치의학석사 학위논문

Shape and location of calcified carotid atheroma on panoramic radiographs compared with CT images

전산화단층영상에서 관찰된 경동맥석회화의
파노라마방사선영상에서의 형태와 위치

2012년 8월

서울대학교 대학원
치의과학과 구강악안면방사선학 전공
박 해 랑

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지도교수 허 민 석

이 논문을 치의학석사 학위논문으로 제출함

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박해랑의 석사학위논문을 인준함

2012년 6월

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Abstract

Shape and location of calcified carotid atheroma on panoramic radiographs compared with CT images

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(Directed by Prof. Min-Suk Heo, DDS, MSD, PhD)

1. Objectives

A number of reports have suggested that panoramic radiography might be useful to aid in detecting calcified carotid atheroma (CCA). The shape and location of calcified carotid atheroma on panoramic radiographs were described by many authors, based on the experimental knowledge, but there has been no report present objective evidence. Therefore the objective of this study was the evaluation of the location and shape of CCA on panoramic radiograph. Computed tomographic (CT) images were regarded as the gold standard.

2. Materials and Methods

The CT images of 342 patients (124 men, 218 women: average age 66.9 years, range 55-95 years) at the Seoul National University Dental Hospital from January 2010 to December 2011 were reviewed by an oral and maxillofacial radiologist. Panoramic radiographs of the patients were also reviewed to detect CCAs with aid of the corresponding CT images. The correlation of radiographic findings between CT images and panoramic radiographs were evaluated. The shape of the CCAs on the panoramic radiographs were allocated to one of 6 types such as single plaque-like, multiple plaque-like, tubular, oval, linear and amorphous type. The relative position to hyoid bone, cervical vertebra, and mandibular angle were evaluated on panoramic radiographs.

3. Results

The 223 sides of 143 patients were diagnosed from CT images as having CCAs and the 114 sides of 82 patients were diagnosed from panoramic radiographs also. The most common location on the CT images was common carotid artery only (75 sides), but 33.3% of them were also detected on panoramic radiographs. Meanwhile, 14 sides of CCAs were detected on the CT images at the common, internal, external carotid artery simultaneously, and 70% of them were also detected on panoramic radiographs. The detection of CCAs on panoramic radiographs was significantly associated with maximum

Hounsfield unit value on CT images, the maximum diameter, the number of cuts and vertical location on CT images.

Regarding the shape of CCAs on the panoramic radiographs, the multiple plaque-like type was most common, followed by single plaque-like, amorphous, tubular, linear and the oval type was least. The most frequent location of CCAs relative to cervical vertebra was at the level of C3 (43.0%) and followed by the level of intervertebral space C3-4 (35.1%). Regarding the location relative to the tip of greater horn of hyoid bone, CCAs were located at the superior to the tip in 50% vertically and the same level of the tip in 58.8% horizontally. Regarding the location relative to the mandibular angle horizontally, CCAs were located medially in 6.1% medially, 14.0% at the same level, and 79.9% laterally.

4. Conclusion

Although the shape of calcified atheroma on panoramic radiographs varied, the 'Plaque-like' type was most common. The most common location of the CCAs was at the level of C3 and superior to the tip of greater horn of hyoid bone vertically and same level of the tip of greater horn of hyoid bone, posterior of mandibular angle horizontally.

Key words: Carotid artery, Atherosclerosis, Vascular calcification, Panoramic radiography, Computed tomography

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Contents

I. Introduction

Cerebrovascular accident is the second leading cause of death in Korea, exceeded only by cancer.[1] It is also the leading cause of severe disability and therefore represents a significant public health problem. Some of these adverse vascular events will have had no prodromal sign nor symptom and many will result in death.[2] More than half of strokes are believed to be the result of atherosclerotic disease at the carotid bifurcation associated with embolization of atherosclerotic debris or a platelet-fibrin clot formed on the plaque surface.[3] Numerous studies have shown that neurologically asymptomatic patients with >50% stenosis of the internal carotid arteries are at increased risk of developing strokes.[4] In view of such a significant problem, all measures aimed at preventing atherosclerosis, and early detection of all those patients at risk of cerebral ischemic attacks, are the main tools for reducing the prevalence of this disease.

