

Comparison of panoramic radiography and  
computed tomography  
for the detection of altered sensation  
of inferior alveolar nerve  
after implantation

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computed tomography  
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of inferior alveolar nerve  
after implantation

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This certifies that the Doctoral Dissertation of  
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힘든 업무 중에도 밝은 표정으로 격려해주고 힘이 되어준 구강악안면방사선과 가족들에게도 감사드립니다.

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마지막으로 항상 내게 용기를 주고 희망을 준 사랑하는 아내 조윤주와 항상 웃는 얼굴로 삶의 기쁨을 주는 사랑스러운 딸 소정이에게 글을 바칩니다.

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저 자 씀

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## **Abstract**

### **Comparison of panoramic radiography and computed tomography for the detection of altered sensation of inferior alveolar nerve after implantation**

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**(Directed by Professor Chang-Seo Park D.D.S., Ph.D.)**

The purpose of this study is to compare the panoramic radiography and computed tomography (CT) for the detection of altered sensation of inferior alveolar nerve (IAN) invasion after implantation.

The sample was composed of 132 implants of 109 patients who showed altered sensation after implantation on the posterior mandible area, from 2004 to 2012. The patients took computed tomography scans after taking clinical examinations and panoramic radiography in Yonsei university dental hospital. Based on the radiographic data, the dimensional relation between cortical wall above IAN and the implant fixture was evaluated in 4 different categories.

There was no definite correlation between the distance between cortical wall above IAN and the apex of implant and visual analogue scale(VAS). Evaluating the invasion of IAN canal using panoramic radiography has a tendency of under-evaluation than using CT. 83% of patients diagnosed 'unclear' or 'away from IAN' in panoramic radiograph showed nerve damage in CT

In conclusion, panoramic radiography is an insufficient method for predicting altered sensation of IAN after implant surgery. In patients who cannot be evaluated with panoramic radiography alone, other clinical examination data and CT taking are essential.

**Keywords** : Panoramic radiography; Computed tomography; Inferior alveolar nerve invasion; Mandible; Implant; Altered sensation

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## **I . INTRODUCTION**

Altered sensation by inferior alveolar nerve(IAN) damage is one of the most common complications after implant surgery on lower molar area. Patients use subjective terms to express the altered sensation; such terms can be used to classify the symptoms as hypoesthesia, paresthesia, or dysesthesia.<sup>1</sup>

They can be caused by failure to measure the length because of image distortion in preoperative exam, improper instrumentation during surgery, damage by local anesthesia and thermal or chemical damage during surgery.<sup>3-5</sup> Above all, it is considered that direct trauma caused by installation of longer implant fixture is the most common cause of the complications.<sup>4-6</sup> Histologically, Hirsch et al. suggested that it is caused by formation of hematoma and osteoma due to direct mechanical injury, pressure on nerve and blood vessels or damage to intraneural blood vessels.<sup>6</sup>

Panoramic radiography is widely used method in evaluating preoperative images in implant surgery. Convenience in taking, low dose of radiation and showing the general bone state in oral cavity are the advantages of the panoramic radiography. However, it is sometimes hard to find the exact location of IAN due to the image distortion and the limitation of the method itself when the bone density is very low.<sup>7</sup> Moreover, it is difficult to measure the exact length because correction of image magnification ratio is necessary.<sup>8-13</sup>

Some clinicians evaluate the patients by VAS. The operator can evaluate the amount of subjective pain that the patient feels by converting them into a numerical scale. This is called VAS, and with scales from 0 to 10, it could be used to compare and evaluate the patients'

condition before and after treatment.<sup>15</sup> The intensity of subjective pain that patients experienced was surveyed from the records of patients.

Despite some disadvantages of CT such as the high radiation dose and expensive cost, it is used to get more specific information before and after implant installation since it makes less image distortion and enables to get three dimensional analysis and more precise measurement in length.<sup>3-5,13</sup>

The purpose of this study is to compare the different radiographic methods for the detection of altered sensation by implant surgery after implantation.

