Microcomputed Tomography Visualization of the Cricoarytenoid Joint Cavity in Cadavers

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Summary: Objectives. To visualize the cricoarytenoid joint (CAJ) cavity of the human cadaver and to correlate its appearance to the CAJ capsule.
Study Design. Prospective.
Methods. A total of 26 cadavers were used for microcomputed tomography arthrography, histology, and epoxy sheet plastination examinations.
Results. (1) The dimension of the CAJ cavity was much larger than the articular surfaces; (2) The posterior capsule of the CAJ was significantly strengthened, contained rich elastin fibers, and shared a common attachment with the posterior cricoarytenoid muscle; (3) The arytenoid cartilage was distanced from the cricoid cartilage at the superomedial aspect of the CAJ.
Conclusions. This study demonstrates that the posterior fibrous capsule is the primary passive stabilizer of the CAJ and suggests that in addition to the gliding, rucking, and rotation, a visor-like jumping of the arytenoid cartilage on the cricoid cartilage may provide further adjustments in motions of the vocal fold. The finding of this study has implications for the biomechanics of the CAJ motion; the differential diagnosis of CAJ disorders, such as CAJ dislocation and subluxation; and surgical correction of the CAJ dysfunction.
Key Words: Cricoarytenoid joint–Arthrography–Micro-CT–Sheet plastination–Joint cavity.

INTRODUCTION

The cricoarytenoid joint (CAJ) is a small multiaxial synovial joint, which plays a pivotal role in respiration and phonation, and has been extensively studied.[1–8] The CAJ permits motion in a gliding, rocking, and rotation fashion.[2–4,7] The function and movement of the CAJ remain subjects of dispute and controversy owing to the relative inaccessibility of the CAJ for direct study and the complexity of the movement of the arytenoid cartilage.[2] Most investigations on the CAJ biomechanics and motion analysis have been based on the surface topography of the facets of the cricoid and arytenoid cartilages.[2,9,10] The size and shape of the articular cavity, however, are also the key determinates for the mobility of a joint.[11,12] The purpose of this study was to visualize the CAJ cavity of the human cadaver and to correlate its appearance to the configuration of the CAJ fibrous capsule by using microcomputed tomography (micro-CT) arthrography with intraarticular filling, histology, and sheet plastination techniques.

MATERIALS AND METHODS

A total of 26 cadavers (11 females and 15 males; age range, 54–93 years with a mean of 78.81 ± 8.55 years) were examined in this study. The cadavers were donated to the Department of Anatomy for the purposes of teaching and research under the Human Tissues Act and fixed with a self-made and formalin-based embalming solution.

Micro-CT

A total of 10 cadavers (4 females and 6 males; age range, 70–93 years with a mean of 81.60 ± 7.01 years) were used for micro-CT examination. The larynx was removed from the cadaver, and the CAJ was carefully exposed and injected with 10–20 μL of the self-made filling material. The injection site was at the posterosuperior aspect of the joint (Figure 1A). The specimen was placed on a holder of 50 mm in diameter with plasticine (JOVI, Spain). Scans were performed on an SkyScan 1172 (SkyScan N.V., Kontich, Belgium).

To collect data for three-dimensional (3-D) reconstruction, an aluminium and copper filter, a rotation step of the specimen every 0.4°, and a frame averaging 5 were used. Rotation was clockwise and up to 195°. A total of 503–523 micro-CT images were collected from each specimen. The collected images were reconstructed as 16-bit TIFF axial sections using the SkyScan *NRecon* software (BRUKER-MICROCT, Kontich, Belgium). The 16-bit TIFF axial sections were used for 3-D reconstruction of the cricothyroid joint. Image processing and 3-D reconstruction were performed with the program *AMIRA* 4.1 (Visage Imaging, San Diego, CA).

Histology examination

Two micro-CT-scanned specimens (an 89-year-old female and an 86-year-old male) were decalcified as recommended by Ted Pella, Inc. (Redding, CA). A Pelco BioWave Pro laboratory microwave oven equipped with a thermistor copper temperature probe and a microwave load cooler (Ted Pella, Inc, Redding, CA) was used for the decalcification process. The specimen was incubated in an ethylenediaminetetraacetic

