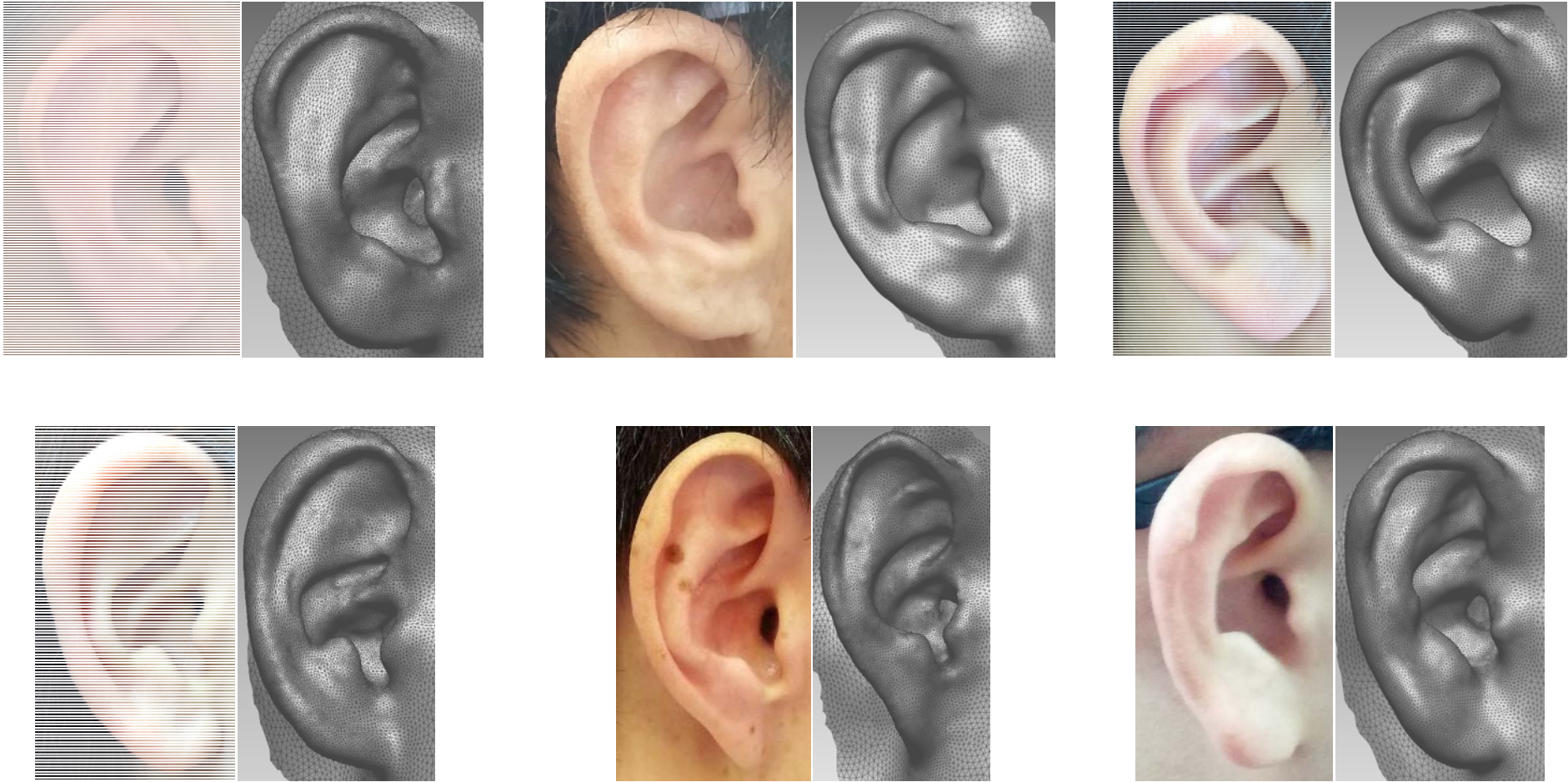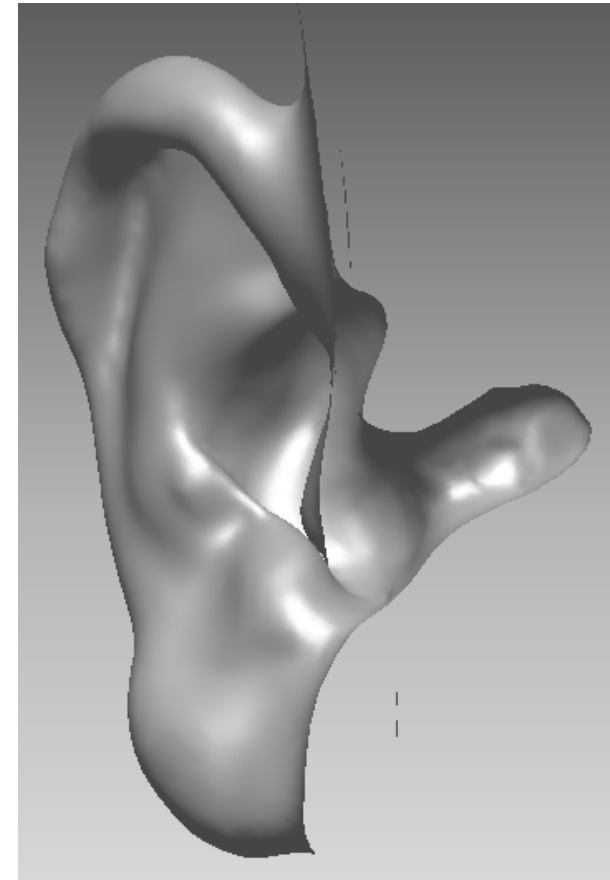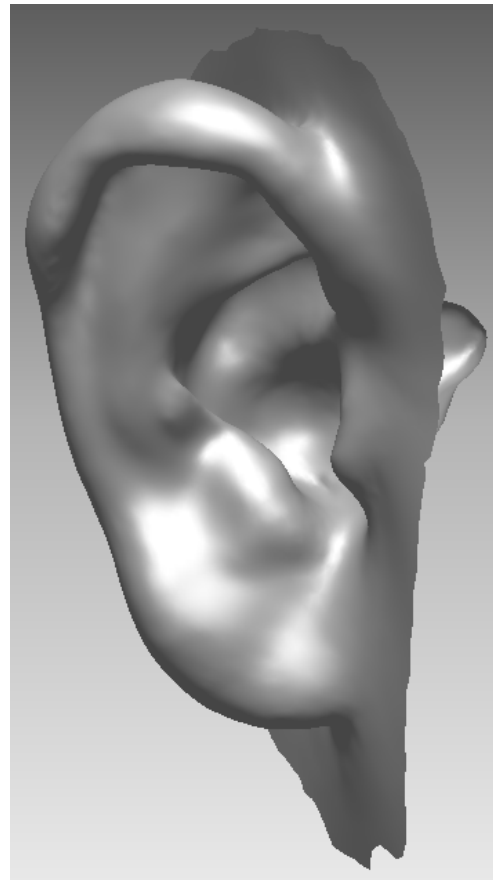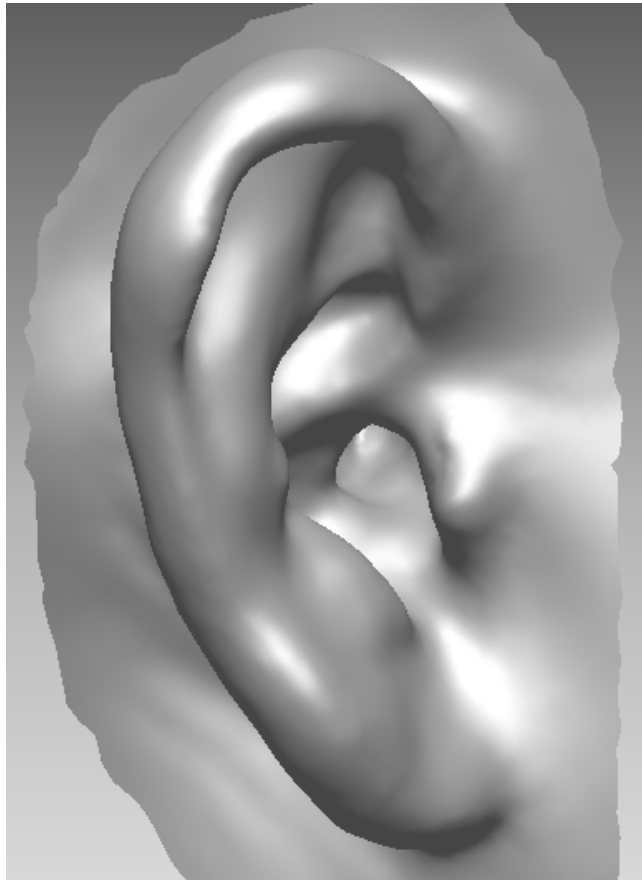| Category	No.	Dimensions	n	mean	SD	min	1%	5%	25%	50%	75%	95%	99%	max
Pinna dimensions	1	ear length	200	63.7	4.2	52.8	54.5	57.0	60.8	63.8	66.6	70.7	72.6	76.7
	2	ear breadth	200	31.2	2.9	22.7	24.8	26.7	29.3	31.0	33.4	35.7	37.1	39.4
	3	ear angle	200	4.9	1.6	1.0	1.0	1.9	4.4	4.9	5.7	7.6	8.3	8.7
	4	ear protrusion	200	16.5	2.8	10.6	11.2	12.3	14.3	16.5	18.2	21.5	23.8	24.9
	5	otobasion superius to otobasion posterius horizontal dist.	200	23.3	2.2	16.7	18.5	19.9	21.8	23.4	25.0	26.7	28.2	32.0
	6	otobasion superius to otobasion posterius vertical dist.	200	23.2	2.2	16.8	18.3	19.6	21.8	23.4	24.6	26.6	28.2	29.4
	7	upper otobasion arc	200	45.0	3.6	36.7	37.6	39.6	42.6	44.8	47.1	50.6	55.5	57.2
	8	center of earphone to otobasion superius dist.	200	30.5	2.5	23.4	25.5	26.5	29.0	30.4	32.1	34.7	36.7	38.8
