

Evaluation of Visibility of the Anterior Loop of the Inferior Alveolar Canal in CBCT Sections at Three Different Slice Thicknesses

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Abstract

Objectives: The mental foramen is an important landmark in osteotomy and implant procedures. The presence and location of an anterior loop mesial to the mental foramen should be evaluated before surgery to avoid mental nerve injury, paresthesia, and bleeding. Considering the significance of detecting the location and position of the anterior loop of the inferior alveolar nerve, we aimed to examine the visibility of the anterior loop, using cone-beam computed tomography (CBCT) sections with different slice thicknesses.

Materials and Methods: Images of the mandibles of 60 patients, referred to a maxillofacial radiology center, were selected. After secondary reconstruction, cross-sectional images were acquired at 0.5, 1 and 2 mm slice thicknesses in the DICOM format. The set of teeth examined in these images ranged from the canine tooth to the first molar at a distance of 3 - 5 mm from the mental foramen. They were then evaluated by two maxillofacial radiologists at slice thicknesses of 0.5, 1 and 2 mm. The images were then categorized into four groups namely the highly visible, visible, nearly visible, and nearly invisible groups based on the visibility of the anterior loop of the inferior alveolar nerve.

Results: According to the results at the different slice thicknesses, visibility of the anterior loop was significantly higher at a slice thickness of 0.5 mm. The difference in visibility was also significant between slice thicknesses of 0.5 and 1 mm and between those of 0.5 and 2 mm. However, there was no significant difference between slice thicknesses of 1 and 2 mm.

Conclusion: Observation of the anterior loop showed greater diagnostic accuracy at a slice thickness of 0.5 mm.

Keywords: Anterior Loop; CBCT; Slice Thickness

Introduction

Treatment of toothless patients using permanent prosthetic implants with distal extension is highly successful [1]. This prosthesis is usually supported by 3 to 6 implants, which are drilled into the lower jaw [2]. There are some limitations in dental implant placement, such as confinement to the mental foramen, especially the anterior loop of the inferior alveolar nerve [1,3]. Trauma after temporary or permanent surgeries has been reported to occur due to these limitations [1,4].

Various studies have been conducted to determine the anatomical position of the mental foramen and its anterior loop. In these studies, the length of the anterior loop was estimated to range from 0.5 to 10 mm [5], and the prevalence of the anterior loop was up to 90%, which indicates the significance of detecting the anterior loop of the inferior alveolar canal [6].

Different studies have been conducted on various radiographic techniques to identify and measure the extension of the anterior loop. The most common imaging techniques include panoramic imaging, periapical imaging, and cone beam computed tomography (CBCT) [1,7]. Computed tomography (CT) is a diagnostic tool used for the precise detection of the anterior loop of the inferior alveolar canal and can produce high-quality cross-sectional images [8,9]. However, this imaging technique has limitations including the use of high radiation doses, high cost, the equipment being capacious, and the requirement of advanced training for interpretation of images [10].

The CBCT system was introduced two decades ago. It is increasingly being used due to its great applicability in the imaging of the glenoid cavity, mandibular morphology, and bone resorption [3,9]. Various factors influence the quality of CBCT images. One of the most important factors is voxel size, which is related to slice thickness; any change in voxel size significantly affects the image quality [11,12]. Slice thickness and reconstruction angle are adjusted by the clinician [13].

Based on previous studies, it can be assumed that slice thickness can affect the quality of images and thus influence the accuracy of detection and measurement of the anterior loop extension. However, considering the scarcity of data on this subject, further studies are necessary [14,15]. Given the importance of the anterior loop as a factor in determining the stage of treatment and the lack of studies in this area, we aimed to investigate the effect of slice thickness of CBCT sections on the visibility of the anterior loop of the inferior alveolar nerve.

Materials and Methods

In this descriptive, cross-sectional study, samples from 60 patients were used, similar to previous studies. A 95% confidence interval, standard deviation of 1.5 mm, and 4% error of estimate were used. The mandibular images of these patients, who were referred to the maxillofacial radiology center, were selected. Patients with pathological problems, radiological lesions, or trauma near the mental foramen were excluded.

After secondary reconstruction, including adjustment of head position (the mandibular arch is parallel to the horizon), as well as contrast and resolution adjustments, cross-sectional images were saved at slice thicknesses of 0.5, 1 and 2 mm. The primary images of patients, who were referred for implant surgery or examination of impacted teeth, were acquired using a Plan meca device (Finland) (84 kV; 12 mA; exposure time, 13 seconds; voxel size, 160 μ m; FOV, 80 \times 100 mm) and stored in the DICOM format.

The images were examined by two maxillofacial radiologists with at least two years of experience as observers. The set of teeth examined in these images ranged from the canine tooth to the first molar at a distance of 3 - 5 mm from the mental foramen. They were then categorized into four groups, namely the highly visible, visible, nearly visible, and nearly invisible groups, based on the visibility of the anterior loop of the inferior alveolar nerve.