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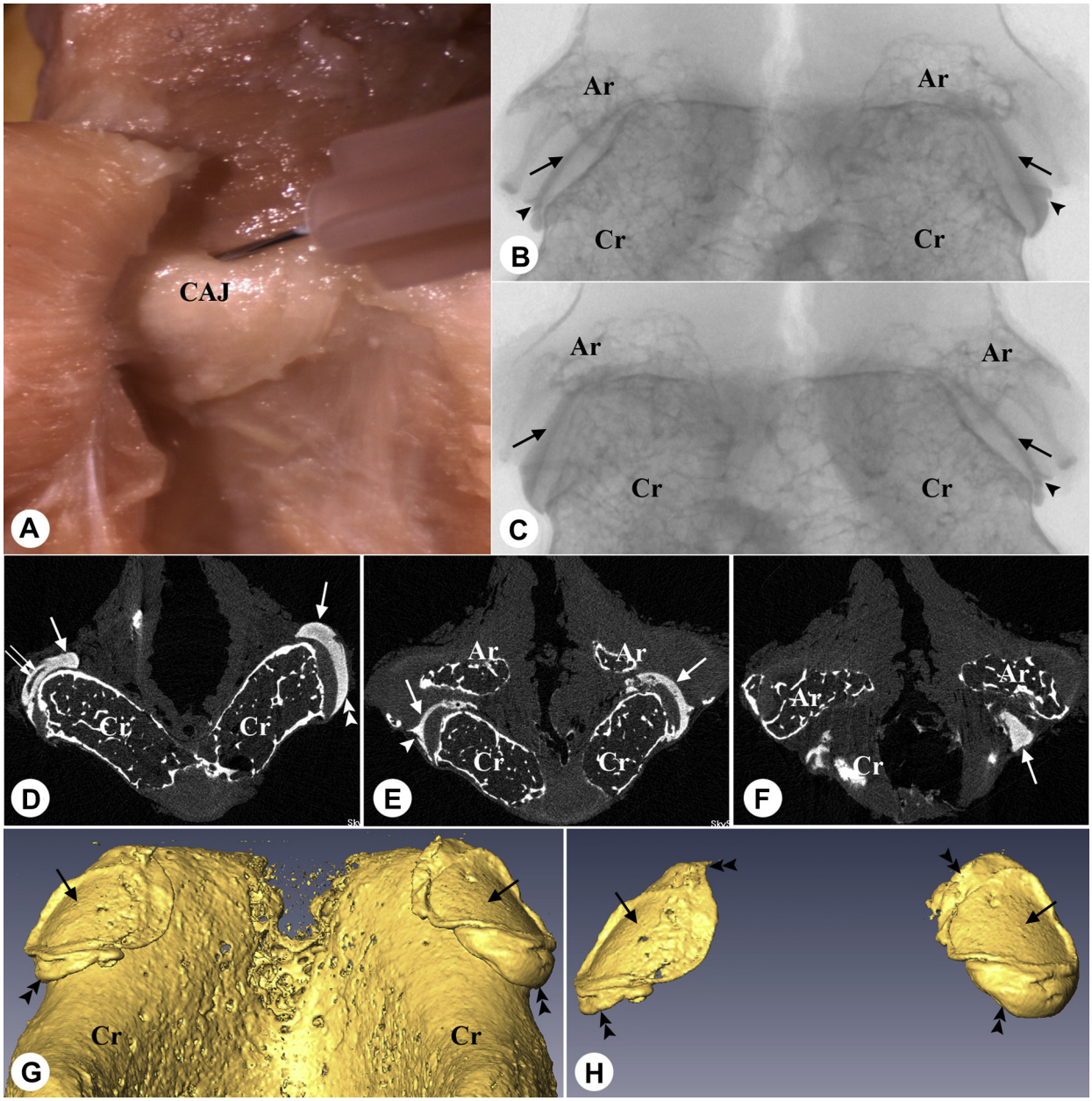

FIGURE 1. Appearance of the cricoarytenoid joint (CAJ) on the micro-CT images of a cadaveric specimen with the CAJ cavity filling. **A.** Shows that the filling was injected into the CAJ cavity via the posterosuperior aspect of the CAJ. **B and C.** Anteroposterior (**B**) and posteroanterior (**C**) view of the CAJ with the injected cavity filling. **D–F.** The transverse slices from the microcomputed tomography data set, which were taken at the inferior (**D**), middle (**E**), and superior (**F**) levels of the CAJ. Double arrows point to air bubbles in the cavity filling. **G and H.** The three-dimensional reconstruction models of the cricoid cartilage with the left and right CAJ cavities (**G**) and the left and right sole CTJ cavities (**H**). Arrows point to the CTJ cavities. Arrowheads point to a small indentation of the cavity filling. Double arrowheads point to the cavity recesses. Ar, arytenoid cartilage; Cr, cricoid cartilage.

acid (EDTA) solution (0.27M EDTA, pH 7.4); microwave irradiation was set at 150 W; the temperature was programmed to the maximum of 35°C. The EDTA solution was replaced every 4 hours. It took about 5 days to fully decalcify the specimens.

The decalcified specimen was dehydrated through a series of alcohol and xylene solution, and embedded in paraffin. Serial transverse or coronal sections were cut at a thickness of 7 μm, stained with either the hematoxylin-eosin or Verhoeff-van Gieson method, and examined under a light microscope (Olympus AX70 Provis, Tokyo, Japan).

Sheet plastination

A total of 16 sets of transverse (five sets), coronal (two sets), and sagittal (nine sets) sections from 16 cadavers (7 females and 9 males; age range, 54–89 years with a mean ± standard deviation of 77.06 ± 9.15 years) were used in the sheet plastination study. The plastination procedure was previously