	9	center of earphone to otobasion posterius dist.	200	27.9	1.6	23.8	24.8	25.4	26.9	27.8	28.9	30.8	32.0	32.3
Concha & earhole Dimensions	1	concha length	200	17.2	1.3	12.9	13.9	15.0	16.4	17.3	18.1	19.1	19.6	21.2
	2	earhole length	200	14.7	1.3	10.1	11.2	12.7	13.9	14.7	15.6	16.7	17.1	18.3
	3	concha width	200	16.8	1.8	11.6	12.9	14.0	15.6	16.9	17.9	19.8	20.7	21.5
	4	center of earphone to anterior cymba conchae dist.	200	4.3	0.4	3.2	3.3	3.5	4.1	4.3	4.5	5.0	5.2	5.3
	5	center of earphone to superior cymba conchae dist.	200	16.6	1.5	12.2	12.7	14.0	15.7	16.6	17.4	18.8	20.1	22.6
	6	earhole major axis length	193	12.9	2.0	7.0	7.7	9.7	11.4	13.0	14.4	15.7	16.3	17.1
	7	earhole minor axis length	193	9.2	2.4	4.7	5.7	6.5	7.7	8.4	10.2	13.4	18.5	20.0
	8	earhole depth	200	8.3	1.2	5.1	5.8	6.4	7.4	8.2	9.1	10.4	11.0	11.3
	9	earhole azimuth angle	200	24.8	8.8	4.6	6.0	9.3	18.5	24.8	31.1	38.7	45.7	53.2
	10	earhole elevation angle	200	-7.7	23.9	-70.5	-64.4	-45.6	-23.4	-8.7	11.2	29.7	43.3	49.0

Comparison of Ear Measurements: Koreans vs. Caucasians

❑ **Koreans ≈ Caucasians**: mean difference ≤ 2 mm in most of ear dimensions (70% ~ 75%)

† $p < 0.05$ ▢ |mean diff| ≤ 2.0 mm   unit: mm

Category	No.	Dimensions	Male			Female			Composite: Gender		
			Korean ($n = 100$)	Caucasian ($n = 50$)	Mean diff.	Korean ($n = 100$)	Caucasian ($n = 46$)	Mean diff	Korean ($n = 200$)	Caucasian ($n = 96$)	Mean diff.
Pinna dimensions	1	ear length	65.5 ± 3.9	61.7 ± 3.9	3.8† (6%)	62.0 ± 3.8	59.3 ± 3.9	2.7† (4%)	63.7 ± 4.2	60.5 ± 4.1	3.2† (5%)
	2	ear breadth	32.9 ± 2.2	33.9 ± 2.3	1.0† (3%)	29.4 ± 2.4	31.4 ± 2.5	2.0† (7%)	31.2 ± 2.9	32.7 ± 2.7	1.5† (5%)
	3	ear angle	4.7 ± 1.7	4.0 ± 2.0	0.7† (16%)	5.0 ± 1.5	4.2 ± 2.3	0.8† (18%)	4.9 ± 1.6	4.1 ± 2.2	0.8† (18%)
	4	ear protrusion	17.8 ± 2.5	16.6 ± 3.5	1.2† (7%)	15.2 ± 2.4	15.7 ± 2.6	0.5 (3%)	16.5 ± 2.8	16.2 ± 3.1	0.3 (2%)
	5	otobasion superius to otobasion posterius horizontal dist.	24.4 ± 2.1	23.6 ± 1.8	0.8† (3%)	22.3 ± 1.8	22.8 ± 1.8	0.5 (2%)	23.3 ± 2.2	23.2 ± 1.8	0.1 (0%)
	6	otobasion superius to otobasion posterius vertical dist.	23.6 ± 2.1	22.0 ± 2.9	1.6† (7%)	22.9 ± 2.2	22.2 ± 2.6	0.7 (3%)	23.2 ± 2.2	22.1 ± 2.8	1.1† (5%)
	7	upper otobasion arc	46.3 ± 3.3	43.8 ± 3.3	2.5† (6%)	43.7 ± 3.4	43.3 ± 3.6	0.4 (1%)	45.0 ± 3.6	43.6 ± 3.5	1.4† (3%)
	8	center of ear to otobasion superius dist.	31.1 ± 2.5	28.5 ± 2.7	2.6† (9%)	29.9 ± 2.4	28.3 ± 2.4	1.6† (6%)	30.5 ± 2.5	28.4 ± 2.5	2.1† (7%)
	9	center of ear to otobasion posterius dist.	28.3 ± 1.7	28.0 ± 1.5	0.3 (1%)	27.6 ± 1.4	27.6 ± 1.4	0.0 (0%)	27.9 ± 1.6	27.8 ± 1.5	0.1 (0%)
Concha & earhole dimensions	1	concha length	17.5 ± 1.3	14.8 ± 1.3	2.7† (17%)	16.8 ± 1.2	14.8 ± 1.3	2.0† (13%)	17.2 ± 1.3	14.8 ± 1.3	2.4† (15%)
	2	earhole length	14.9 ± 1.3	12.3 ± 1.4	2.6† (19%)	14.4 ± 1.2	12.2 ± 1.2	2.2† (17%)	14.7 ± 1.3	12.3 ± 1.3	2.4† (18%)
	3	concha width	17.2 ± 1.7	16.9 ± 1.9	0.3 (2%)	16.5 ± 1.7	16.5 ± 1.6	0.0 (0%)	16.8 ± 1.8	16.7 ± 1.8	0.2 (1%)
	4	center of ear to anterior cymba conchae dist.	4.3 ± 0.4	4.5 ± 0.5	0.2† (5%)	4.3 ± 0.4	4.5 ± 0.6	0.2† (5%)	4.3 ± 0.4	4.5 ± 0.6	0.2† (5%)
	5	center of ear to superior cymba conchae dist.	16.7 ± 1.5	15.4 ± 1.7	1.3† (8%)	16.4 ± 1.4	16.2 ± 2.0	0.2 (1%)	16.6 ± 1.5	15.8 ± 1.9	0.8† (5%)
	6	earhole major axis length	12.8 ± 1.8	13.0 ± 2.1	0.2 (2%)	13.0 ± 2.1	12.6 ± 2.0	0.4 (3%)	12.9 ± 2.0	12.8 ± 2.1	0.1 (1%)
	7	earhole minor axis length	9.0 ± 2.2	8.5 ± 2.3	0.5 (6%)	9.3 ± 2.6	8.1 ± 1.8	1.2† (14%)	9.2 ± 2.4	8.3 ± 2.1	0.8† (10%)
	8	earhole depth	9.0 ± 1.1	8.6 ± 1.0	0.4† (5%)	7.6 ± 0.9	8.0 ± 1.1	0.4† (5%)	8.3 ± 1.2	8.3 ± 1.1	0.0 (0%)
	9	earhole azimuth angle	24.9 ± 8.3	30.5 ± 7.9	5.6† (20%)	24.6 ± 9.4	33.4 ± 10.7	8.8† (31%)	24.8 ± 8.8	31.9 ± 9.4	7.1† (25%)
	10	earhole elevation angle	-9.3 ± 23.1	-5.6 ± 23.7	3.7 (5%)	-6.1 ± 24.7	5.9 ± 21.1	12.0† (13%)	-7.7 ± 23.9	-0.1 ± 23.1	7.6 (13%)

Comparison of Ear Measurements: Male vs. Female

❑ **Overall size: Male > Female** (mean difference: 3.5 mm for Koreans, 2.5 mm for Caucasians)

❑ **Detailed size: Male ≈ Female** (mean difference ≤ 2 mm: 80% for Koreans, 100% for Caucasians)

† $p < 0.05$ ☐ |mean diff| ≤ 2.0 mm

unit: mm

| Category	No.	Dimensions	Korean			Caucasian			Composite: Race		
			Male (n = 100)	Female (n = 100)	Mean diff.	Male (n = 50)	Female (n = 46)	Mean diff.	Male (n = 150)	Female (n = 146)	Mean diff.
Pinna dimensions	1	ear length	65.5 ± 3.9	62.0 ± 3.8	3.5† (5%)	61.7 ± 3.9	59.3 ± 3.9	2.4† (4%)	64.2 ± 4.3	61.1 ± 4.0	3.1† (5%)
	2	ear breadth	32.9 ± 2.2	29.4 ± 2.4	3.5† (11%)	33.9 ± 2.3	31.4 ± 2.5	2.5† (8%)	33.3 ± 2.3	30.1 ± 2.6	3.2† (10%)
	3	ear angle	4.7 ± 1.7	5.0 ± 1.5	0.3 (6%)	4.0 ± 2.0	4.2 ± 2.3	0.1 (5%)	4.5 ± 1.8	4.8 ± 1.8	0.3 (6%)
	4	ear protrusion	17.8 ± 2.5	15.2 ± 2.4	2.6† (16%)	16.6 ± 3.5	15.7 ± 2.6	0.8 (6%)	17.4 ± 2.9	15.4 ± 2.5	2.0† (12%)
	5	otobasion superius to otobasion posterius horizontal dist.	24.4 ± 2.1	22.3 ± 1.8	2.1† (9%)	23.6 ± 1.8	22.8 ± 1.8	0.7† (3%)	24.1 ± 2.0	22.5 ± 1.8	1.7† (7%)
	6	otobasion superius to otobasion posterius vertical dist.	23.6 ± 2.1	22.9 ± 2.2	0.7† (3%)	22.0 ± 2.9	22.2 ± 2.6	0.2 (1%)	23.1 ± 2.5	22.7 ± 2.3	0.4 (2%)
	7	upper otobasion arc	46.3 ± 3.3	43.7 ± 3.4	2.5† (6%)	43.8 ± 3.3	43.3 ± 3.6	0.5 (1%)	45.5 ± 3.5	43.6 ± 3.5	1.9† (4%)
	8	center of ear to otobasion superius dist.	31.1 ± 2.5	29.9 ± 2.4	1.2† (4%)	28.5 ± 2.7	28.3 ± 2.4	0.2 (1%)	30.2 ± 2.8	29.4 ± 2.5	0.8† (3%)
	9	center of ear to otobasion posterius dist.	28.3 ± 1.7	27.6 ± 1.4	0.7† (3%)	28.0 ± 1.5	27.6 ± 1.4	0.4 (1%)	28.2 ± 1.7	27.6 ± 1.4	0.6† (2%)
Concha & earhole dimensions	1	concha length	17.5 ± 1.3	16.8 ± 1.2	0.6† (4%)	14.8 ± 1.3	14.8 ± 1.3	0.0 (0%)	16.6 ± 1.8	16.2 ± 1.6	0.4† (2%)
	2	earhole length	14.9 ± 1.3	14.4 ± 1.2	0.5† (3%)	12.3 ± 1.4	12.2 ± 1.2	0.2 (1%)	14.1 ± 1.8	13.7 ± 1.6	0.4† (3%)
	3	concha width	17.2 ± 1.7	16.5 ± 1.7	0.8† (4%)	16.9 ± 1.9	16.5 ± 1.6	0.4 (2%)	17.1 ± 1.8	16.5 ± 1.7	0.6† (4%)
	4	center of ear to anterior cymba conchae dist.	4.3 ± 0.4	4.3 ± 0.4	0.0 (0%)	4.5 ± 0.5	4.5 ± 0.6	0.1 (0%)	4.4 ± 0.5	4.3 ± 0.5	0.1 (2%)
	5	center of ear to superior cymba conchae dist.	16.7 ± 1.5	16.4 ± 1.4	0.3 (2%)	15.4 ± 1.7	16.2 ± 2.0	0.8† (5%)	16.3 ± 1.7	16.3 ± 1.6	0.0 (0%)
	6	earhole major axis length	12.8 ± 1.8	13.0 ± 2.1	0.2 (2%)	13.0 ± 2.1	12.6 ± 2.0	0.4 (3%)	12.9 ± 1.9	12.9 ± 2.1	0.0 (0%)
	7	earhole minor axis length	9.0 ± 2.2	9.3 ± 2.6	0.2 (3%)	8.5 ± 2.3	8.1 ± 1.8	0.4 (5%)	8.9 ± 2.2	8.9 ± 2.4	0.1 (0%)
	8	earhole depth	9.0 ± 1.1	7.6 ± 0.9	1.4† (16%)	8.6 ± 1.0	8.0 ± 1.1	0.5† (7%)	8.9 ± 1.1	7.7 ± 1.0	1.1 (15%)
	9	earhole azimuth angle	24.9 ± 8.3	24.6 ± 9.4	0.3 (1%)	30.5 ± 7.9	33.4 ± 10.7	2.9 (9%)	26.8 ± 8.6	27.4 ± 10.6	0.6 (2%)
	10	earhole elevation angle	-9.3 ± 23.1	-6.1 ± 24.7	3.1 (4%)	-5.6 ± 23.7	5.9 ± 21.1	11.4 (13%)	-8.0 ± 23.3	-2.4 ± 24.2	5.7 (7%)

Representative Ears

❑ **Determined 5 representative ears (2.5, 25, 50, 75, and 97.5%iles) by considering all the ear dimensions**

Smallest
(2.5%ile)

Small
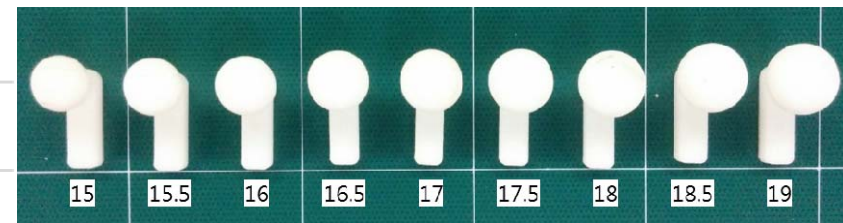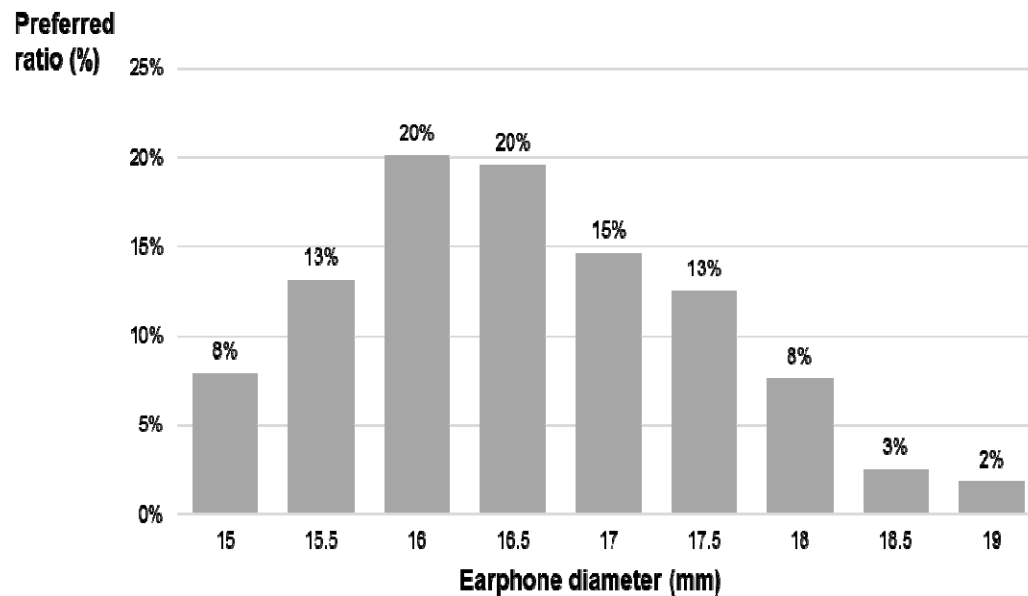(25%ile)
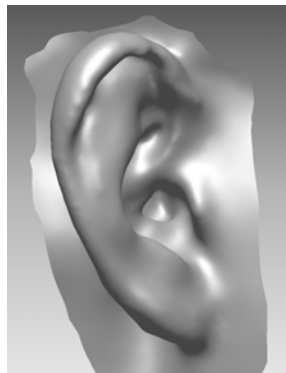
Medium
(50%ile)

Large
(75%ile)

Largest
(97.5%ile)

Analysis of Preferred Earbud Size

❏ **Fabricated earbud prototypes with different diameters (15 to 19 mm; 0.5 mm interval)**

❏ **Ask participants (*n* = 296) to select the most preferred sizes of earbud**

Ethnicity	Gender	Preferred size	Concha width
Korean	M	16.9 ± 0.9	17.2 ± 1.7
	F	16.3 ± 0.8	16.5 ± 1.7
	Composite	16.6 ± 0.9	16.8 ± 1.8
Caucasian	M	16.5 + 1.1	16.9 + 1.9
	F	16.5 ± 1.1	16.5 ± 1.6
	Composite	16.5 ± 1.1	16.7 ± 1.8
Range		**16.3 ~ 16.9 mm**	**16.5 ~ 17.2 mm**

Design of Ear-Band by Ear Root Shape Analysis

❑ **Extracted the contour of the ear root**

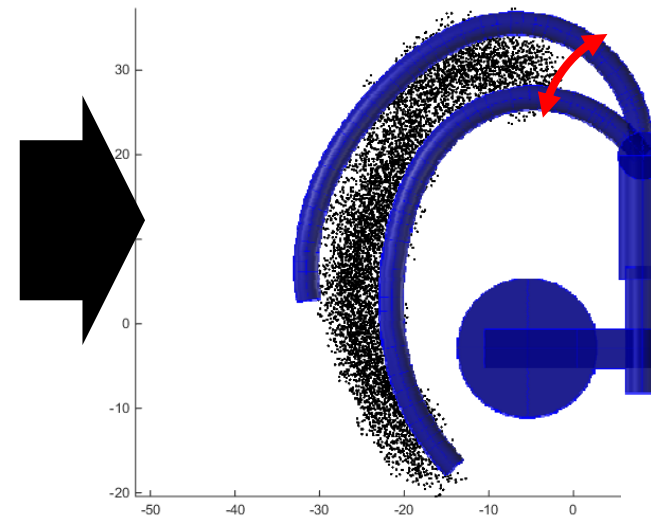❑ **Designed ear-band based on the size and shape variation of the ear root**

