Case Report

Location of the Mandibular Incisive Canal Related to the Placement of Dental Implants: A Case Report

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Cone-beam computerized tomography (CBCT) can show an uncommon mandibular incisive canal that cannot be detected by panoramic radiography, which is used preoperatively to form the initial plan of the size and length of an implant fixture for surgical placement in the mandibular interforaminal area. Determination of the position and anatomical configuration of the mandibular incisive canal is challenging. The purpose of this case report is to discuss anatomical variations in the mandibular incisive canal and the mental canal by reviewing previous studies. Furthermore, we propose that the anterior loop length of the mental canal near the mental foramen, as well as the diameter of the mandibular incisive canal, should be verified by CBCT prior to performing implant surgery in the anterior mandibular area to prevent possible nerve damage.

Key Words: mandibular incisive canal, incisive canal diameter, anterior loop length, CBCT

Introduction

Some of the inadvertent complications that can occur during implant surgery in the mandibular interforaminal area are neurosensory alterations due to damage to the nerves in the mandible, including the inferior alveolar nerve (IAN) and its branches.[1] These complications can occur if some of the critical anatomical structures, such as the mandibular incisive canal (MIC), anterior mental loop length (ALL), and mental foramen (MF), are not properly identified and protected.[1] Damage to these anatomical structures often arises due to clinicians' surgical mistakes and failure to verify these configurations.[2] It is imperative to identify the exact locations of these anatomical structures before implant surgery using current advanced methods, including appropriate radiographic techniques, ultrasound technology, and magnetic resonance imaging.[3,4]

The IAN, as one of the mandibular divisions of the trigeminal nerve, runs forward and downward to the MF between the lingual and buccal cortical plates of the mandible through the mandibular canal, dividing into the mental nerve and the incisive nerve.[5,6]

In the vicinity of the MF, the transition of the mental nerve from the IAN can be classified into 3 patterns, namely, an anterior loop pattern (61.5%), a straight pattern, and a vertical pattern, which innervate to the soft tissue of the chin, lower lip, and mental areas.[7] In cases where the loop pattern is observed, which is the most common, studies have found that the mean ALL varies from 1.74 mm[7] to 5.0 $\pm$ 1.8 mm.[8] Recently, Yuki Uchida et al reported that the longest ALL observed was 9 mm and that 8 of 140 hemimandibles had an ALL of 5 mm or longer.[9]

The mandibular incisive nerve may run through the intramedullary space, and the MIC may not be detectable or may be ill-defined by conventional radiography. There are anatomical research results supporting the existence of a true MIC, located medial to the MF with less cortical bone and a canal diameter that narrows toward the anterior mandible.[5,10–13] Juodzbalys et al found a clearly defined MIC medial to the MF.[14] Mraiwa et al studied the location and direction of the MIC. Statistically, the MIC ran in a slightly downward direction toward the symphysis, located 9.7 mm (SD, 1.8 mm) from the mandibular cortical border.[12]

When placing implants mesial to the MF, the configuration of the ALL and both the diameter and direction of the MIC should be verified.[15] In cases of an incisive canal with a large diameter, drilling during implant placement may injure the mandibular incisive nerve, resulting in stretching of and damage to the IAN.[16]

Kohavi and Bar-Ziv described the postoperative complications relating to the placement of implant fixtures in the interforaminal area that penetrated the upper border of the MIC on cone-beam computerized tomography (CBCT) images.[15,17] Additionally, Wismeijer et al reported that permanent sensory disturbances in the lower lip occurred in 7% of 110 edentulous patients treated with an implant-retained or implant-supported overdenture using 2–4 implants in the interforaminal area.[15,18] However, all of the fixtures were installed with a safety distance of 3 mm from the MF.[15,18]

Despite a number of studies being conducted to provide anatomical descriptions of the MF and MIC, the clinical implications of the ALL and MIC have not been fully or significantly considered in the context of surgical procedures in the lower anterior region.

