Dose Evaluation of Eye Lens for Pediatric Inner Ear X-ray Diagnosis

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background

・Cochlear implant is the only auditory acquisition method for a deaf person who can not sufficiently obtain the effect of wearing a hearing aid. It is possible to acquire the language ability by wearing a cochlear implant and hearing practice early even in the congenital deafness child who is prone to delay in the development of the language.

・In recent years, the effectiveness of auditory application using cochlear implant has been recognized. Correspond with the number of surgeries in the cochlear implant is increasing every year. About half of them are children under the age of seven.

・In the Oto-Rhino-Laryngological Society of Japan(ORLSJ) , the adaptation standards for pediatric cochlear implants were reviewed and the adaptation age of medical interventions was lowered to one year or older in 2014.

・The image diagnosis of inner ear is performed by repeated examination. Although X-ray Computed Tomography(X-ray CT)imaging is mainly used, the X-rays are irradiated from whole circumference, so there are many organ exposures other than the target. Therefore, it is important to evaluate the eye lens absorbed dose.

・Recently, digital X-ray tomosynthesis using flat panel detectors (DT) has been used to diagnose the inner ears of pediatric patients.

purpose

The purpose of this research was to measure the eye lens absorbed dose during inner ear diagnosis using DT and to compare this dosage with X-ray CT.

methods

（1）DT

①Measurement of energy

The semiconductor detector ACCU-GOLD(AGMS- DM+ : Radcal) was placed on the bed of the X-ray TV device(SONIALVISION G4 : SHIMADZU), and the half value layer was measured. The effective energy of the incident primary X-ray was calculated from the value of the obtained half value layer. Irradiation conditions were the tube voltage of 60～110 KV, and the addition filter of Cu0.1 mm.

②Measurement for the eye lens absorbed dose

The cylindrical phantom was placed on the bed of the X-ray TV system. The phantom width is φ100 mm (the average head size of the newborn)(from 0 to 1 years old)) and φ150 mm(the average head size of the child (from 1 to 15 years old)). We performed tomosynthesis, assuming the conditions for an inner ear examination of an infant (posterior-anterior view(PA) and anterior-posterior view(AP)). A small optically stimulated luminescence(OSL) dosimeter(nanodot: Nagase Landauer, Ltd.) were positioned on the eye lens of a phantom at each view of the imaging, and the air kerma was measured(Fig.1).

Irradiation condition were the tube voltage of 60～110 kV, the addition filter of Cu0.1 mm, swing angle of ±20° ,and 76 photographs of a flame. The eye lens absorbed dose was calculated by multiplying the measured air kerma to the mass energy absorption coefficient ratio of the air and the eye lens.

（2）X-ray CT

Each cylindrical acrylic phantom was placed on the bed of the X-ray CT device (Supria: Hitachi).The small OSL dosimeter was attached to the eye lens position. The air kerma was measured by tube voltage of 80～120 kV, tube current of 50 mA. In addition, the eye lens absorbed dose were calculated in DT as well.