Extraction of ear root contour
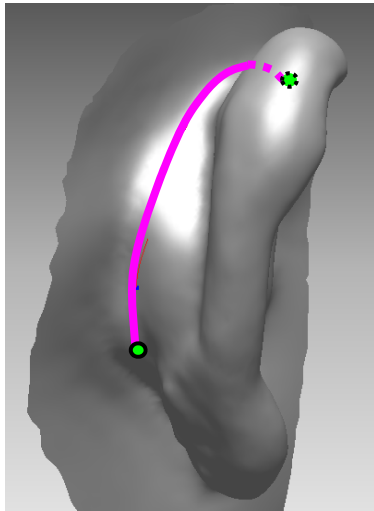
Variation of ear root shape
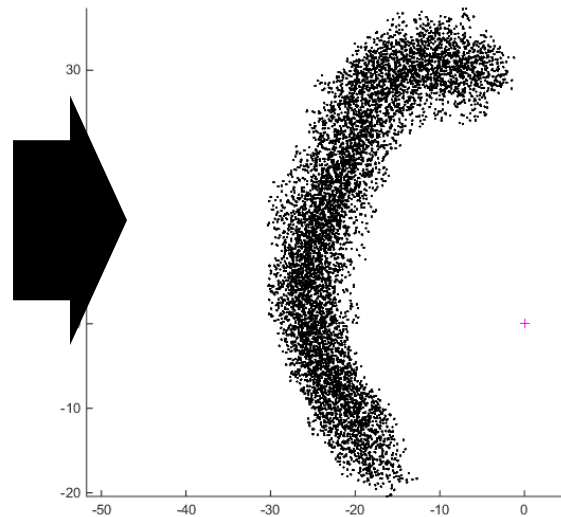
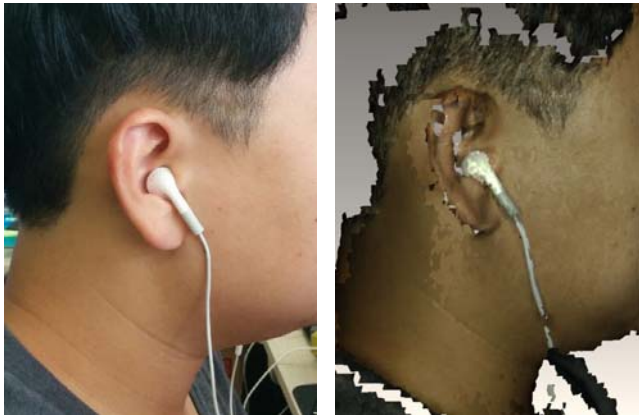**design of shape & adjustment range of ear-band (illustrated)**

Applications

Analysis of Earphone Wearing Characteristics

❑ Scanned ears while an earphone was used to **identify the use characteristics of the earphone by users**

❑ Applied the use characteristics of earphone for **virtual fit analysis of an earphone design**
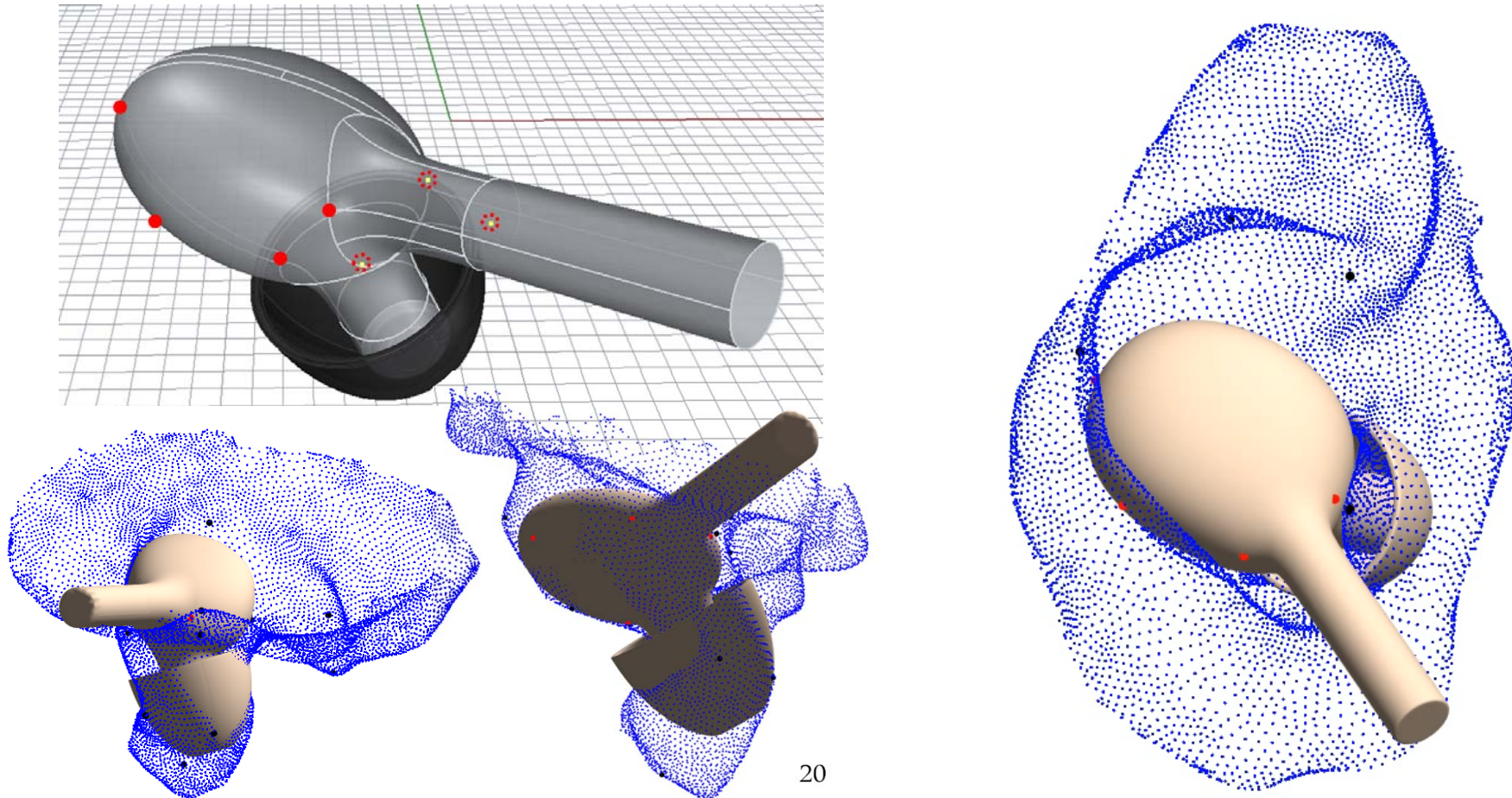
3D scan of the ear
with an earphone

