学 位 論 文

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Usefulness of multislice-CT using multiplanar reconstruction in the preoperative assessment of the ossicular lesions in the middle ear diseases

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ABSTRACT

Objective: The aim of the study is to evaluate the usefulness of multislice computed tomography (MSCT) using multiplanar reconstruction (MPR) in obtaining preoperative information on the ossicular lesions of middle ear diseases by comparing the ossicular findings of MPR images with the operative findings.

Methods: Sixty-two ears and 10 ears with preoperative middle ear diseases underwent 4- and 64-detector row CT of the temporal bone in Kagawa University Hospital, respectively. MPR images of three ossicles were created at the planes parallel to the long axis of ossicles.

Results: The findings of the three ossicles in MPR images were compatible with their operative findings in approximately 91% of 72 ears with various middle ear diseases. There was no significant difference in the coincidence rate of both findings between 4- and 64-detector row CT scanners. The ears with no soft tissue shadows around the ossicles had the coincidence rate of 96–100% in each ossicular part, whereas the coincidence rate was lower in the ears with soft tissue shadows around the ossicles.

Conclusion: MPR imagings of the ossicles provide accurate preoperative information on the ossicular lesions in middle ear diseases. The 4-detector CT is still a useful device for imaging of the ossicles.

1. Introduction

Multislice computed tomography (MSCT) provides a superior image quality of a high-resolution compared with a single-slice scanning because of improved detail resolution along the patient's *z* axis and an increased scan velocity [1,2]. It has been widely pointed out that MSCT is useful in the assessment of temporal bone pathology [3]. Several imaging techniques such as multiplanar reconstruction (MPR) images, three-dimensional images and virtual endoscopy [4–8] have been applied in the diagnosis of the middle ear diseases. The auditory ossicular chain has recently been assessed by these imaging techniques [9–12]. In Kagawa University Hospital MPR images of three ossicles have been taken in routine together with the axial and coronal images since 1999. The usefulness of these MPR images in the evaluation of the ossicular lesions in the middle ear diseases was examined by

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comparing the findings of MPR images with operative findings. We also examined the difference in the evaluation of the ossicular lesions between 4- and 64-detector row CT scanners.

2. Materials and methods

Sixty-two ears of 61 patients (31 men, 30 women) ranging 5–72 years old with a mean age of 42.8 years underwent a preoperative MSCT using a 4-detector row in Kagawa University Hospital. Their diseases were cholesteatoma in 29 ears, chronic otitis media in 23 ears, trauma in 5 ears, malformation in 4 ears and stapes fixation in 1 ear.

Ten ears of 10 patients (4 men, 6 women) ranging 17–72 years old with a mean age of 41.8 years underwent a preoperative MSCT using a 64-detector row in Kagawa University Hospital. The disease was cholesteatoma in all ears.

MSCT imaging was performed using a 4-detector-row CT scanner (Aquilion®, Toshiba Medical Systems Corporation, Tokyo, Japan) from 2001 to 2007, and a 64-detector-row CT scanner (Aquilion®) from 2008 to 2010. The axial spiral scans were obtained using the following parameters:

MSCT imaging was performed using a 4-detector row CT scanner (Aquilion®, Toshiba Medical Systems, Tokyo, Japan) from 1999 to 2003, and using a 64-detector row CT scanner (Aquilion®) from 2011 to 2012. The axial spiral scans were obtained using the following parameters: a helical pitch of 3.5, 0.5-mm collimation thickness, 1 s rotation time, 0.2-mm reconstruction interval, high-resolution reconstruction algorithm (FC 80), 512 × 512 matrix, 100-mm field of view, a tube current of 350 mA, a tube voltage of 120 kV, a window width of 4000, and a window level of 400. The acquired high-resolution data were transferred to a workstation (ALATO VIEW®, Toshiba and zaiostation 2®, Ziosoft, Inc., Tokyo, Japan). The MPR images were created in the planes parallel to the long axis of the ossicles and then analyzed on the monitor screen by the expert radiologist in temporal bone radiology (Y.T.), to whom no information on the operation findings of the ossicles was given.