In these two clinical reports, the ALL and MIC, which are

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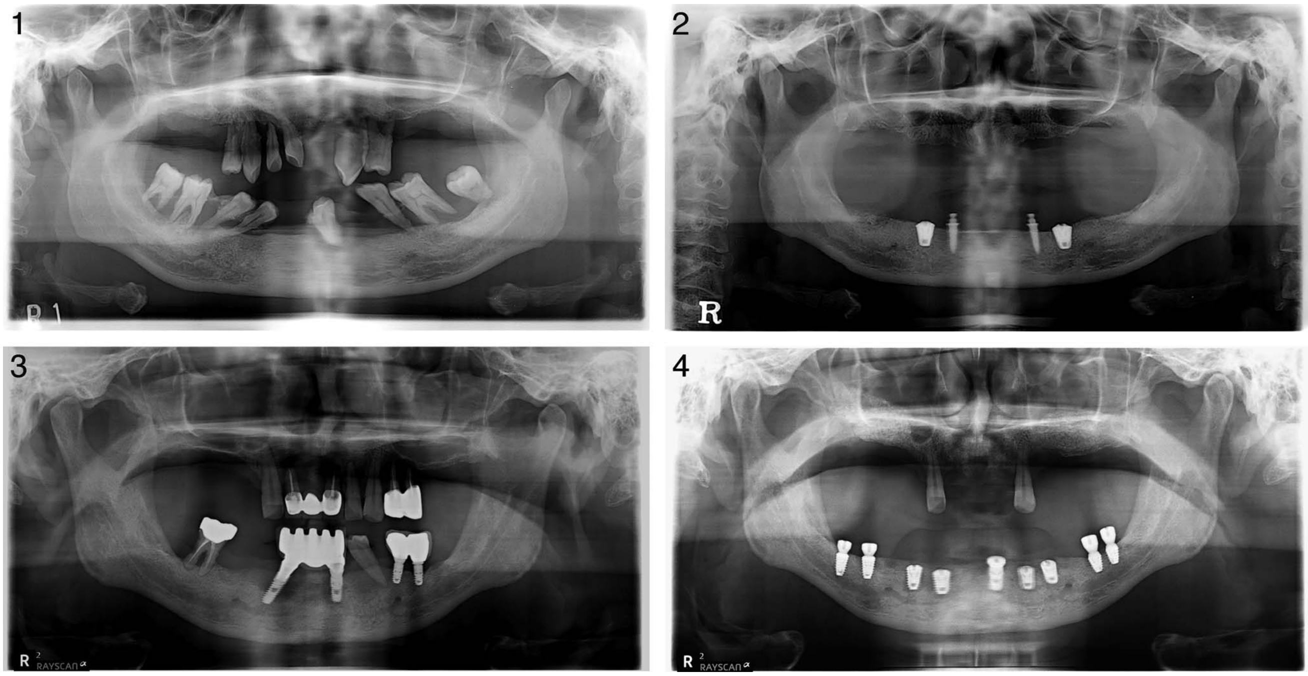

Figures 1–4. Figure 1. Pretreatment panoramic radiograph. **Figure 2.** Postsurgical panoramic radiograph. **Figure 3.** Pretreatment panoramic radiograph. **Figure 4.** Postsurgical panoramic radiograph.

rarely identified by panoramic radiography, could be detected by CBCT. We propose anatomical factors that should be considered prior to implant surgery in the mandibular interforaminal area to preclude injury to these anatomical structures.

Case Report 1

A 48-year-old female visited the Department of Advanced General Dentistry at Yonsei University Dental Hospital seeking comprehensive dental treatment for the improvement of chewing function. She complained of chewing difficulty due to severely mobile teeth. The medical history of the patient was nonspecific, and no experience related to dental prostheses was reported.

A clinical intraoral examination revealed that a number of teeth had been lost due to periodontal inflammation, and the remaining teeth were diagnosed as hopeless on the basis of periodontal and radiographic examinations (Figure 1). Total extraction of the remaining teeth was planned under conditions of premedication with antibiotics.

Three treatment options were presented to the patient. The first prosthetic modality was an implant-retained overdenture on the mandible and a complete conventional denture on the maxilla. The second option was an implant-retained overdenture on both arches. The third option was a complete conventional denture on both arches. The first prosthetic option was chosen, considering that the treatment was affordable for the patient. According to the treatment plan, all of the remaining teeth were extracted during two serial appointments, followed by the delivery of removable interim prostheses for both arches.

Treatment plan

The location of the mandibular implant fixtures was planned for both canines in the interforaminal area, and the size of the implant fixtures (12 [L] × 3.8 [D] mm) was initially selected based on panoramic radiography and clinical examination of the alveolar ridge. Four months after delivery of the removable interim prostheses, the mandible was examined by panoramic radiography and CBCT. The MIC in the interforaminal region and the position of the MF could be determined by CBCT. Additionally, the branching pattern and the ALL of the mental canal could be delineated according to the CBCT images (Table 1).

The incisive canal diameter (ICD), which was 2.78 mm (determined by height, H) at the left mental canal and 3.76 mm (H) at the right, continuously narrowed toward the midline (Table 2).