Carotid duplex ultrasonography(CDUS) is the standard of care for the initial diagnosis of carotid artery bifurcation disease.[5] Although accurate and inexpensive, the screening of large symptom-free populations has been shown to be cost-ineffective unless the prevalence of significant disease is 4.5% or greater, a condition not met even when limited to the elderly.[6] Currently, indications for CDUS which are acceptable for reimbursement include: cervical bruit; amaurosis fugax; focal or cerebral transient ischemic attacks; drop attacks or syncope;

episodic dizziness with symptoms characteristics of transient ischemic attacks; evaluation and follow-up of cervical bruits.[5]

Many patients undergoing dental examination and treatment undergo panoramic radiography as part of their routine care. Panoramic radiographs might be useful to assess carotid atheroma (CCA) it often includes the region of the carotid bifurcation and show the presence of CCA. While not all calcifications observed on panoramic radiographs represent significant stenosis of the carotid arteries, and not all hemodynamically significant stenosis includes calcifications that are detectable on radiographs, the incidental detection of calcifications on panoramic radiographs during routine dental examination of neurologically asymptomatic patients has been suggested as a cost-effective screening method for CDUS referral.[7] The panoramic radiograph does not have the potential of the CDUS for early diagnosis and stroke prevention, but it can be an additional valuable method. As it requires no additional time or cost, its information concerning the carotid vessel should be used as a coproduct of a standard dental procedure.[8]

Since Friedlander et al[9] first reported the detection of CCAs by means of panoramic radiographs, a number of studies have also described the detection of CCAs on panoramic radiographs. Those studies suggested an overall prevalence rate of CCA on panoramic radiographs of approximately 2% to 5% in the general dental outpatient population and approximately 5% in patients 55 years of age and older.[7,9-14] And higher rate of CCAs observed in panoramic radiographs of certain subgroups, e.g., males, individuals >40 years old, smoker, individuals with hypertension, diabetes, or hypercholesterolemia, and individuals who have undergone renal transplantation or head and neck radiation therapy.[11,12,15-21]

The preveious studies on CCAs on panoramic radiographs mainly shape and localization to the adjacent anatomic structures such as mandibular angle, cervical vertebra, and hyoid bone. The shape and location of CCAs were described in many ways according to the authors.[22-24] Those descriptions were based on the author' s experimental and anatomical knowledge without objective evidence. Thus, the purpose of this study was to evaluate the shape and location of CCAs on panoramic radiographs using CT images as gold standard.

Ⅱ. Materials and Methods

The contrast enhanced CT images of 342 patients (124 men, 218 women: average age 66.9 years, range 55−95 years) at Seoul National University Dental Hospital from January 2010 to December 2011 were reviewed. The inclusion criteria were (1) the patient were 55 or older (2) with panoramic radiograph taken within 1 year from the time of CT exam. (3) The CT images taken after administration of contrast medium since enhanced CT could identify the vessels easily. With poor quality of radiographs or have underwent neck dissection surgery were excluded.

CT images

The CT images were acquired using Siemens Somatom Sensation 10 (Siemens AG, Forchheim, Germany), set at 120 kV, 100 mA, and 3 mm slices. Intravenous contrast medium (Ultravist 370, Shering AG, Berlin, Germany) was injected at rate of 2~3 ml/sec.

The CT images were reviewed by an experienced oral and maxillofacial radiologist. CCA on CT images, defined as a discrete, well−circumscribed region in the carotid wall that appeared hyperdense to the surrounding parenchyma and has contrast−enhanced lumen with wide window settings. For each patients, the exact location of CCAs in the artery, maximum Hounsfield units (HU) value of CCA, maximum diameter of CCA on the axial image, number of cuts that CCAs were detected, vertical location of CCA relative to cervical vertebra were determined.

Panoramic radiographs

The panoramic images had been taken by experienced oral and maxillofacial radiographers using Orthopantomograph OP100 (Instrumentarium Corp., Tuusula, Finland). All images had been obtained using PSP image plates (12×10 inch) and read by an FCR system (Fuji Computed Radiography 5000R, Fuji Photo Film Co. Ltd., