Assessment of Acute Osteomyelitis in the Mandible using Diffusion Weighted MR Imaging

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Running title: Assessment of Acute Osteomyelitis in the Mandible using DWI

Key words: Osteomyelitis, MRI, DWI, ADC-value

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1 Abstract

Diffusion-weighted imaging (DWI) has been used for differentiation of malignant tumors of head and neck from benign tumors. However, few studies have reported about apparent diffusion coefficient (ADC) values in the mandible with osteomyelitis using DWI. The purpose of our present study was to investigate the mean of ADC values in the mandibular bone marrow with acute osteomyelitis and normal subjects.

We evaluated the magnetic resonance imaging studies of 50 patients from April 2018 to March 2019. The present study investigated to mean of ADC values in the normal and acute osteomyelitis. Furthermore, both groups ADC values differences also examined. We analyzed these data using the Mann-Whitney U test. $P < 0.05$ was reasoned to significance.

The ADC values in bone marrow with acute osteomyelitis were significantly higher than those of normal group ($P < 0.05$). ADC values were significantly differences between normal group and acute osteomyelitis group. This information suggested that useful for the quantitative evaluation of osteomyelitis.

Key Words: Osteomyelitis, MRI, DWI, ADC value

2 Introduction

Osteomyelitis of the mandible is most commonly caused by bacterial infections (1). In adults, osteomyelitis is usually an acute or chronic infection that develops follow to an open wound to the bone and around soft tissue. Acute osteomyelitis is caused by hematogenous spread or direct inoculation, and bacterial growth within the bone induces an acute suppurative response. Chronic osteomyelitis represents bone destruction and sequestrum formation. It is usually treated with medicine and surgical cleaning. Although, it can persist lengthening for years with frequent treatment failure or relapse (2, 3).

Radiological imaging techniques play an essential part in the early diagnosis and follow-up of skeletal inflammatory conditions. The importance of radiology and imaging in the cases of osteomyelitis of the jaws is well documented in the past literature. It has also been reported that magnetic resonance imaging (MRI) is helpful in the diagnosis of mandibular osteomyelitis (4-9). DWI make use of the brownian motion of water protons in biological tissue. This movement mirrors the tissue unique diffusion capacity and can be used to characterize the organization. This movement brings results that dispersion phase of diffusion hyposensitized protons of water along the applied diffusion gradients and consecutively to a loss of signal on DWI. This signal loss is

proportional to the diffusion intensity used and the mobility of water protons (10-12). DWI data based on MRI can be used for determination of quantitative diffusion values such as the ADC. ADC is a parameter for the amount of diffusion (proton of water) in the tissue. Many studies have reported evaluation to ADC values in musculoskeletal region such as normal bone marrow, osteoporosis, osteomyelitis, malignancy and trauma (13-15). However, there was a little attention to evaluate osteomyelitis of the mandible using DWI.

The purpose of the present study was to investigate the mean of ADC values in the mandibular bone marrow with acute osteomyelitis and normal subject.

3 Materials and Methods

We designed and implemented a retrospective cohort study, which was approved by our university ethics committee (EC19-011). Patients were underwent magnetic resonance imaging at the Nihon University School of Dentistry Hospital, Matsudo, Chiba, Japan, from April 2018 to March 2019. Normal group (12 men, 10 women, 48-90 years of age, mean age 70.09 years) were consisted from outpatients who underwent MRI in oral maxillofacial area. Acute osteomyelitis groups (10 men, 18 women; 20- 87 years of age, mean age 57.14 years) were diagnosed by typical clinical symptoms (Severe pain and redness in the area of the infection, Vincent‘s and Yumikura symptom) and typical MR imaging (T1WI, T2WI, STIR) according to criteria of Baltensperger et al (16). Exclusion criteria were a history of radiotherapy, and disease (e.g., hematological disorders and inflammatory diseases, tumor or cyst of the mandible) affecting the mandibular bone marrow.

MRI was performed with a 1.5-T superconductive MR unit (Intera Achieva® 1.5 T Nova; Philips Medical Systems, Netherlands) and head coil. T1-weighted images (T1WI) were acquired using the following parameters: TR/TE = 550/15 and 120 msec. T2-weighted images (T2WI) were acquired using the following parameters: TR/TE = 3500/120 and 120 msec, 6.0 mm section thickness, 192 × 256 matrix, 120 × 120 mm