Regarding the length of bone available for the implant fixture, 11 mm and 10 mm was measured in the left and right

Table 1

Anterior loop length (ALL) of the mandible

	ALL (Right)	ALL (Left)	ALL
Case 1	4.14 mm	2.49 mm	3.71 mm
Case 2	3.07 mm	2.97 mm	3.28 mm

Table 2

Incisive canal diameter (height) at various positions on the mandible*

		At the MC	4 mm from the MC	6 mm from the MC	12 mm from the MC
Case 1	ICD (left)	2.78 mm	1.86 mm	1.80 mm	0.88 mm
	ICD (right)	3.76 mm	1.65 mm	1.70 mm	0.93 mm
Case 2	ICD (left)	3.16 mm	3.21 mm	2.43 mm	1.41 mm
	ICD (right)	2.86 mm	2.65 mm	2.49 mm	1.54 mm

*ICD indicates incisive canal diameter; MC, mental canal.

mandibular canine area, respectively, from the upper border of the MIC. A computer-assisted bone-supported surgical implant guide was designed to establish the required safety zone using a CBCT-based computer simulation. A safety margin of 2 mm above the upper border of the MIC and 3.5 mm medial to the mental canal was set to avoid causing sensory dysfunction.

Treatment progress

Two dental implant fixtures 6.0 (D) × 8 (L) mm in size (Dentium, Seoul, Korea) were placed in the mandibular canine areas with an initial stability of over 35 Ncm using the computer-assisted surgical implant guide. At the same time, two mini implant fixtures 2.5 (D) × 8 (L) mm in size were placed in the lateral incisor areas to support the removable interim mandibular prostheses and to hinder loading of the implant fixtures during the healing period.

Postsurgery radiography was used to verify that all of the fixtures were located at appropriately the preplanned locations, and no surgical complications were reported (Figure 2).

Two months later, a second implant surgery was performed to connect the healing abutments, and the 2 mini implants were removed. The implant sites were inspected by opening the flap with a minimal crestal incision, and two healing abutments (4.0 [D] × 2.0 [H]) mm in size were connected.

The maxillary complete denture and mandibular implant-retained overdenture were delivered, and prescheduled regular checkups were performed at a 6-month interval to control oral hygiene and occlusion.

Neither neurosensory dysfunction nor discomfort related to the osteotomy for the implant treatment was reported for 3 years, but the locator attachment on the left side required repair due to loss of retention.

Case Report 2

In the case of a 56-year-old male seeking comprehensive dental treatment, the existence of the MIC was clearly observed by panoramic radiography, but the branching pattern of the mental canal near the MF could not be identified (Figure 3).

Treatment progress

Four months after extraction, CBCT was performed to plan the computer-assisted surgical implant guide for the mandibular implant surgery. Basis on the CBCT analysis for the implant placement, an available bone length of 8 mm and 10 mm was measured in the left and right mandibular first premolar area, respectively, above the upper border of the MIC. The ICD was 3.16 mm (H) at the left mental canal and 2.86 mm (H) at the right mental canal (Table 2).

One month later, dental implant fixtures (4.5 [D] × 8 [L] mm) in size (Dentium, Seoul, Korea) were placed in the right and left mandibular first premolar areas using the surgical guide with an initial stability over 35 Ncm. The implant in the left first premolar area was inserted with a lingually tilted path, and an additional bone graft was applied due to the inadequate bone height. A safety margin of 2 mm above the upper border of the MIC and 3.5 mm mesially from the mental canal was set to avoid causing sensory dysfunction.

Postsurgery radiography verified that all of the fixtures were located at appropriately the preplanned locations, and no complications were reported (Figure 4).

Neither neurosensory dysfunction nor discomfort related to the osteotomy for the implant treatment has been reported by the patient.

Discussion

Nerve damage related to implant surgery in the mandibular interforaminal area can result from the stretching, compression, or partial or total transection of a nerve.[5] The cause of nerve damage can be categorized into 3 types: direct, stretching or compression, and indirect.

Direct nerve damage includes injury to branches of the IAN caused by engaging the anterior loop of the mental canal and MIC. Damage caused by stretching or compression is considered an injury to the IAN because an implant placed near the MIC can involve the mandibular incisive nerve, which can cause stretching or compression of the main trunk.

Indirect nerve damage can also lead to sensory disturbances. The placement of a fixture too close to vital structures, such as the mental canal and MIC, can be a causative factor of mechanical stress to these structures, resulting in neurosensory complications.[5]

The pattern of transition from the IAN to the mental nerve and the extension and position of the MIC may be preoperative factors that should be examined in detail to achieve successful implant treatments in the mandibular interforaminal area.