## **II. MATERIALS & METHODS**

### **1. Materials**

We analyzed patients at Yonsei university dental hospital who have experienced nerve complications after fixture installation on lower molar area by trauma of IAN. The study sample consisted of 109 patients, 33 (30.28%) males and 76 (69.72%) females, of average age 53.29 years (range 24-78 years). 132 injury sites were obtained from 109 patients in total including 23 patients who have had bilateral affected sites.

Inclusion criteria are as follows:

1. Clinical symptoms caused by the IAN damage, and VAS charting performed in department of oral medicine.
2. Both panoramic radiography and CT takings in this hospital.

Patients with altered sensation due to lingual nerve damage, inflammation or complications during local anesthesia were excluded from this research. Moreover, patients with radiographic image taken from other hospitals were also excluded from the study since the image quality after scanning could influence the results.

### **2. Methods**

#### **A. Clinical evaluation**

Specialist on oral medicine evaluated the patients with altered sensation by various clinical exams, such as pin pricking test, light touch, two point discrimination, direction test, pain threshold, and VAS.

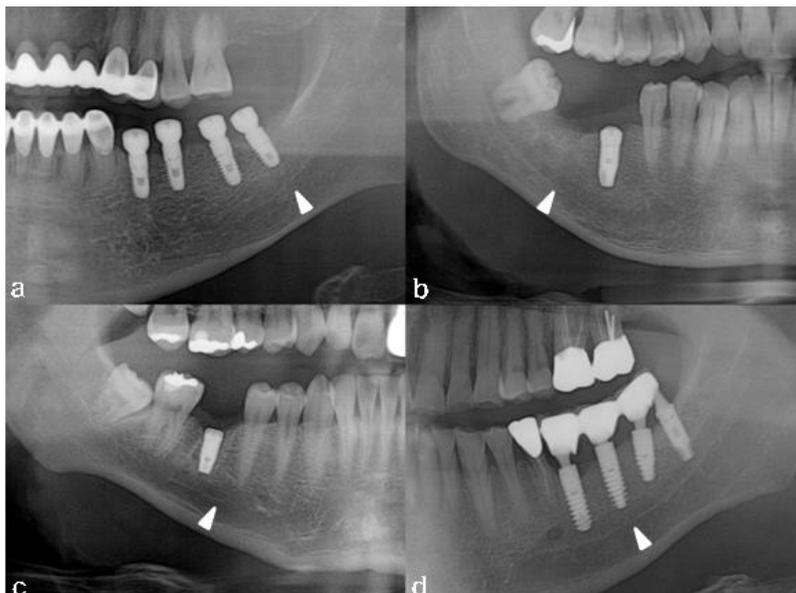
## B. Radiographic evaluation

Panoramic radiography was performed with CRANEX3+® (SOREDEX, Helsinki, Finland), and CT was performed with HISPEED advantage® (GE medical, Milwaukee, USA). All of the panoramic radiography and CT images were interpreted two times by two experienced oral and maxillofacial radiology specialists.

The patients were categorized into two groups: '0: Unclear' and 'Clear' according to the clearness of upper cortical layer of IAN canal in both panoramic radiography and CT images. Additionally, 'Clear' group was further divided into three subgroups: '1: away from IAN', '2: contact with IAN(below 1mm in CT and 2mm in panoramic radiography images), and '3: invading IAN canal' by Bartling et al.<sup>21</sup> (Table 1, Figure 1,2)

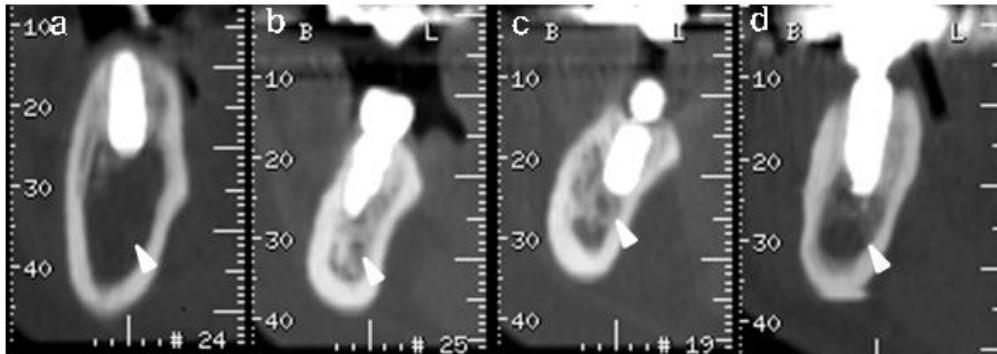
**Table 1.** Criteria of radiographic evaluation

Score	Subtype	Criteria
0	Unclear	Upper cortical layer of IAN is unclear
1	Away from IAN	Over 1mm from IAN in CT and 2mm in panoramic radiography images
2	Contact with IAN	Below 1mm from IAN in CT and 2mm in panoramic radiography images
3	Invading IAN canal	Discontinuity of superior cortical wall of IAN



**Figure 1.** Example of subgroup on panoramic radiography. Arrowhead indicates suspected IAN canal.

a: Unclear; b: Away from IAN; c: Contact with IAN; d: Invading IAN canal



**Figure 2.** Example of subgroup on CT. Arrowhead indicates suspected IAN canal.

a: Unclear; b: Away from IAN; c: Contact with IAN; d: Invading IAN canal

### C. Statistical analysis

The root set was analyzed using the Statistical Package for Social Science, Ver 19.0 (SPSS, Chicago, IL). Cohen's kappa value was used for intra and interobserver reliability assessment, comparison of evaluations between panoramic radiography and CT, and Kendall's Tau was used for comparison between CT evaluation and VAS.

The results were considered significant at  $P < 0.05$ .

## III. RESULTS

### 1. Distribution of VAS in clinical examinations

According to clinical evaluation, there were 109 patients. Distribution of VAS on 109 patients are shown on Table 2.

**Table 2.** Distribution of VAS in clinical examinations

VAS	0-0.9	1-1.9	2-2.9	3-3.9	4-4.9	5-5.9	6-6.9	7-7.9	8-8.9	9-9.9	10
Frequency	3	6	3	7	24	23	10	7	16	2	8

## 2. Distribution of scores in radiographic evaluations

132 injury sites were obtained from 109 patients in total including 23 patients who have had bilateral affected sites. Distribution of scores in panoramic and CT images are shown on Table 3.

**Table 3.** Distribution of scores in panoramic and CT images.

	Panoramic radiography		CT	
	Number of implant	%	Number of implant	%
0	45	34.1	2	1.5
1	16	12.1	10	7.6
2	26	19.7	14	10.6
3	45	34.1	106	80.3
Total	132	100.0	132	100.0

Evaluating the results of the final exam of the CT scans, 80.3% of the patients showed disruption in continuity of the IAN canal, 10.6% of the patients showed with close proximity of the canal and the implant fixture but with continuity, and another 7.6% of the patients showed IAN canal that were free from contact with the fixtures.

Cohen's kappa value of both intra-observer and interobserver agreement show almost perfect agreement in both panoramic radiography and CT.

## 3. The correlation between VAS and radiographic evaluation.

The correlation between VAS and radiologic evaluation are shown on the table 4-1, 4-2, 5-1, 5-2.

**Table 4-1.** The correlation between VAS and panoramic radiography result

Panoramic radiography evaluation	VAS											
		0-0.9	1-1.9	2-2.9	3-3.9	4-4.9	5-5.9	6-6.9	7-7.9	8-8.9	9-9.9	10
0		0	2	2	4	9	8	4	4	5	0	1
1		0	0	0	1	3	5	0	1	1	1	1
2		1	2	0	1	6	3	2	1	2	1	3
3		2	2	1	1	6	7	4	1	8	0	3

**Table 4-2.** The correlation between VAS and panoramic radiography result.

		VAS
	N	109
Result of Panoramic radiography evaluation	Kendall's Tau	-0.075
	p-value	0.438

**Table 5-1.** The correlation between VAS and CT images

VAS		0-0.9	1-1.9	2-2.9	3-3.9	4-4.9	5-5.9	6-6.9	7-7.9	8-8.9	9-9.9	10
CT evaluation	0	0	0	0	0	1	0	1	0	0	0	0
	1	0	0	0	1	0	4	0	0	0	1	1
	2	0	1	0	1	5	1	3	1	1	1	0
	3	3	5	3	5	18	18	6	6	15	0	7

**Table 5-2.** The correlation between VAS and CT in CT images

		VAS
	N	109
Result of CT evaluation	Kendall's Tau	-0.068
	p-value	0.460

Kendall's Tau statistic method was used to compare the result of VAS with CT evaluation. The obtained result shows p-value higher than 0.05 in all values, suggesting that Tau value has no significance. Therefore it could be concluded that there are no correlation between the results of VAS and radiographic images.

In evaluating the diagnostic capacity of panoramic radiographs, patients who were diagnosed 'unclear' or 'away from IAN' in panoramic radiography were classified then compared with CT results. Grouping in CT follow the previous division category, and the result is shown in table 6.

#### 4. Comparison between estimated panoramic radiography result

In evaluating the diagnostic capacity of panoramic radiographs, patients who were diagnosed 'unclear' or 'away from IAN' in panoramic radiography were classified then compared with CT results. Grouping in CT follow the previous division category, and the result is shown in table 6.

**Table 6.** Comparison between estimated panoramic radiography result from the patients who had unclear image on panoramic radiography and their CT result

		CT evaluation			
		0	1	2	3
Panoramic radiography evaluation	0	2	4	4	35
	1	0	6	3	7
	2	0	0	7	19
	3	0	0	0	45

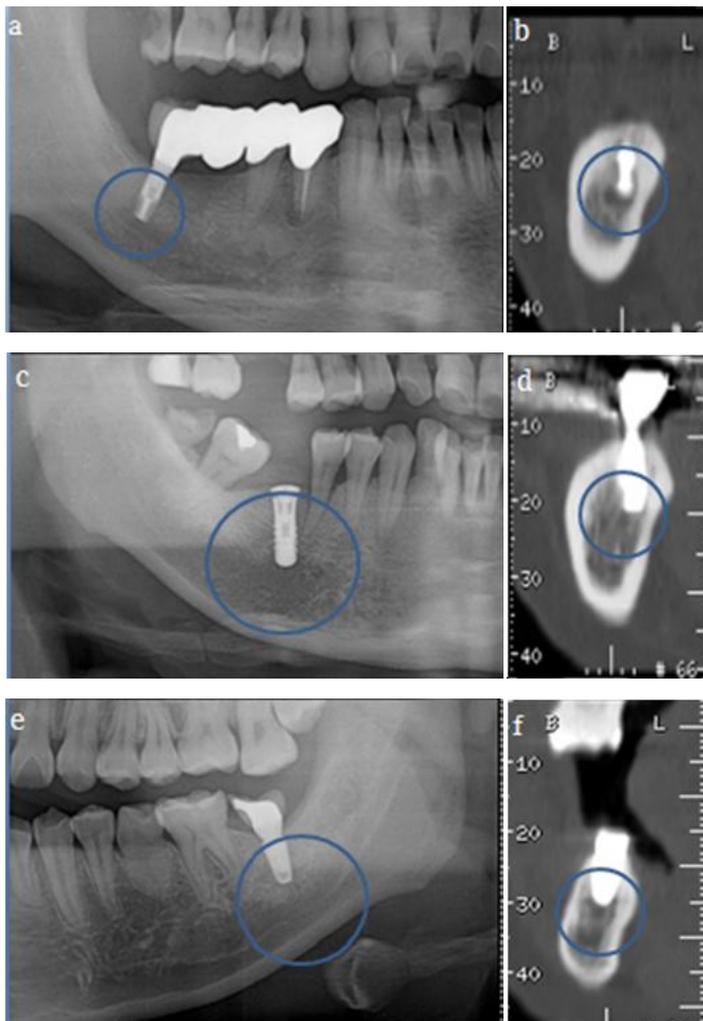
Based on the results obtained from above, 83% of the patients with 0 or 1 diagnosis in panoramic radiography were diagnosed with nerve damage when analyzed by CT. Hence there is a tendency to misdiagnose or underestimate the severity of damage when using panoramic radiography view.