The chart findings of the ossicles described by the operators (N.M., H.H., T.M. and O.Y) to whom no findings of MPR images assessed by the radiologist (Y.T.) had been given prior to the operation.

The chart findings of the MPP images and the operation were analyzed based on a three point scoring system: 2 if it was intact and well defined, 1 if present but not well defined or partially eroded, and 0 if destroyed and absent. Every structure with a score of 1 or 2 was taken to be positive and 0 was taken to be negative [12]. Based on these results, we calculated the sensitivity (the number of cases which was observed as positive both in one type of MPR images and in the surgery/the number of cases which was observed as positive in surgery), specificity (the number of cases which was observed as negative both in one type of MPR images and in the surgery/the number of cases which was observed as negative in surgery) and coincidence rate [(the number of cases which was observed as positive both in one type of MPR images and in surgery + the number of cases which was observed as negative both in one type of MPR images and in surgery)/the total number of cases] for every structure [12].

Chi-square test was used in the statistical analysis of the coincidence rate of the findings, and $p < 0.05$ was considered statistically significant.

3. Results

3.1. Representative MPR images of the ossicles in diseased ears

MPR images of the ossicles were constructed as shown in Fig. 1. The parts of the malleus, the incus and the stapes

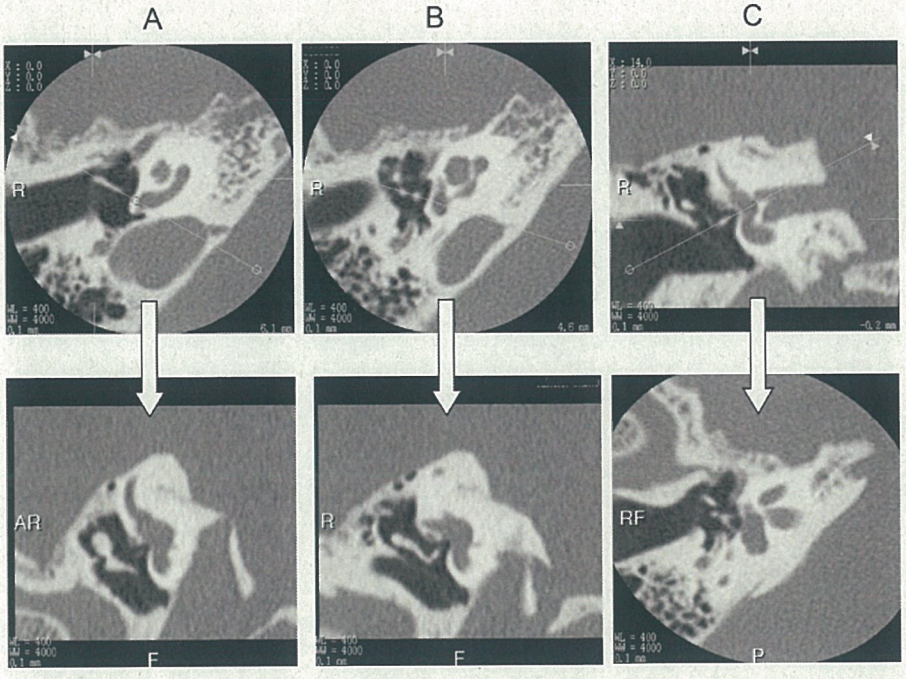

Fig. 1. The construction of MPR images of the ossicles. (A) Malleus, (B) incus, and (C) stapes.

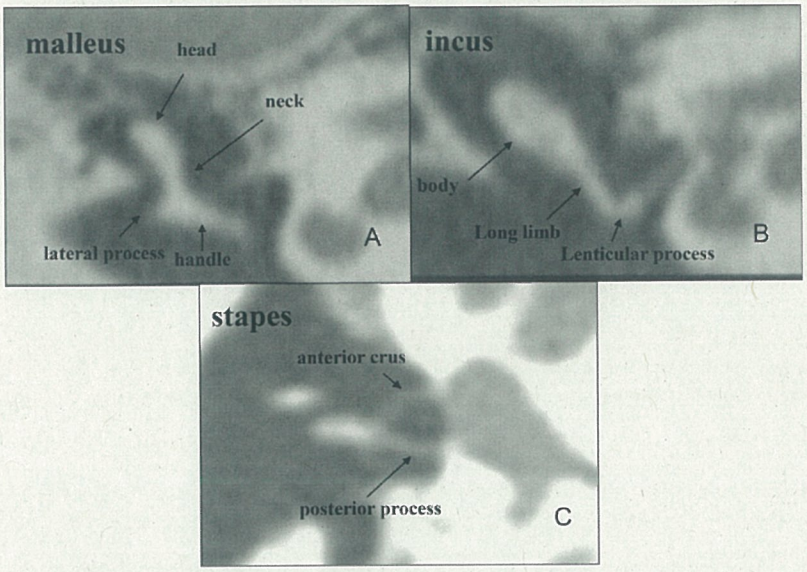

Fig. 2. The ossicular parts shown in MPR images of the ossicles. (A) Malleus, (B) incus, and (C) stapes.

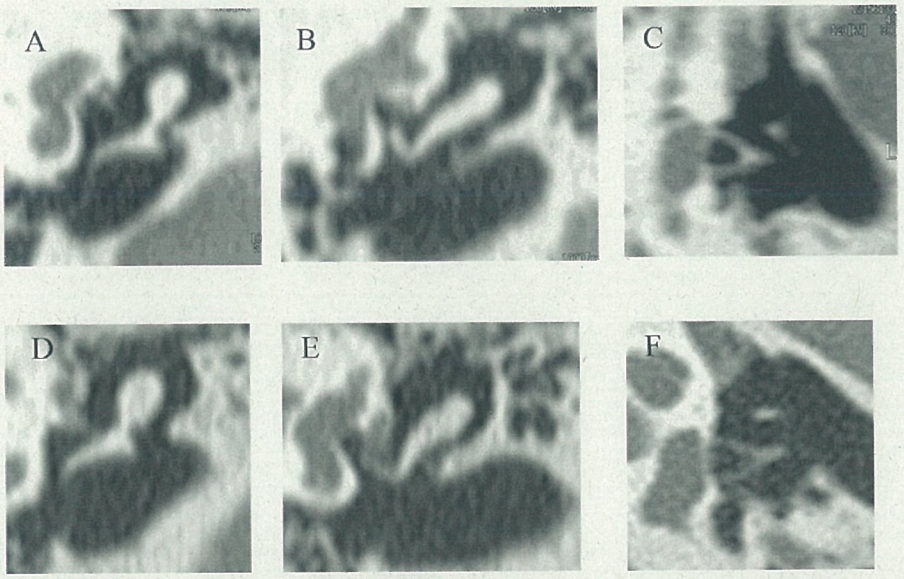

Fig. 3. MPR images using 4- and 64-detector row CT scanners in normal ossicles. The upper images (A–C) and the lower images (D–F) were made using 4- and 64-detector row CT scanners, respectively. Left: malleus, middle: incus, right: stapes.

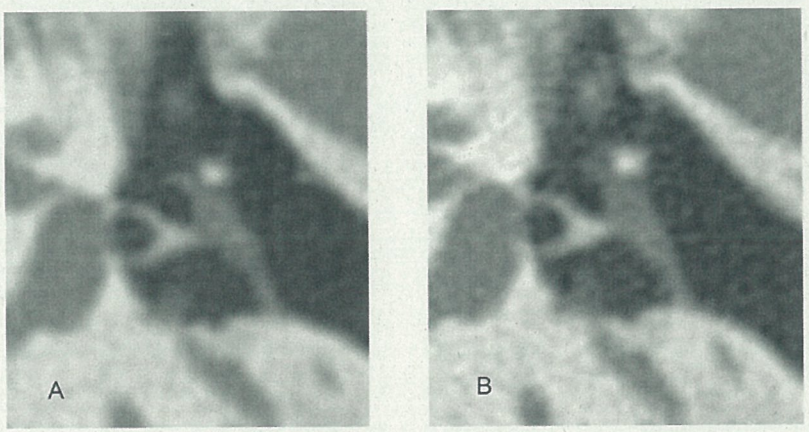

Fig. 4. MPR images of the stapes with 4- and 64-detector row CT scanners in the same postoperative ear with cholesteatoma.

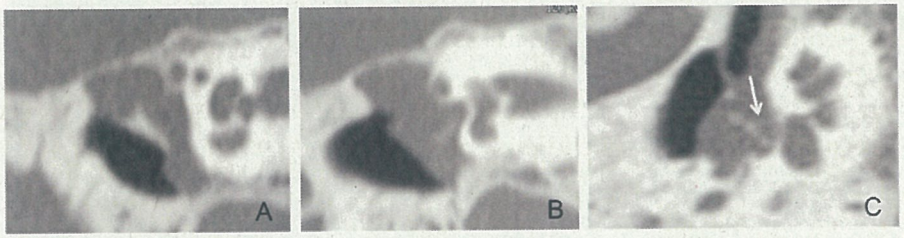

Fig. 5. MPR images with 4-detector row CT scanner in an ear with attic cholesteatoma. The malleus head and incus are destroyed, and the crura of the stapes are erosive as shown by the arrow. (A) Malleus, (B) incus, and (C) stapes.

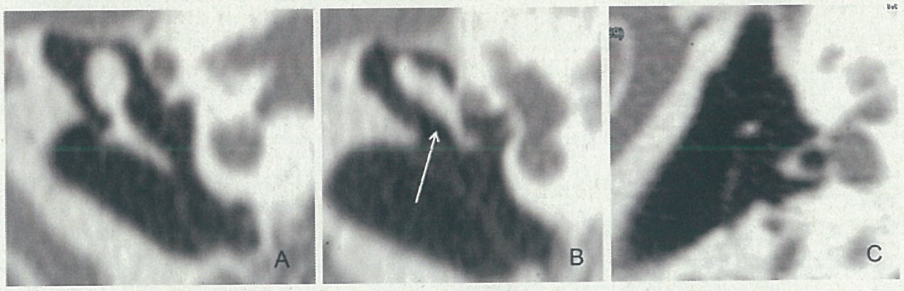

Fig. 6. MPR images with 4-detector row CT scanner in an ear with traumatic ossicular discontinuity. The incus is dislocated as shown by the arrow. (A) Malleus, (B) incus, and (C) stapes.

Table 1
The quantity evaluation for each ossicular parts in CT and surgical operation.

The ossicular parts	CT (score)			Operation (score)			Sensitivity (%)	Specificity (%)	Coincidence rate (%)
	2	1	0	2	1	0			
Malleus head	53	14	5	51	15	6	100	83.3	98.6
Malleus handle	65	1	6	68	0	4	97.1	100	97.2
Incus body	46	13	13	44	17	11	95.1	90.9	94.4
Long limb of incus	42	9	21	64	0	8	96.1	90.5	94.4
Lenticular process of incus	50	4	18	48	2	22	98	79.3	91.7
Superstructure of stapes	48	14	9	61	4	6	98.5	100	97.2

are shown in Fig. 2. MPR images using 4- and 64-detector row CT scanners were identical in normal ossicles as shown in Fig. 3.

Fig. 4 shows MPR images of the stapes in 4- and 64-detector row CT scanners in the same ear with cholesteatoma having undergone type 3 tympanoplasty using columella made from the autologous auricle cartilage. There was no difference in spatial resolution between both CT scanners. Fig. 5 shows an example of MPR images of 4-detector row CT in an ear with cholesteatoma, which demonstrated the destruction of the malleus head and the whole incus with erosive superstructure of the stapes. Fig. 6 shows an example of MPR images of 4-detector row CT in an ear with traumatic ossicular discontinuity, which demonstrated the dislocated incus.

Table 2
The coincidence rate of ears with cholesteatoma between 4- and 64-detector row CT.