MF, mental canal, and ALL

The MF has been used as an important landmark in the interforaminal area of the mandible for implant surgery, even though anatomical variations in its size and location have been noted.[3,19]

These case reports demonstrate the anterior loop pattern, which is the most common pattern of the transition of the mental nerve from the IAN (Table 1). Kyung-Seok Hu et al reported that the transition can be classified into 3 patterns: the anterior loop pattern, which accounts for approximately 61.5% of all transition patterns, and the straight and vertical patterns, which account for approximately 23.1% and 15.4%, respectively.[7]

Regarding the length between the anterior border of the

TABLE 3

Incisive canal distance from the mandibular (Mn.) cortical border at various positions*

		At the MC	4 mm from the MC	Near Canine Area	Near Incisor Area
Case 1	Distance to the Mn. border (left)	10.26 mm	8.71 mm	8.30 mm	8.66 mm
	Distance to the Mn. border (right)	9.74 mm	8.81 mm	8.04 mm	8.61 mm
Case 2	Distance to the Mn. border (left)	9.36 mm	8.21 mm	7.90 mm	7.01 mm
	Distance to the Mn. border (right)	10.08 mm	8.80 mm	8.50 mm	7.94 mm

*ICD indicates incisive canal diameter.

MF and the mesial point of the anterior loop of the mental canal (ie, the ALL), one previous study found that the ALL was approximately 1.74 ± 0.9 mm.[7] Hwang et al reported a mean ALL of 5.0 ± 1.8 mm,[8] and Yuki Uchida et al found an ALL longer than 5 mm in almost 6% of biopsies (of 140 hemi-mandibles), the longest of which was 9 mm.[9] In our first case, the ALL was 4.14 mm (right) and 2.49 mm (left), and in the second case, the ALL was 3.07 mm (right) and 2.97 mm (left). In both cases, the ALL values on the right and left were different. These ALL values were all above the value of 1.74 mm reported by Kyung-Seok Hu et al[7] but below the value of 5.0 mm reported by Hwang et al[8] (Table 1).

The optimal safety zone in the vicinity of the MF remains controversial. We set a safety distance of approximately 3.5 mm anteriorly from the most mesial point of the anterior loop of the mental canal. Misch et al recommended that an implant fixture should be placed with a safety distance of 2 mm or more from the anterior loop.[20] Greenstein et al also recommended a safety margin of 2 mm to avoid nerve damage caused by bone compression around the implant fixture.[5,21] However, Magnusson recommended a safety margin of approximately 5 mm from the anterior loop of the mental canal or MF with no anterior loop.[22] Therefore, we set the median value, 3.5 mm, as the horizontal safety distance.

MIC

Recent studies have supported the existence of a true MIC, which branches off from the mandibular canal and runs through the intratrabecular and cancellous bone of the chin. Obradovic et al investigated the presence of a true MIC using 105 cadaveric mandibles and reported that the MIC could be found in 92% of 70 dentulous mandibles and in 31% of 30 edentulous mandibles.[23]

In our first case, the incisive canal could not be identified and appeared as a trabecular space by panoramic radiography, but it could be identified and delineated by CBCT. In the second case, the incisive canal could be observed clearly by panoramic radiography, and the ALL could be measured by CBCT (Figures 5 through 8).

Mardinger et al performed anatomical and radiographic research by examining 46 hemi-mandibles. Anatomically, the incisive nerve bundles emerged from the inferior part of the mental canal, and in 10 hemimandibles, the MIC showed a complete cortical border. In 26 (56%) of the hemimandibles, the MIC could be observed by radiography. However, clear identification was possible in only 11of the 26 hemimandibles, and in other cases, the MIC could barely be detected.[15]

With discrepancies between the anatomical prevalence and radiographic visibility of the MIC, the mandibular interforaminal region could no longer be a safe region for surgical procedures.

Detailed information on the diameter and position of the MIC should be obtained to achieve a successful surgical outcome. According to Mardinger et al, the mean ICD at the mental canal was 2.09 mm, while it was 1.69 mm at 4 mm from the mental canal, 1.25 mm near the canine area, and 0.98 mm near the lateral incisor area.[15]

Table 2 shows the ICD at each point (0 mm, 4 mm, 6 mm, and 12 mm) from the mental canal in our case reports. The ICDs were relatively larger than the average ICDs (Table 2; Figures 5 through 8). The location of the MIC was similar in our case studies to that of the average MIC, and the direction was relatively flat (Table 3).

Regarding the extension and position of the MIC in relation to the mandibular cortical border, the MIC was located 9.7 ± 1.8 mm from the lower mandibular border near the MF area and 7.2 ± 2.1 mm in the incisor area, and the canal narrowed as it crossed to the symphysis, as determined based on a study of 50 mandibles.[13] In the present case reports, the distance between the MIC and lower mandibular cortical border was comparable to that reported by Mriawa et al, being 9.74 mm and 10.08 mm in the right MF area, and 8.61 mm and 7.94 mm in the right incisor area, respectively.