## IV. DISCUSSION

Nerve injury is one of the most common complications after implant surgery and there is a risk that the aftereffects may progress irreversibly and can cause permanent damages. The prevalence of IAN damage by implantation varies from 0-44% in previous studies.<sup>16-19</sup> According to a study based on a survey carried out by Ryu et al. IAN damage caused by implant installation succeeds extraction in taking up to 24.6% of all IAN damages.<sup>20</sup> However, when considering the prevalence of permanent altered sensation cannot be recovered, irreversible IAN injury caused by implant installation is remarkably higher than the one by extraction.<sup>17,18,21</sup> The best way to prevent the nerve damage is surgeon's careful approach during procedure, but when nerve damage is sustained, proper treatment should be taken.<sup>4</sup>

Therefore, various clinical and radiographic examinations are essential in order to identify nerve damage. In this study, we have evaluated various factors of the diagnostic capacity of the most commonly used dental radiography.

We analyzed 132 implant fixture sites from 109 patients categorized by the criteria mentioned before. The subjects have taken both panoramic radiography and CT twice, at the same time by two observers and the intra- and interobserver agreement were analyzed. Criteria were classified into 0, 1, 2, 3 as mentioned before.



**Figure 3.** Variable imaging evidence between panoramic and CT radiography on the same patient.

a, b: Identical imaging. IAN is obviously observed in both panoramic and CT images.

c, d: Different imaging. The site of IAN is not clearly shown on panoramic radiography, but damage of IAN is shown on CT.

e, f: Different imaging. There is enough distance between the IAN and the fixture shown on panoramic image, but they are in close contact on CT image.

Intraobserver and interobserver agreement were calculated by Cohen's Kappa value and it showed almost perfect agreement. Therefore both panoramic radiography and CT results are dependable, and these results may be used in following procedures.

In panoramic radiography, magnification occurs due to its imaging principle, and actual distance between implant fixture and IAN canal could be overestimated, which implies an under-evaluation of the IAN damage by implants.<sup>7</sup> Figure 3 is the examples chosen by this study. All CT scans manifestly show fixtures invading the IAN canal. However, in some panoramic radiographies, either the distance between the fixture and the IAN canal cannot be accurately evaluated, or the invasion of the nerve canal is unclear due to the uncertain location of the IAN canal.

Therefore, we performed method pair samples test on the samples excluding the patients with unreadable panoramic radiography. According to the result on the table, panoramic radiography images tend to underestimate the degree of the damage compared to that of CT in all cases which showed significant difference. These results imply that even when a considerable amount of distance seems to be obtained in panoramic radiographs, CT scans could show implant fixtures that are invading and thus damaging the IAN canals. Therefore, if panoramic radiography is the only imaging device used before implant installation, the safety margin should be set over 2mm.<sup>22-24</sup> It could be proven that there is a risk in making a exam of nerve complication using panoramic radiography alone.

As in results deduced by Choi et al, there were no definite correlation between VAS and nerve damage in all cases,<sup>26</sup> and this suggests that the degree of nerve damage cannot be assessed by the amount of patient discomfort.