Virtual fit analysis of an earphone
with a 3D ear scan
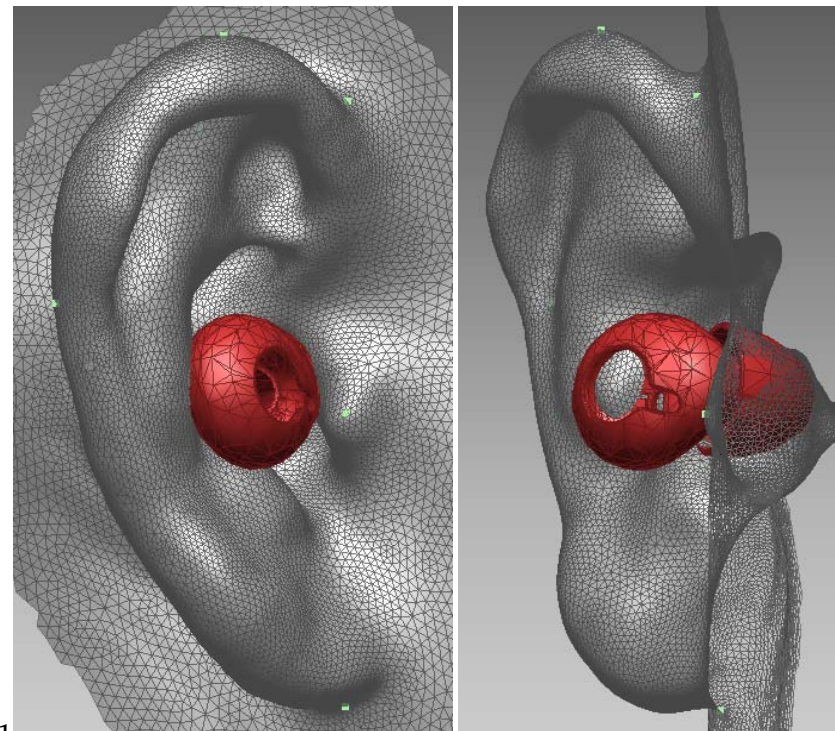
Virtual Fit Analysis

❑ **Virtual fit simulation** to find an **optimal shape and size of earphone**

❑ **Placed an earphone based on** **the relationship between ear landmarks and earphone landmarks identified from the use characteristics analysis of earphone**

Analysis of Contour and Volume of Concha

❑ **Extraction of the contour and volume of ear concha for earphone shape and size design**

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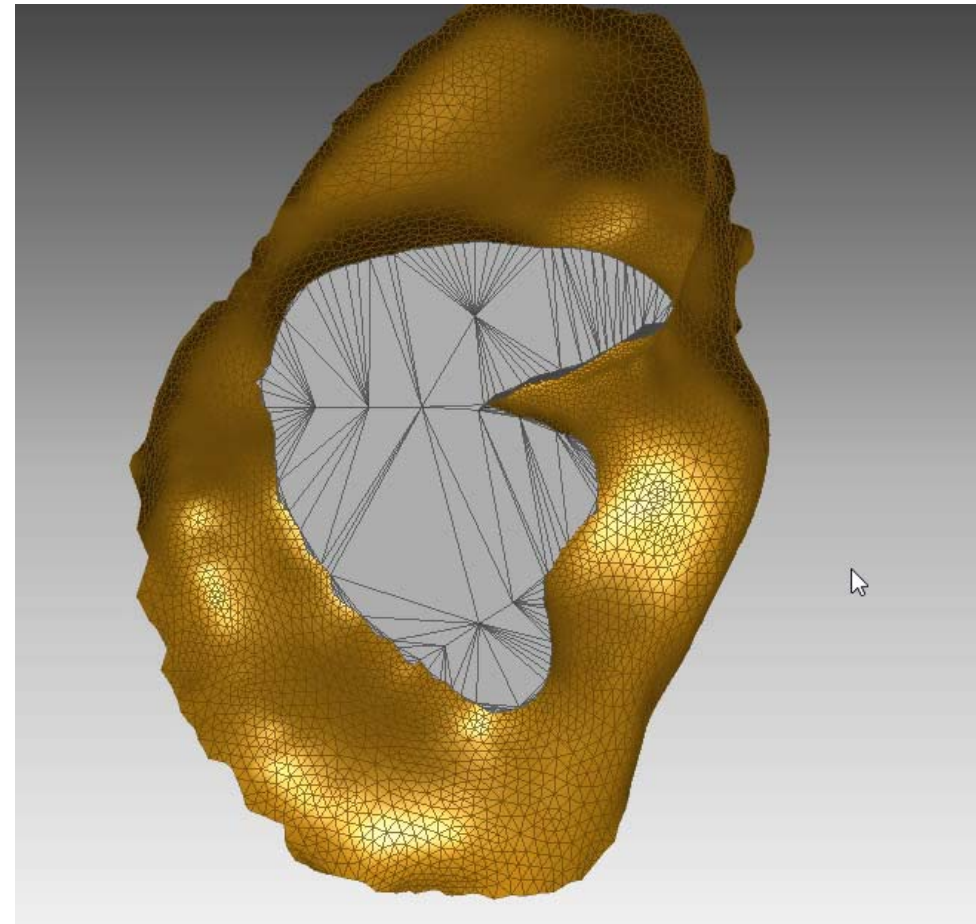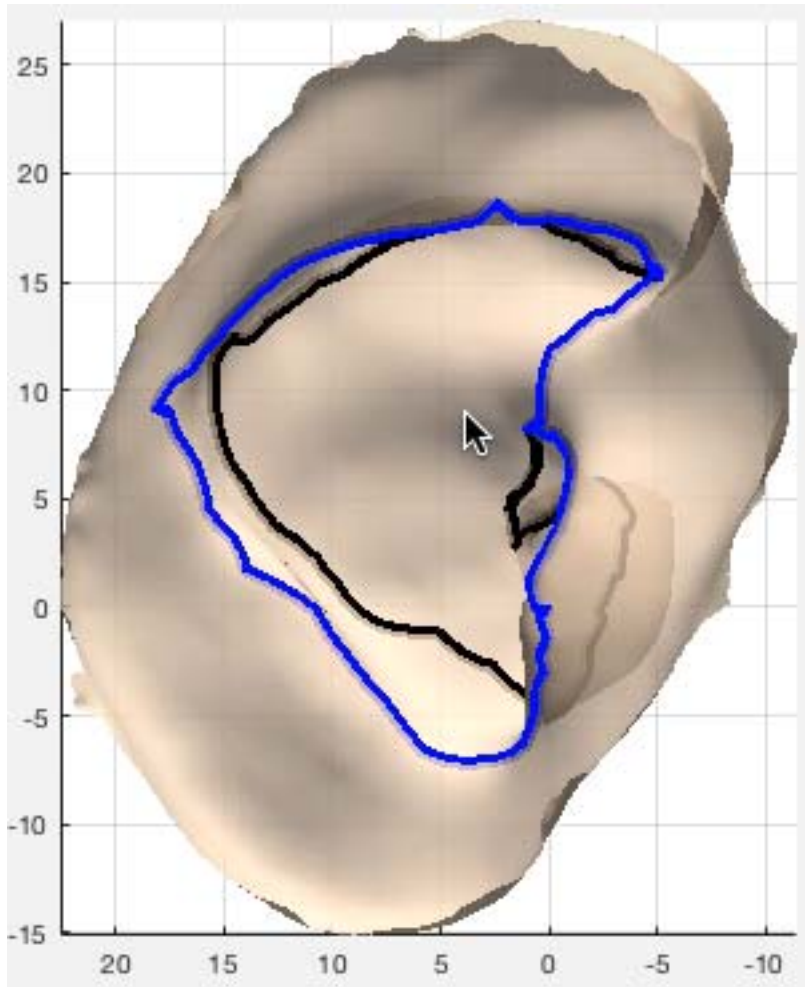
Discussion (1/3)

❑ Collected **3D ear scans (pinna and earhole)** through a process of **scanning, casting, editing, and merging**

⇒ Applicable to **design of ear wearable products** (earphones, hearing-aids, headsets, glasses, goggles, and ear protector)

❑ **Compared ear measurements** between Koreans and Caucasians and those between females and males
  ✓ **Koreans ≈ Caucasians**: mean difference ≤ 2 mm in most of ear dimensions (70% ~ 75%)
  ✓ **Overall size: Male > Female** (mean difference: 3.5 mm for Koreans, 2.5 mm for Caucasians)
     Detailed size: Male ≈ Female (mean difference ≤ 2 mm: 80% for Koreans, 100% for Caucasians)

❑ **Established 5 representative ears** (2.5, 25, 50, 75, and 97.5%iles) in terms of overall ear dimensions
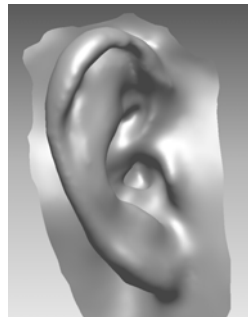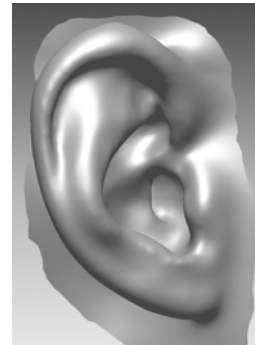
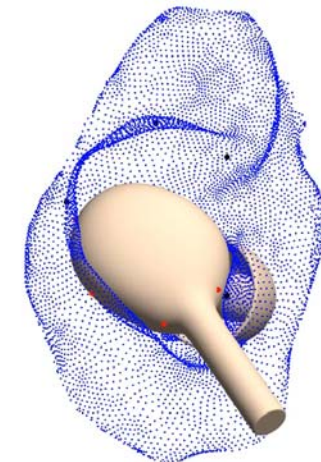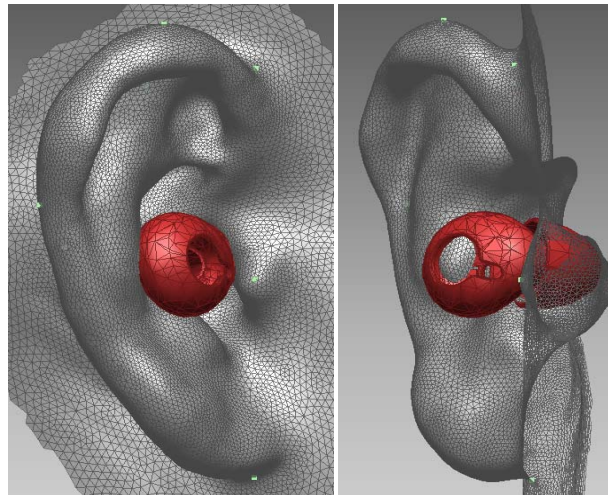| Smallest (2.5%ile)	Small (25%ile)	Medium (50%ile)	Large (75%ile)	Largest (97.5%ile)

Discussion (3/3)

❑ **Applied the ear scans to develop an ergonomic earphone design** by:
1. Analysis of **preferred size of earbud by ear size** (e.g., diameter of earbud)
2. Analysis of **shape variation of ear root** for ear-band design
3. Analysis of **fit** (e.g., shape and size of earphone, length of eartip)
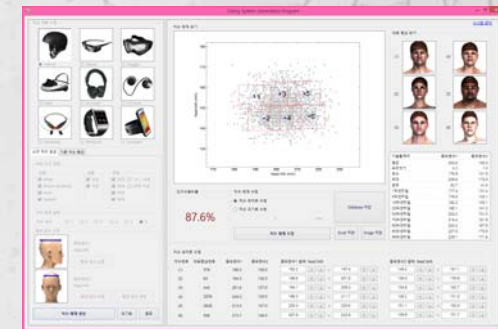
Representative Ears

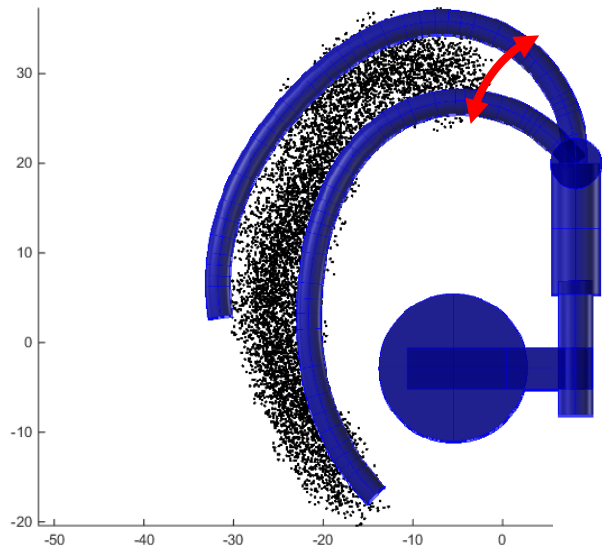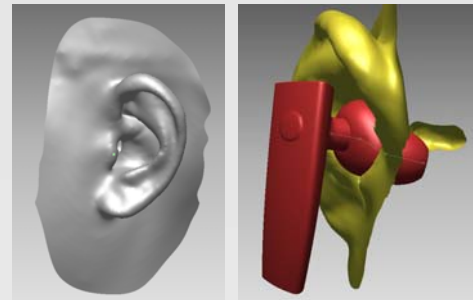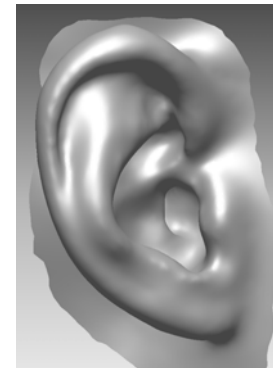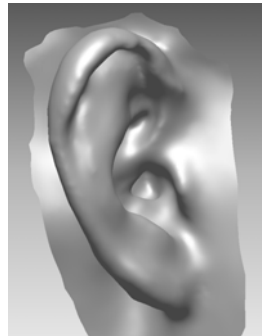|		EL01	EL04	EL05	EL06	EL07	EW01	EC01	EA01	EA02	CL01	CL04	CL05	CL06	CL07	CL08	CW01	CW02	ECL01	ECW01	ECD01	ECA01	ECA02		
		ear length	otobasion superius to otobasion posterius horizontal length	otobasion superius to otobasion posterius vertical length	center of concha to otobasion superius length	center of concha to otobasion posterius length	Ear breadth	upper otobasion curvature	pinna rotation angle	pinna flare angle	cavum concha length	center of concha to anterior cymba concha length	center of concha to superior cymba concha length	superior cavum concha to anterior cymba concha length	posterior concha to anterior cymba concha length	center of concha to incisura intertragica length	cavum concha width	cavum concha depth	ear canal length	ear canal width	ear canal depth	ear canal azimuth angle	ear canal elevation angle		
		하	중	중	중	중	하	중	하	하	상	중	중	하	중	상	상	상	상	상	상	상	상		
Small	real-case (ID = 264)	56.2	19.1	23.9	30.6	29.5	24.2	42.	3.0	22.1	12.6	6.4	16.3	7.5	13.	9.5	14.3	5.9	6.7	7.0	9.7	8.5		8.5를 0.5에 가깝게 수정
	real - 2.5%	2.6	-0.2	7.2	5.5	2.6	-1.7	.9	2.4	4.7	0.1	0.9	2.5	4.2	1.	1.2	0.7	0.8	-0.2	1.4	2.6	8.0		
	%(real - 2.5%)/M	4.2%	-0.7%	31.3%	18.2%	8.4%	-5.2%	.5%	50.1%	16.8%	0.3%	12.2%	14.7%	66.8%	7.2%	11.0%	4.1%	10.9%	-1.8%	17.9%	26.0%	58.3%	4.8%	
Medium	real-case (ID = 156)	68.2	24.5	24.0	31.5	31.4	35.0	49.0	4.9	24.7	16.8	7.4	16.4	5.8	16.	10.9	17.2	6.7	11.5	8.2	8.8	13.5	4.0	4.0을 10.2에 가깝게 수정
	real - M	5.5	1.0	1.1	1.0	0.2	3.1	3.5	0.0	-3.6	0.3	-0.3	-0.4	-0.6	-0.	0.2	0.1	-0.7	1.5	0.2	-1.4	-0.3	-6.3	
	%(real - M)/M	8.7%	4.2%	4.7%	3.4%	0.6%	9.7%	7.7%	0.2%	-12.6%	1.7%	-3.3%	-2.6%	-9.0%	-1.1%	2.2%	0.8%	-9.7%	15.2%	2.9%	-13.4%	-1.9%	-61.3%	
Large	real-case (ID = 75)	69.7	25.2	28.1	34.6	37.2	33.9	53.	3.7	21.2	19.7	9.7	21.2	8.4	20.	13.7	22.0	10.8	12.3	10.1	15.3	13.1	0.1	
	real - 97.5%	-1.7	-2.2	-0.9	-2.7	0.9	-3.2	-0.4	-5.6	-23.3	-0.4	-1.5	0.9	-0.8	0.	0.1	1.3	0.7	-0.4	-0.7	0.5	-23.3	-27.9	
	%(real - 97.5%)/M	-2.6%	-9.5%	-4.1%	-9.0%	2.8%	-9.9%	-1.0%	-113.7%	-82.5%	-2.2%	-20.1%	5.2%	-12.2%	1.9%	1.0%	7.5%	9.7%	-3.7%	-8.4%	4.9%	-160.9%	-272.0%	
2.5 %ile	real	53.6	19.1	16.7	25.1	26.8	25.8	39.	0.6	17.4	12.5	5.4	13.	3.3	12.	8.3	13.6	5.1	6.9	5.6	7.1	0.5	0.5	
M	real	62.8	23.5	22.9	30.4	31.2	31.9	45.5	4.9	28.2	16.6	7.7	16.8	6.3	16.	10.7	17.1	7.4	10.0	8.0	10.1	13.7	10.2	
97.5 %ile	real	71.4	27.4	29.1	37.3	36.3	37.1	54.	9.3	44.5	20.1	11.2	20.3	9.1	20.	13.6	20.7	10.1	12.7	10.7	14.8	36.4	27.9	