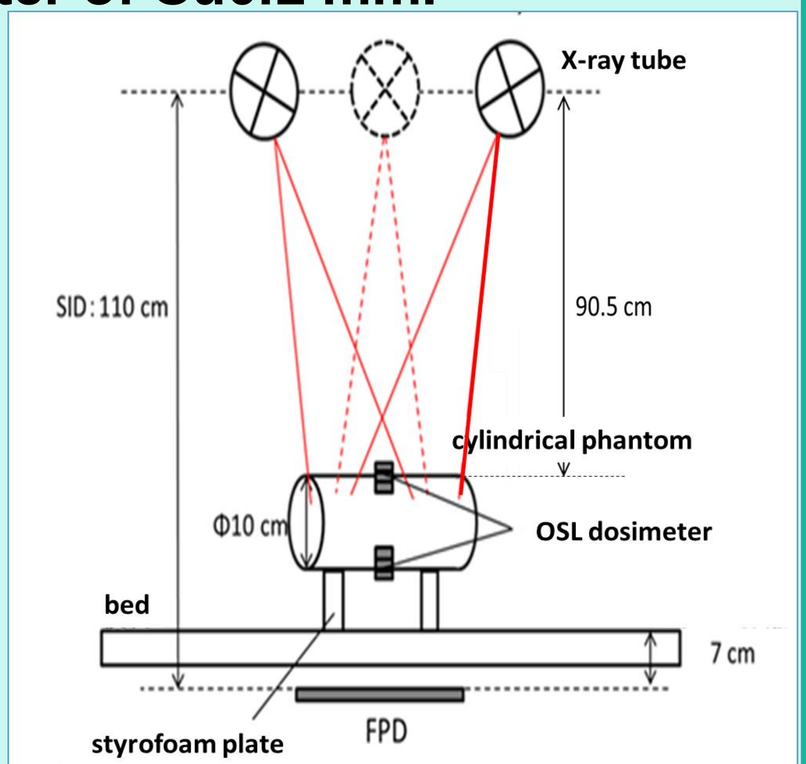

Figure 1 An example of detector arrangement for measurement of air kerma at a eye lens position

results/discussion

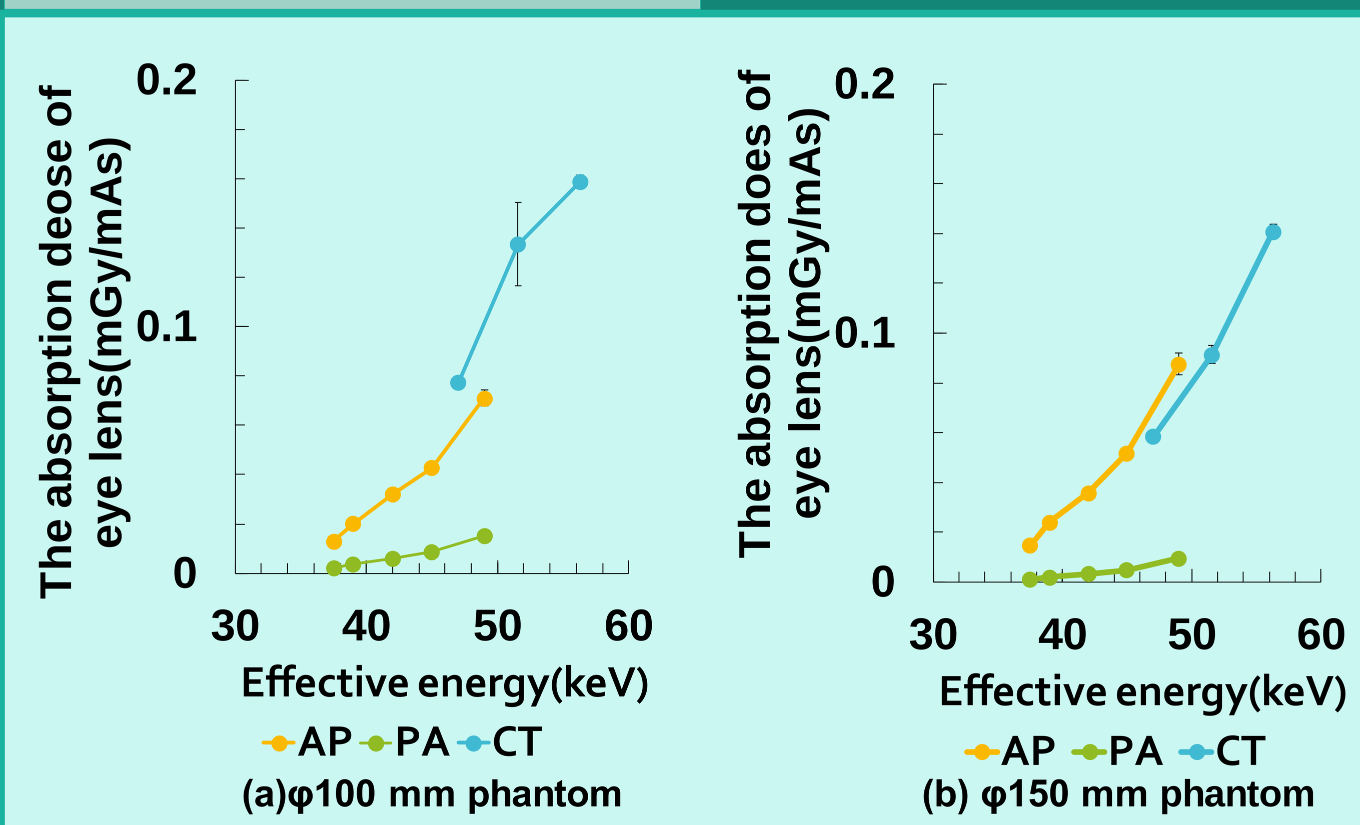

Figure 2 Comparison of the eye lens absorbed dose (DT and X-ray CT)