field of view, and one acquisition. Short tau inversion recovery (STIR) images were obtained using a spin echo sequence with the following parameters: TR/TE = 2500/60 and 180 msec, respectively. Other study conditions were set as follows: 6.0 mm section thickness, 320 × 256 matrix, 230 × 195.5 mm field of view, and 1 acquisition. Diffusion-weighted study conditions were set as follows: TR/TE = 5100/70 msec; 6.0 mm section thickness, 256×256 matrix, 250×250 mm field of view, and 1 acquisition. ADC map was made on MRI console. The regions of interest (ROIs) were manually drawn on the ADC map on which the mandibular bone marrow from lower first premolar to lower second molar in normal groups. In acute osteomyelitis groups, the regions of interest were manually drawn on the ADC map which was high signal intensity area on STIR. The mandibular canal, root and cortical bone were excluded. On ADC map, ADC values of bone marrow (normal and acute osteomyelitis) were independently measured and recorded by two oral radiology specialists. When disagreements occurred, the radiologists reached the final size by consensus.

Each of the two groups were then compared using the Mann-Whitney U-test. These analyses were performed with a statistical package (SPSS version 21.0®, IBM Japan Inc., Tokyo, Japan). $P < 0.05$ was considered to indicate significance.

4 Results

Table 1 shows mean ADC values of the total cases in the mandibular bone marrow with acute osteomyelitis group and normal group. On DWI, the mean ADC values in normal group of men were 0.97± 0.09×10^{-3} mm^2/s and of women were 0.99±0.10×10^{-3} mm^2/s. The mean ADC values in acute osteomyelitis group of men were 1.18± 0.11×10^{-3} mm^2/s and of women were 1.26±0.08×10^{-3} mm^2/s.

Table 2 shows mean ADC values of the normal group and acute osteomyelitis group in the mandible. The mean ADC values were 0.98±0.10×10^{-3} mm^2/s and 1.23±0.10×10^{-3} mm^2/s, corresponding to the normal group and acute osteomyelitis group, respectively (Fig. 1). Significantly different was found between normal group and osteomyelitis group ($P < 0.05$).

5. Discussion

Significant different ADC values were found in the osteomyelitis between normal group and acute osteomyelitis group in this study. Osteomyelitis results from hematogenous spread, but direct spread from trauma and/ or ulcers is also relatively common. In the early stages of infection, the bacteria multiply and cause a local inflammatory response, causing local bone edema. Over time, the infection is demarcated by the edges of the granulation tissue and the deposition of new bone. Furthermore, drainage and/ or surgical debridement is often necessary (2), (3), (17). MRI enables early detection of osteomyelitis. MRI is thought to the most helpful radiological imaging technique to evaluate suspected osteomyelitis, because of its ability to demonstrate changes in the water content of bone marrow with an excellent structural definition and spatial resolution. Acute osteomyelitis is characterized by bone marrow edema. This sign is seen on MRI and is detected 1-2 days after the outbreak of infection (18). Among them, diffusion seems to be influenced by parameters such as viscosity, temperature and pressure. In addition, physiological parameters can also affect diffusion; these parameters are significant because extracellular matrices and fluids are of great importance in the clinically. Physiological parameters include cellularity, amount and ratio of intracellular and extracellular fluid, nucleus-to-cytoplasm ratio, and

vascularity. Significant changes these parameters, the pixel intensity of the diffusion weighted sequence may change (15). By calculating the ADC value, reflect the tissue specific diffusion capacity of the organization. Therefore, ADC value is objective parameter that can be used to characterize tissues. Many studies have reported that bone marrow diffusion using ADC value in the past (19). However, there were few reports of ADC value in the evaluation of osteomyelitis in the mandible. Sasaki (20) reported that the mean ADC value for bone marrow in normal cases were $0.97\pm0.17\times10^{-3}$ mm^2/s. In spondylodiscitis, restricted diffusion resulting in high signal intensity on DWI (21). And, low ADC values were reported, similar to malignancy (21). A possible explanation for these reports is that hyper cellularity and the presence of macromolecules lower the diffusivity in inflammatory tissue. In contrast, this present study found the mean ADC values of acute osteomyelitis were statistically significantly higher than normal.
The present study found that ADC value in the mandible increased in patients with acute osteomyelitis. This information may be useful for indistinguishable from malignant tumors on conventional X-rays and regular MRI.

In conclusion, the present study examined the ADC value of bone marrow of the mandible and significant differences were seen between the normal group and acute osteomyelitis group.

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Conflict of Interest: The authors have declared that no COI.