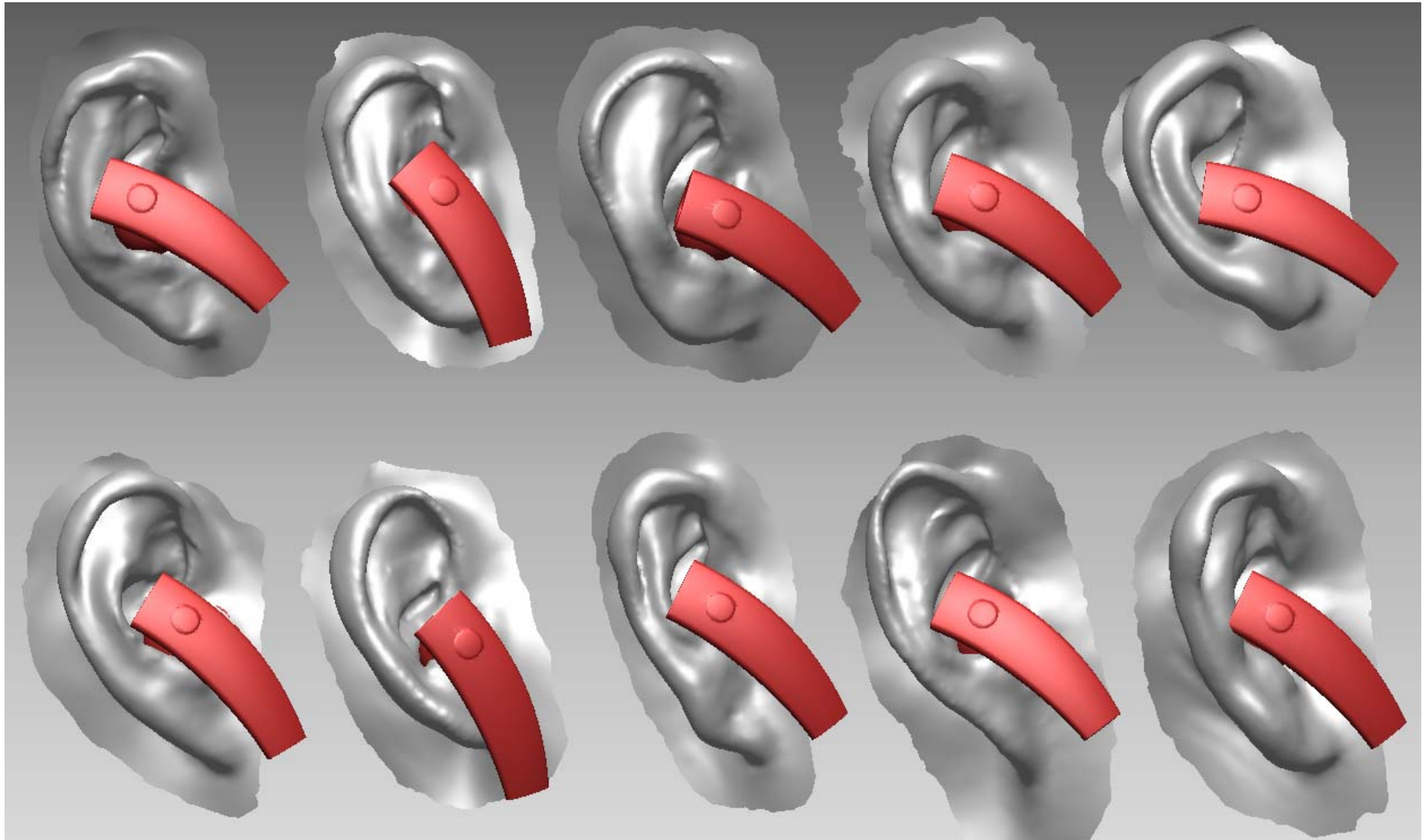Min (2.5%ile)　　Small (25%ile)　　Medium (50%ile)　　Large (75%ile)　　Max (97.5%ile)

Example: Earphone Wearing Types

Example: Contact of Earphone Tip at the Earhole

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