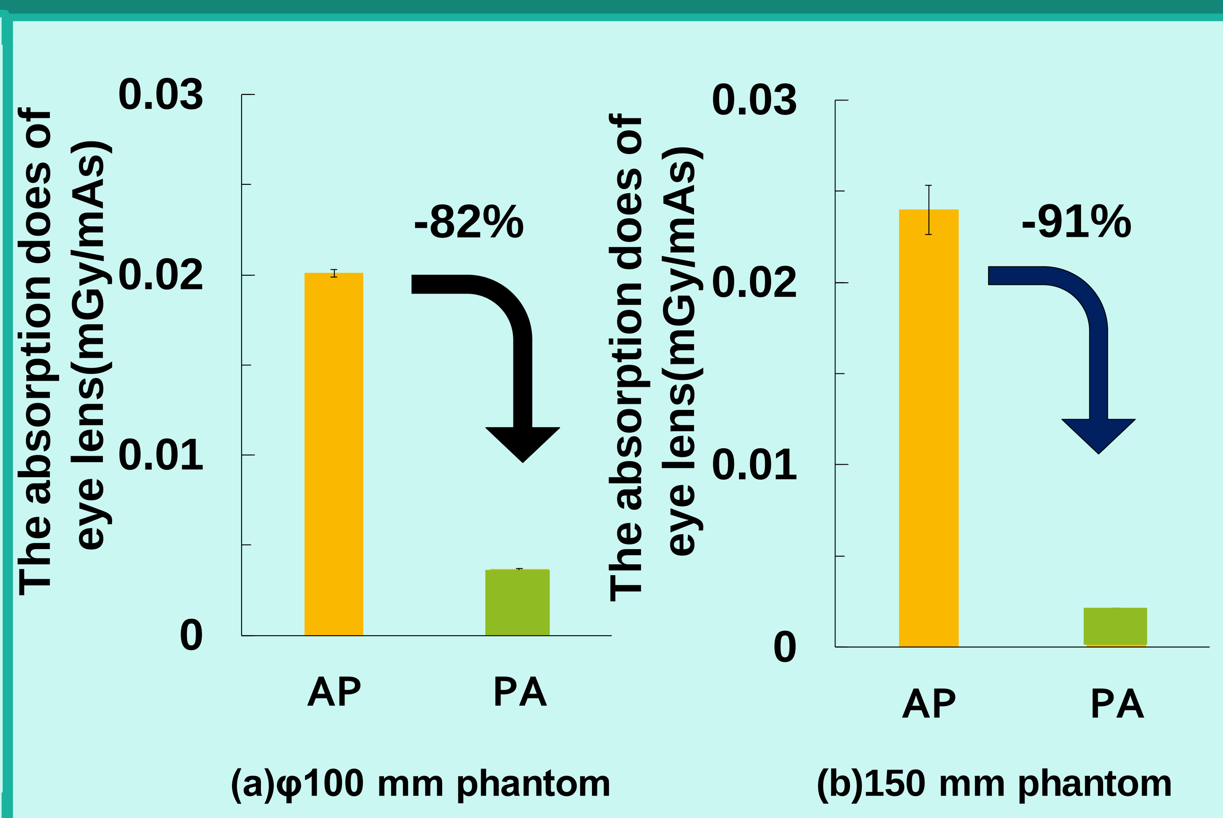

Figure 3 Attenuation rate for AP to PA by phantom diameter （tube voltage 70 kV）

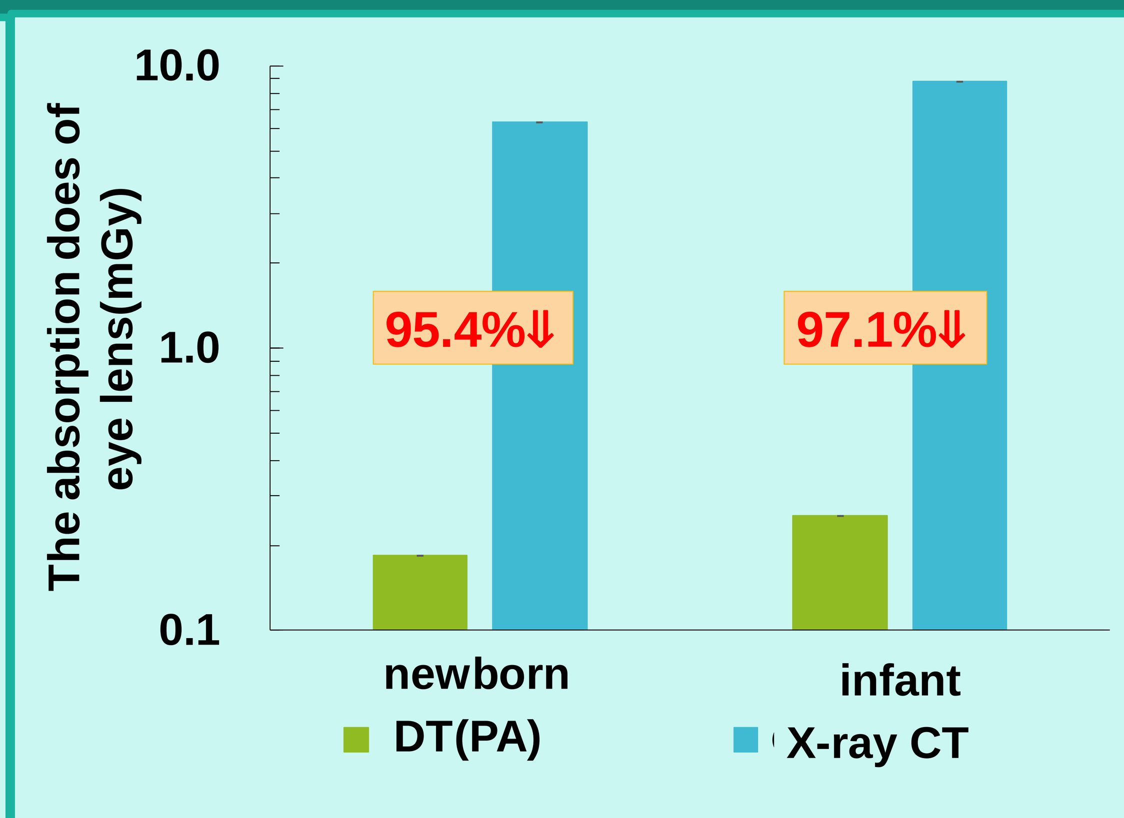

Figure 4 The eye lens absorbed dose by modality （using clinical condition）

The results of the eye lens absorbed dose of DT and X-ray CT were shown in Figure 2. In φ100 mm phantom, the eye lens absorbed dose was decreased by CT > AP> PA.

Attenuation rate by the difference position of DT was shown in Figure 3. when placed in a PA, as the phantom thickness increased, the absorbed dose decreased. On the contrary, when in an AP, as phantom thickness increased, the absorbed dose increased. In an AP, as the phantom diameter becomes large, the distance from the X-ray tube decreases, so the incidence dose is increased according to the inverse square rule of the distance. In DT, the attenuation rate for AP to PA became larger as the phantom diameter increases.

The eye lens absorbed dose of X-ray CT (120 kV) and DT (PA) (80 kV) calculated using clinical condition was shown in Figure 4. The eye lens absorbed dose of DT (PA) was reduced by more than 95% compared with X-ray CT, regardless of patient size.

conclusion

The DT(PA) is effective for reducing the eye lens absorbed dose, since that is kept low compared with X-ray CT. In clinical practice, the difference of the inner ear X-ray CT conditions at each hospital is large, and also DLP is about 40 times different. Therefore, it is necessary to select the appropriate modality in consideration of the radiation susceptibility of the organ and to optimize the radiation exposure.