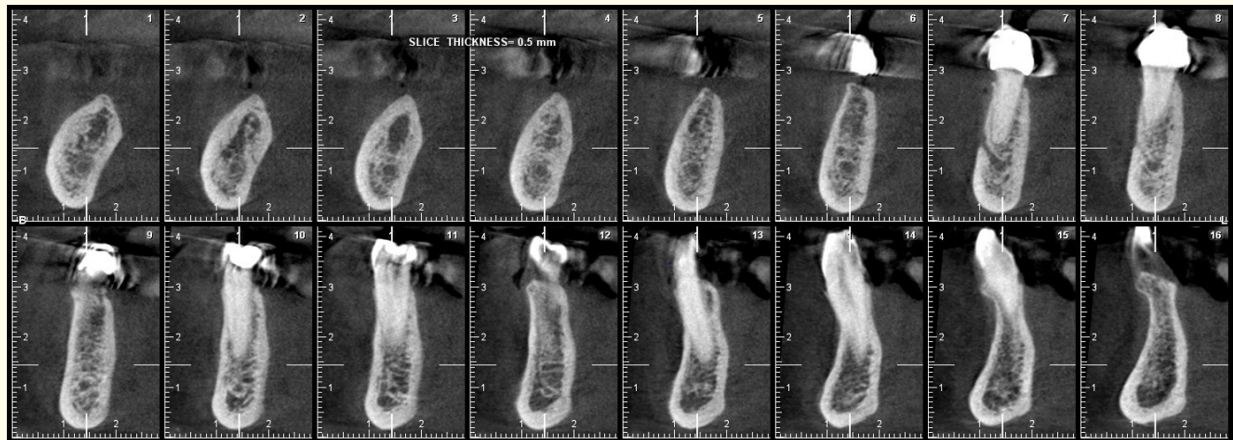


Figure 1: An example of an image reconstruction at 0.5-mm slice thickness.

The collected data were analyzed using analysis of variance and the Tukey’s test in the SPSS software package version 20.

Results

In the present study, images from 60 patients, with an average age of 35 years, were examined to assess the effect of slice thickness of CBCT sections on the detection accuracy of the anterior loop of the inferior alveolar canal nerve.

Interobserver comparison (observers A and B) at a slice thickness of 0.5 mm

According to observer A, 41.7% of the samples were highly visible, 55% were visible, and 3.3% were nearly visible, while observer B reported that 46.7% of the samples were highly visible, 48.3% were visible, and 5% were nearly visible.

Interobserver comparison (observers A and B) at a slice thickness of 1 mm

According to observer A, 33.3% of the samples were highly visible, 55% were visible, 8.3% were nearly visible, and 3.3% were nearly invisible, while observer B reported that 26.7% of the samples were highly visible, 55% were visible, 13.3% were nearly visible, and 5% were nearly invisible.

Interobserver comparison (observers A and B) at a slice thickness of 2 mm

According to observer A, 33.3% of the samples were highly visible, 56.7% were visible, and 10% were nearly visible, while observer B reported that 25% of the samples were highly visible, 61.7% were visible, and 13.3% were nearly visible.

Slice thickness		0.5 mm Number (%)	1 mm Number (%)	2 mm Number (%)	P-value
Visibility					
Observer A	Highly visible	25 (41.7%)	20 (33.3%)	20 (33.3%)	0.0001
	Visible	33 (55%)	33 (55%)	34 (56.7%)	
	Nearly visible	2 (3.3%)	5 (8.3%)	6 (10%)	
	Nearly invisible		2 (3.3%)		
Observer B	Highly visible	28 (46.7%)	16 (26.7%)	15 (25%)	0.001
	Visible	29 (48.3%)	33 (55%)	37 (61.7%)	
	Nearly visible	3 (5%)	8 (13.3%)	8 (13.3%)	
	Nearly invisible		3 (5%)		
Total		60 (100%)	60 (100%)	60 (100%)	

Table 1: The anterior loop of the inferior alveolar nerve at different slice thicknesses.

Slice thickness	0.5 mm	1 mm	2 mm
ICC	0.81	0.88	0.84
P-value	0.0001	0.0001	0.0001

Table 2: The intraclass correlation coefficient (ICC) between observers at different slice thicknesses. The intraclass correlation coefficient (ICC) between observers was estimated to be 0.84, which is desirable.

Two-by-two comparison of slice thicknesses	P-value
Slice thicknesses of 1 mm and 0.5 mm	0.018
Slice thicknesses of 0.5 mm and 2 mm	0.029
Slice thicknesses of 2 mm and 1 mm	1.000

Table 3: Two-by-two comparison of slice thicknesses.

The P-value was significant for two-by-two comparison of slice thicknesses of 0.5 and 1 mm, and 0.5 and 2 mm. However, the P-value was not significant for two-by-two comparison of slice thicknesses of 1 and 2 mm.

Slice thickness	Mean rank
0.5 mm	1.77
1 mm	2.13
2 mm	2.10

Table 4: Comparison of the accuracy of anterior loop observation at different slice thicknesses.

The data were qualitatively ranked from highly visible (code 1) to nearly invisible (code 4). The mean rank was measured for comparisons: 1.77 for 0.5 mm; 2.13 for 1 mm; and 2.10 for 2 mm. The lowest mean rank was observed at a slice thickness of 0.5 mm; therefore, this slice thickness was superior to others ($P = 0.000$) and the anterior loop was highly visible. The difference between 1- and 2-mm slice thicknesses was not statistically significant.

Discussion

The mental foramen is an important landmark during osteotomy and implant procedures. The location and possible presence of an anterior loop of the mental nerve mesial to the mental foramen should be evaluated before surgery to avoid mental nerve injury, paresthesia, and bleeding [2]. Several studies have been conducted on the different radiographic techniques used to identify and measure the anterior loop extension. The most common imaging techniques include panoramic imaging, periapical imaging, and CBCT [1,7]. Generally, CBCT is the most efficient imaging technique, given its high precision, low radiation dose, and low cost compared to CT [16].

In a study by Juan., *et al.* which examined the anterior loop using CT scans, the prevalence of the anterior loop of the inferior alveolar nerve was 90% in the study population. However, in the present study, the anterior loop was detected in more than 90% of subjects [6]. One of the parameters that can affect the quality of CBCT images is slice thickness; it can influence both image quality and radiation dose [17]. Few studies have examined the effect of slice thickness on CBCT images and visibility of anatomical structures [18]. Therefore, considering the significance of the location and position of the anterior loop of the inferior alveolar nerve canal, and the scarcity of relevant studies on this subject, we aimed to investigate the visibility of the anterior loop at different slice thicknesses of CBCT sections.

In the present study, CBCT images of 60 patients at slice thicknesses of 0.5, 1 and 2 mm were examined. The mean rank of the slice with a thickness of 0.5 mm was significantly lower than that of slices with thicknesses of 1 and 2 mm. Therefore, the anterior loop was highly visible in slices of this thickness. However, the difference between 1-mm and 2-mm slice thicknesses was not statistically significant.

Sirin., *et al.* analyzed and compared images by changing the slice thickness from 0.2 to 4 mm. They concluded that 0.2 and 1 mm were the desirable slice thicknesses [11]. This finding is in agreement with the results of the present study, which indicated that lower slice thicknesses have a higher diagnostic accuracy.

Chadwick., *et al.* in their study, changed the slice thickness from 1 to 5 mm. They concluded that the highest diagnostic accuracy was obtained at a 1-mm slice thickness [12]. Jung., *et al.* investigated image quality using slice thicknesses of 1.25, 2.5, 3.5 and 5 mm for quantitative measurement in CT scans. They revealed that a lower slice thickness leads to a higher image quality [19]. These findings from other studies are in agreement with the findings of the present study.

In a study by G. Pour and B. Arzi, cross-sectional images with slice thicknesses of 0.5, 1, and 2 mm were evaluated by two observers. They reported a significant difference in visibility of the inferior alveolar canal at different slice thicknesses ($P = 0.20$). They concluded that slice thickness had no effect on the visibility of the inferior alveolar canal in cross-sectional images [18]. Similarly, in the present study, slice thicknesses of 1 and 2 mm were not significantly different with regard to visibility of the inferior alveolar canal. However, a slice thickness of 0.5 mm significantly improved the diagnostic quality of images. Differences in the results can be attributed to the type of anatomical landmark and type of devices.

Moreover, Sezgin., *et al.* investigated the possible effects of slice thickness (0.2, 0.6, 1.0, 1.4 and 2.2 mm) on volume computation in CBCT images of bone defects from sheep mandibles. The results showed that volumetric measurements at 0.2, 0.6, and 1 mm slice thicknesses were not different from the actual volumes. However, the estimations were different at slice thicknesses of 1.4 and 2.2 mm. Finally, they concluded that slice thicknesses up to 1 mm can be used to estimate the amount of intrabony lesions [20]. The discrepancies can be attributed to the type of variable, which was the estimated volume in the aforementioned study, and diagnostic accuracy for observation of the anterior loop in our study. In the present study, the anterior loop could be observed in images at all slice thicknesses. Nevertheless, at a slice thickness of 0.5 mm, the diagnostic accuracy of images was higher.

Conclusion

The anterior loop of the inferior alveolar nerve was detectable at all slice thicknesses. However, a higher diagnostic accuracy was reported at lower slice thicknesses. Therefore, slice thickness does not significantly affect diagnostic quality if the main goal is to determine the absence or presence of the anterior loop. However, in close examinations, where measurement of width or distance from the mental foramen is performed, lower slice thicknesses show greater diagnostic quality.

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