Why is CBCT essential?

It is well known that the MF can be easily detected radiographically; thus, many dental practitioners have used the MF as a landmark for determining the location and depth of implant fixtures. Panoramic radiography has been widely used for this purpose. However, high-accuracy images cannot be expected from panoramic radiography due to its inherent deficit in accuracy associated with multidirectional distortion, as well as the superimposition of images in 2-dimensional radiography.[21] In-Soo Kim et al examined 120 mental foramina that were exposed during an operation and concluded that the values measured by panoramic radiography were not statistically comparable to those that were measured directly.[3]

The existence of the MIC has been investigated in radiographic and anatomical studies, but the prevalence and clinical implication of this canal remain controversial. It is assumed that this is due to the unreliable detection of the MIC

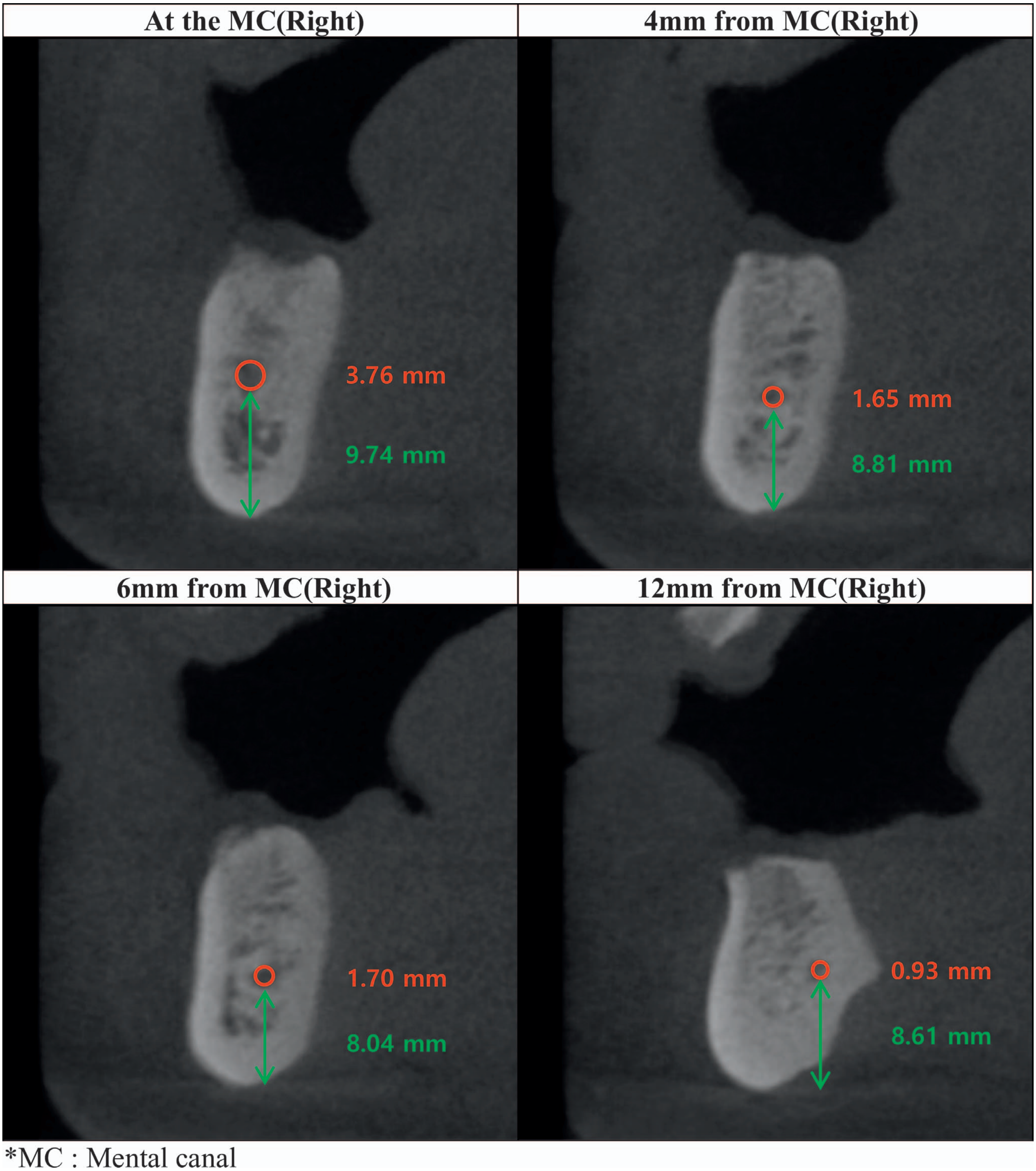

Figure 5. Mandibular incisive canal (right).

by panoramic radiography, the most conventional diagnostic tool.

In our first case study, the MIC was not detected via panoramic radiography. Therefore, at first, the implant fixtures were selected with a regular size (10 mm long). After performing CBCT, it was recognized that the patient's ICD was larger than average. The mental nerve had an anterior loop pattern, and the ALL was longer than 3 mm. Therefore, the implant fixtures had to be reset to a shorter (8 mm) size to avoid nerve damage. However, the MIC could be detected by panoramic radiography, but the size and shape of the MIC near the MF, as well as the ALL of the mental canal, could be determined by CBCT in the second case study.

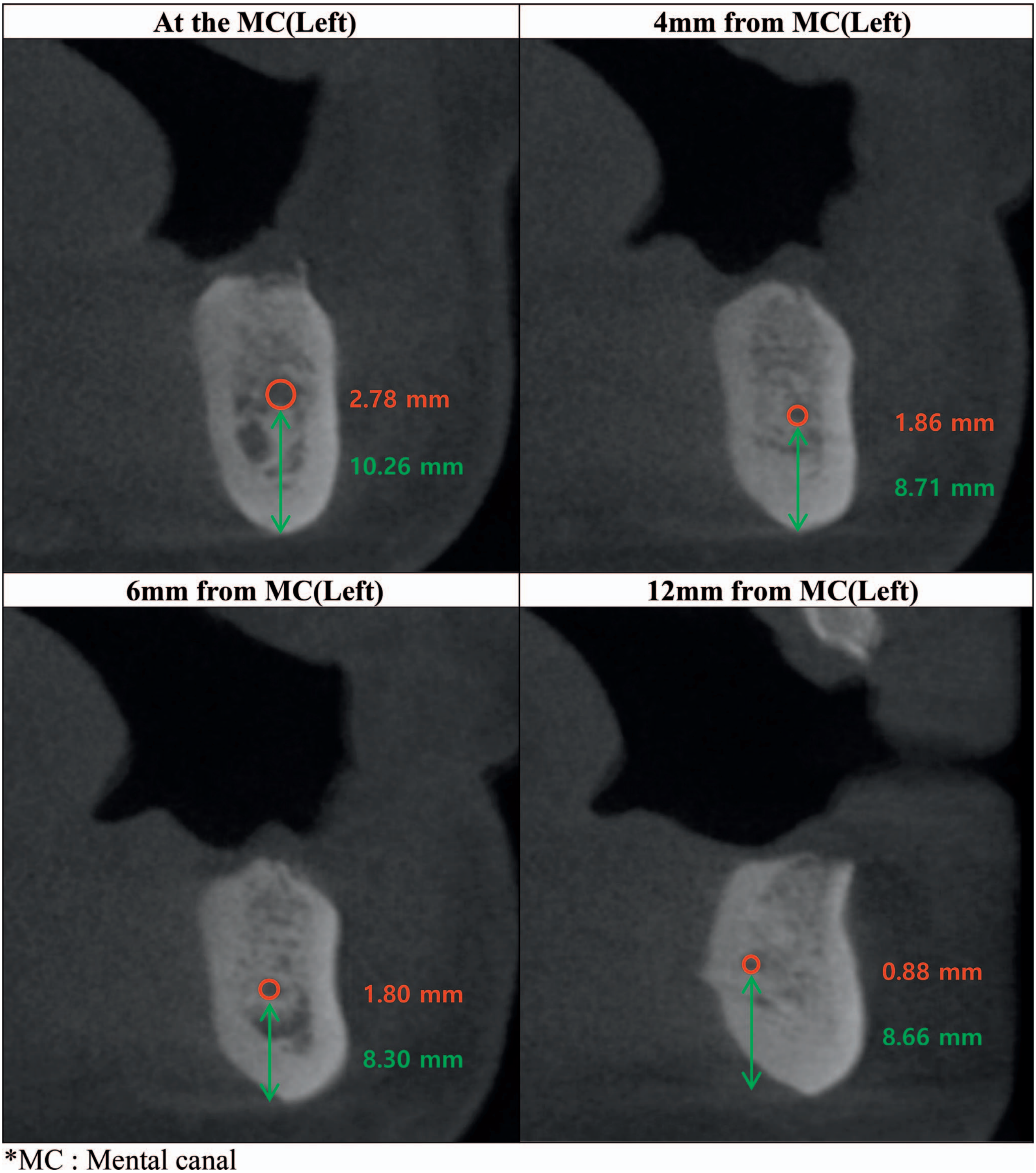

FIGURE 6. Mandibular incisive canal (left)

Pires et al reported that the MIC could be identified in 83% of CBCT images.[24] However, according to the study reported by Jacobs and colleagues, only 15% of panoramic radiographs showed the presence of the MIC.[25] According to Sema Murat et al, nerve damage occurred in 31.8% of cases of implant surgery performed based on periapical radiographs, but the complication rate was only 4.5% when CBCT images were used for the diagnosis and treatment plan.[26]

Further research on the information of the ALL and ICD in CBCT studies of large groups of mandibles should be performed to determine the clinically applicable safety margin to ensure the success of implant therapy in the anterior mandibular area.

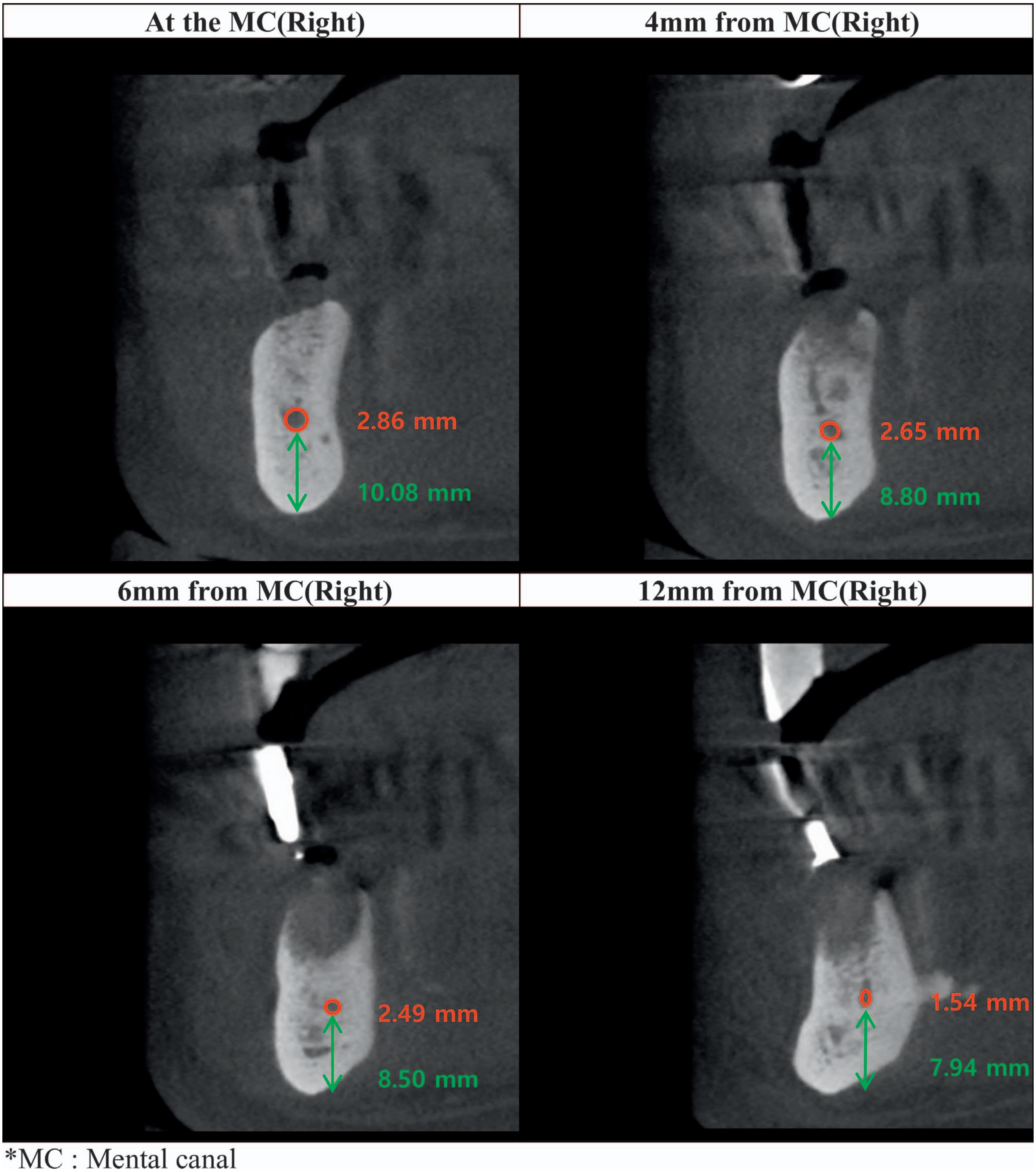

Figure 7. Mandibular incisive canal (right)

Conclusion

The mandibular interforaminal area is generally considered to be a relatively safe zone for implant surgery where various other surgical procedures are actually performed. Nevertheless, surgical complications related to implant surgery in the interforaminal area, which are likely to be related to failure of the anatomical identification of the anterior loop of the mental canal, the MIC and the MF, have been reported.