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Fig. 1

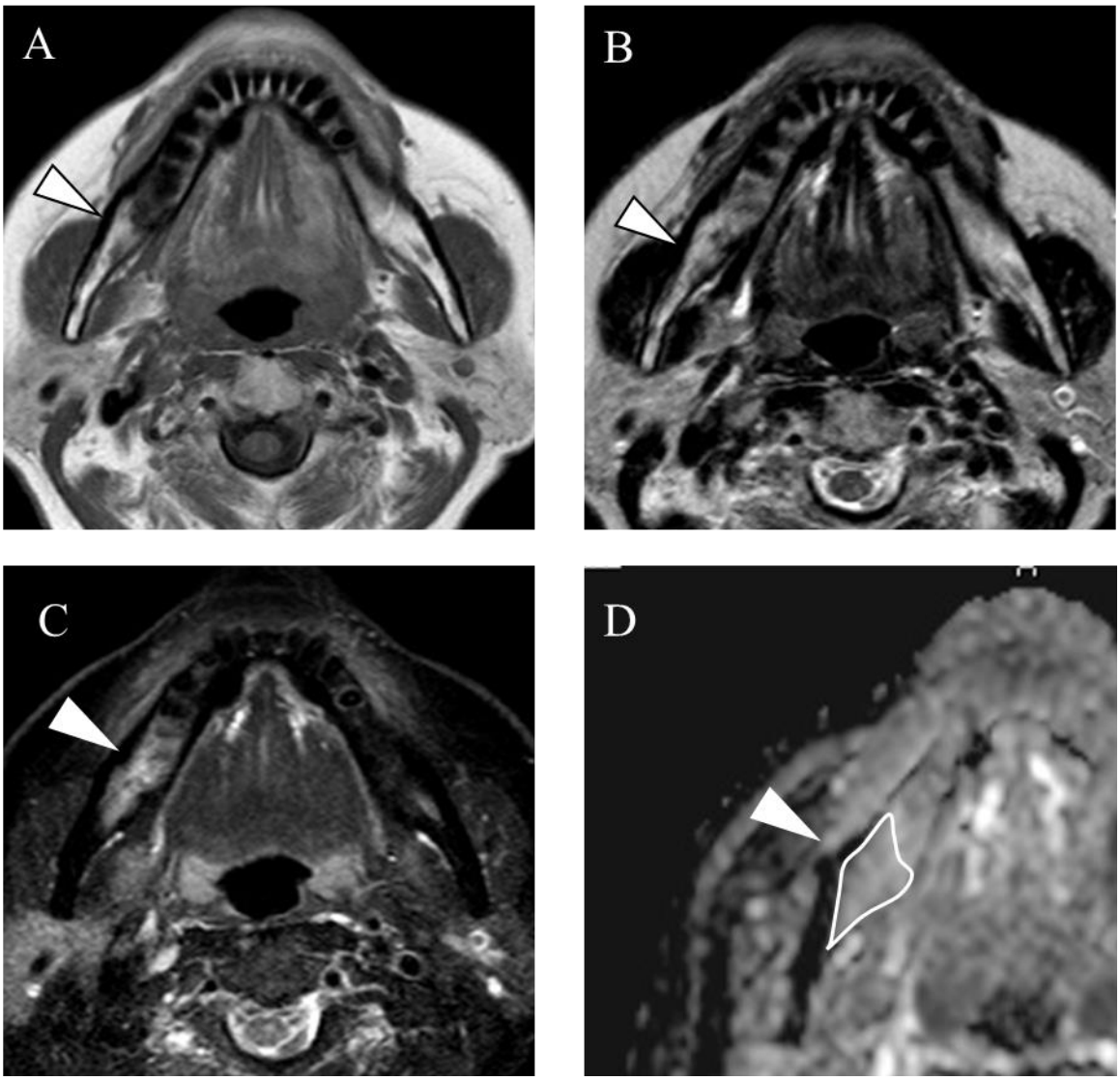

Fig. 1　65-year-old women.

A: Axial T1-weighted MR image shows a low signal intensity in right side of mandibular bone marrow (arrowhead).

B, C: Axial T2-weighted MR image and STIR image show a high signal intensity in right side of mandibular bone marrow (arrowhead).

D: ADC map shows a high signal intensity in right side of the mandibular marrow on region of interest (ROI) (arrowhead).

Table 1　Mean ADC values of the total cases.

Patients (n=50)	Mean ADC value±SD of Male ($\times 10^{-3}$ mm²/s ±SD)	Mean ADC value±SD of Female ($\times 10^{-3}$ mm²/s ±SD)
Normal (n=22)	0.97±0.09 (n=12)	0.99±0.10 (n=10)
Acute osteomyelitis (n=28)	1.18±0.11 (n=10)	1.26±0.08 (n=18)

Table 2　Mean ADC values: Normal versus Acute

	Bone marrow status	
	Normal (n=22)	Acute Osteomyelitis (n=28)
Mean ADC value±SD ($\times 10^{-3}$ mm²/s ±SD)	0.98±0.10	1.23±0.10
	*	

* : $P < 0.05$