Likewise, due to the limitations of panoramic radiography itself, interpretation result of panoramic radiograph tends to underestimate the degree of nerve damage. Accordingly, it is necessary to take CT for the patients suspected to have nerve complications after implant surgery for precise exam. Since there is no significant correlation between the intensity of subjective pain and the degree of nerve damage, it is more reasonable to identify nerve damage by the existence of symptom rather than the intensity of pain and take care of patients who have symptoms immediately

## V. CONCLUSION

Based on these results, it is difficult to evaluate altered sensation caused by the IAN damage by VAS score. Moreover, in case where panoramic radiograph is insufficient for accurate evaluation of the patient discomfort, additional CT taking is needed for the precise diagnosis.

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국문요약

# 임플란트 식립 후 하치조신경 감각 이상의

## 식별을 위한 파노라마 방사선사진과

### 전산화 단층 사진의 비교

김희준

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(지도교수 박창서)

임플란트 식립 후 감각 이상 환자의 평가 방법에서 파노라마와 CT가 사용되고 있으며 해부학적 구조물의 위치관계를 파악함에 있어 CT가 가장 정확한 영상 정보를 제공하는 것으로 알려져 있으며 식립체와 하치조신경관의 위치 관계 평가에 있어서 가장 정확한 정보를 제공해 주고 있다. 이와 더불어 하치조신경 손상의 진단을 위한 임상 검사 결과들이 종합적으로 고려되어 하치조신경 손상 여부를 파악하게 된다. 그러나 이러한 검사들의 정확도가 CT영상에서 얻어지는 해부학적 위치 관계와의 상관성에 대한 연구는 많지 않다. 이에 임플란트 식립 후 감각 이상 환자의 임상 검사 결과와 CT영상 정보를 비교 분석하여 각각의 진단능을 평가하여 임상 검사 결과에서의 CT촬영 필요성에 대한 기준을 제시하고자 한다.

2004년부터 2012년까지 하악 구치부에 임플란트 식립 후 감각 이상이 발생하여 연세대학교 치과eogkr병원에 내원한 109명의 환자, 132개의 식립체 중 임상 검사상에서 이상 소견을 보여 임플란트에 의한 신경 손상이 실제로 나타난 것으로 추정되어 파노라마와 CT를 모두 촬영한 환자들을 선택하였다. 모든 환자들의 영상은 구강악안면 방사선학 전문가들에 의해 4단계로 분류되었으며 이를 바탕으로 관찰자내 일치도, 관찰자간 일치도, 두 영상 진단 간의 비교, VAS와의 비교, 파노라마 영상에서 명확히 하치조신경관의 위치를 평가할 수 없는 환자의 CT 진단 등과의 평가를 시행하였다.

관찰자내 일치도와 관찰자간 일치도는 0.6-0.8로 거의 완벽에 가까운 일치도를 보였다. 파노라마 영상과 CT영상의 직접 비교시 통계학적으로 유의성있는 차이를 보였으며, 파노라마 영상이 실제의 손상 정도를 과소 평가하는 경향이 있었다. VAS 결과는 전체, 성별, 연령에 따른 차이 없이 신경 손상의 정도와 상관 관계를 보이지 않았다. 파노라마 영상에서 하치조 신경관의 해부학적 위치를 평가할 수 없는 환자의 83%에서 CT영상에서 하치조 신경관의 손상을 보이고 있었다.

결론적으로, 파노라마 영상은 임플란트 식립 후 감각 이상이 나타난 환자의 진단에 있어서 하치조 신경의 손상 여부를 평가하는 데 불충분한 방법이며, 이러한 환자의 진단에 있어서는 CT와 다른 임상 검사를 포함한 부가적인 진단 도구를 이용한 종합적인 평가가 이루어져야

한다고 생각된다.

핵심되는 말 : 파노라마 영상; 전산화 단층 촬영; 하치조신경 손상; 하악; 임플란트; 감각 이상