To avoid nerve damage resulting from dental implant

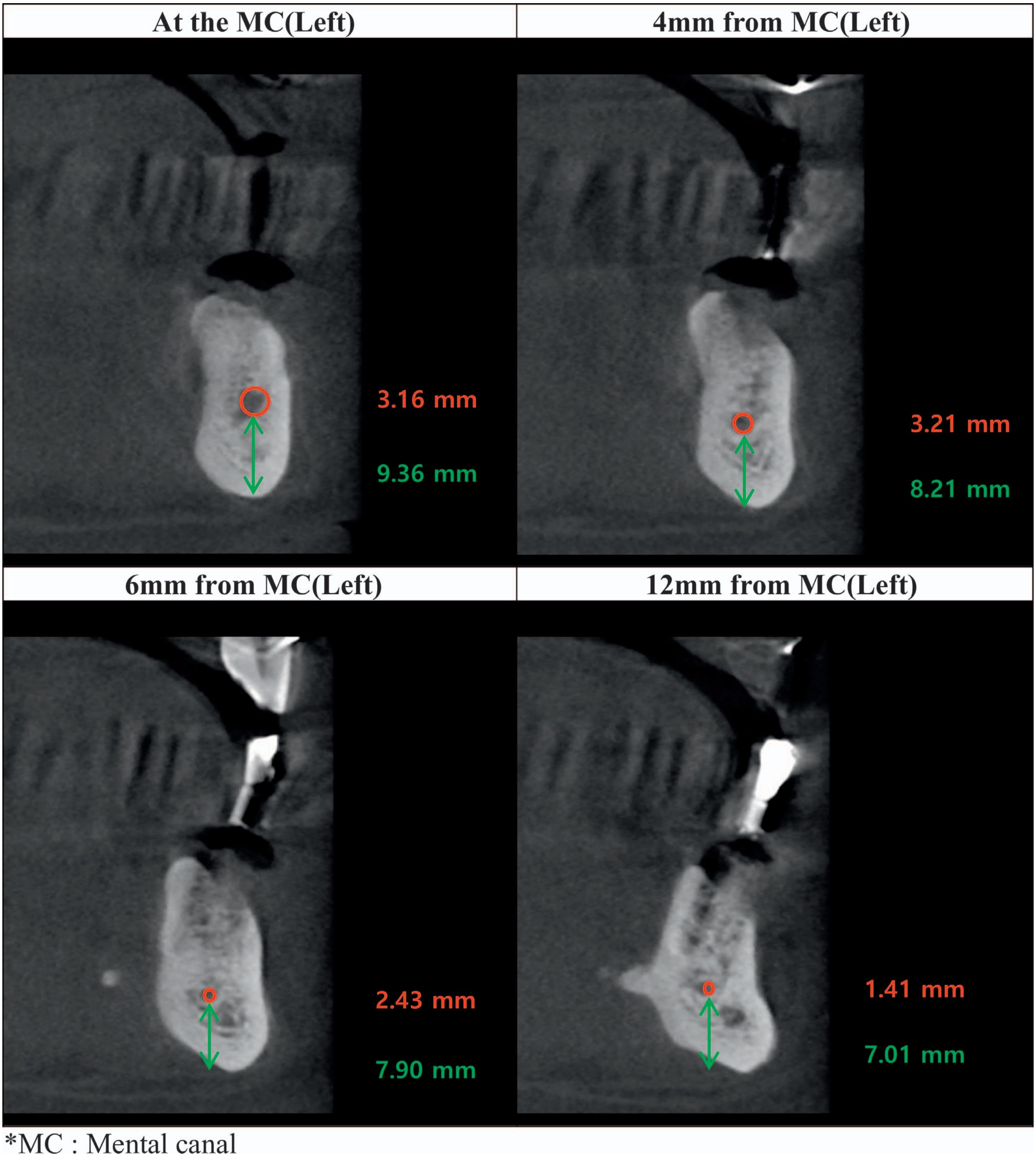

Figure 8. Mandibular incisive canal (left).

surgery in the mandibular interforaminal area, anatomical structures, such as the MIC, ALL, MF, and mental nerve, should be analyzed by CBCT rather than by panoramic radiography, especially in cases of a mandibular interforaminal area with a large ALL or ICD.

Abbreviations

ALL: anterior loop length
CBCT: cone-beam computerized tomography
IAN: inferior alveolar nerve
ICD: incisive canal diameter

MF: mental foramen

MIC: mandibular incisive canal

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