The ossicular parts	4-Detector row CT	64-Detector row CT
Malleus head	28/29 (96.6%)	10/10 (100%)
Malleus handle	27/29 (93.1%)	10/10 (100%)
Incus body	26/29 (89.7%)	10/10 (100%)
Long limb of incus	26/29 (89.7%)	10/10 (100%)
Lenticular process of incus	27/29 (93.1%)	10/10 (100%)
Superstructure of stapes	28/29 (96.6%)	9/10 (90%)

3.2. Comparison of the ossicular findings between MPR image and operation

The coincidence rate of the findings between MPR images and the operation was 97–99% in the malleus head, the malleus handle and the superstructure of the stapes, and 91–94% in the body, long limb and lenticular process of the incus (Table 1). There was no significant difference in the coincidence rate of ears with cholesteatoma between 4- and 64-detector row CT (Table 2). The coincidence rate in each ossicular part was observed in 96–100% of ears with no shadows around the ossicles, whereas the coincidence rate in long limb and lenticular process of the incus, and superstructure of the stapes was lower in ears with soft tissue shadows (Table 3). There was a significant difference in the coincidence rate of lenticular process of the incus between the ears with shadows and without shadows. There was no significant difference in the coincidence rate of ears with cholesteatoma, chronic otitis media, trauma, and malformation (Table 4).

Table 5 shows the coincidence rate in various types of tympanoplasty. The ears with type 1 tympanoplasty had the

Table 3
The quantity evaluation for every structure in the ossicular chain with or without shadows in MPR images and operation.

The ossicular parts	With shadows						Sensitivity (%)	Specificity (%)	Coincidence rate (%)
	CT (score)			Operation (score)					
	2	1	0	2	1	0			
Malleus head	30	11	3	29	12	3	100	100	100
Malleus handle	32	1	4	34	0	3	97.1	100	97.3
Incus body	23	12	10	21	16	8	91.9	87.5	91.1
Long limb of incus	20	7	14	20	6	15	96.2	86.7	92.7
Lenticular process of incus	24	4	12	23	1	16	95.8	68.8	85
Superstructure of stapes	19	10	7	28	4	4	93.8	100	94.4
The ossicular parts	Without shadows						Sensitivity (%)	Specificity (%)	Coincidence rate (%)
	CT (score)			Operation (score)					
	2	1	0	2	1	0			
Malleus head	23	3	2	22	3	3	100	66.7	96.4
Malleus handle	33	0	2	34	0	1	97.1	100	97.1
Incus body	23	1	3	23	1	3	100	100	100
Long limb of incus	22	2	7	23	2	6	96	100	96.8
Lenticular process of incus	26	0	6	25	1	6	100	100	100
Superstructure of stapes	29	4	2	32	1	2	100	100	100

Table 4
The quantity evaluation for each ossicular parts in CT and operation in each disease.

The ossicular parts	Cholesteatoma						Sensitivity (%)	Specificity (%)	Coincidence rate (%)
	CT (score)			Operation (score)					
	2	1	0	2	1	0			
Malleus head	22	13	4	19	15	5	100	80	97.4
Malleus handle	34	1	4	37	0	2	94.6	100	94.9
Incus body	16	12	11	12	17	10	93.1	90	92.3
Long limb of incus	16	6	17	17	4	18	95.2	88.9	92.3
Lenticular process of incus	26	1	12	25	0	14	100	85.7	94.9
Superstructure of stapes	22	10	7	31	4	4	97.1	100	94.9
The ossicular parts	Chronic otitis media						Sensitivity (%)	Specificity (%)	Coincidence rate (%)
	CT (score)			Operation (score)					
	2	1	0	2	1	0			
Malleus head	22	0	1	22	0	1	100	100	100
Malleus handle	22	0	1	22	0	1	100	100	100
Incus body	20	1	2	22	0	1	95.5	100	95.7
Long limb of incus	18	3	2	17	4	2	100	100	100
Lenticular process of incus	18	3	2	16	2	5	100	40	87
Superstructure of stapes	18	3	1	21	0	1	100	100	95.7
The ossicular parts	Trauma						Sensitivity (%)	Specificity (%)	Coincidence rate (%)
	CT (score)			Operation (score)					
	2	1	0	2	1	0			
Malleus head	5	0	0	5	0	0	100	–	100
Malleus handle	5	0	0	5	0	0	100	–	100
Incus body	5	0	0	5	0	0	100	–	100
Long limb of incus	5	0	0	5	0	0	100	–	100
Lenticular process of incus	4	0	1	4	0	1	100	100	100
Superstructure of stapes	5	0	0	5	0	0	100	–	100
The ossicular parts	Malformation						Sensitivity (%)	Specificity (%)	Coincidence rate (%)
	CT (score)			Operation (score)					
	2	1	0	2	1	0			
Malleus head	3	1	0	4	0	0	100	–	100
Malleus handle	3	0	1	3	0	1	100	100	100
Incus body	4	0	0	4	0	0	100	–	100
Long limb of incus	2	0	2	3	0	1	100	50	75
Lenticular process of incus	2	0	2	3	0	1	100	50	75
Superstructure of stapes	2	1	1	2	1	1	100	100	100

Table 5
The coincidence rate of ears with each type of tympanoplasty.

The ossicular parts	Type of tympanoplasty		
	Type I	Type III	Type IV
Malleus head	17/17 (100%)	43/44 (97.7%)	8/8 (100%)
Malleus handle	17/17 (100%)	43/44 (97.7%)	7/8 (87.5%)
Incus body	17/17 (100%)	40/44 (90.9%)	8/8 (100%)
Long limb of incus	17/17 (100%)	41/44 (93.2%)	7/8 (87.5%)
Lenticular process of incus	17/17 (100%)	39/44 (88.6%)	7/8 (87.5%)
Superstructure of stapes	16/16 (100%)	43/44 (97.7%)	7/8 (87.5%)

coincidence rate of 100%, whereas the coincidence rate was by 2–12% lower in ears with tympanoplasty of type 3 and type 4. There were no significant differences among the three types of tympanoplasty in all ossicular parts.

4. Discussion

The present study demonstrates a high coincidence rate of ossicular findings between MPR imaging and the operation. Particularly in ears with no soft tissue shadow around the ossicles, the coincidence rate of the ossicular findings was near 100%. The coincidence rate of the findings on the each parts of the incus was 85–92.7% and superstructure of the stapes was 94.4% in ears with soft tissue shadows around the ossicles. The ears with no shadows around the ossicles had significantly higher coincidence rate of lenticular process of the incus than those with shadows. Although the coincidence rate tended to be lower in ears with cholesteatoma than that in ears with other diseases, the coincidence rate may depend on the presence of soft tissue shadows around the ossicles rather than the kind of diseases. In case with soft shadow around the ossicular chain, radiologists have a tendency to overestimate the ossicular region by partial volume effect. To improve this problem, thinner collimation thickness in CT will be effective. The MPR images provide accurate information on the lenticular process of the incus and the superstructure of the stapes which are important to reconstruct the ossicular chain. Zhang et al. [12] have reported that MPR images of the lenticular process of the incus and the superstructure of the stapes had the coincidence rate of 70–80% in ears with chronic otitis media including cholesteatoma. Guo et al. [16] and Liu et al. [11] reported that MPR images of the lenticular process of the incus had the coincidence rate of 89% in ears with chronic otitis media, and the superstructure of the stapes had the coincidence rate of 96% in ears with chronic otitis media and 75% in ears with cholesteatoma. Using conventional axial and coronal section plane, Liu et al. [11] reported that the superstructure of the stapes had the coincidence rate of 40% in ears with cholesteatoma. In addition, partial defects of the stapes crus could not be correctly diagnosed by conventional section planes [17], and sensitivity, specificity and accuracy levels of conventional section planes were lower than those of MPR [11].

In the present study, 4- and 64-detector row CT scanners made in the same company were used. Currently, a 64-detector row CT is becoming increasingly used in hospitals. Although a 64-detector row CT has greatly superior temporal resolution compared to a 4-detector row CT [13], there is no significant difference in spatial resolution of temporal bone between two types of CT scanners [14]. Our recent study revealed no difference in MPR images of the stapes between two types of CT scanners [15]. The 4-detector CT is still a useful device for imaging of the ossicles.

5. Conclusion

MPR images are useful in evaluating the pathology of the ossicles in the middle ear diseases except the movement of the stapes footplate. In more than 97% of ears the findings of MPR imaging in head and handle of the malleus, and superstructure of the stapes were compatible with the operative findings. The ears with no soft tissue shadows around the ossicles had the excellent coincidence rate of ossicular findings between MPR image and operation. The 4-detector CT is still a useful device for imaging of the ossicles.

Conflict of interest

None.

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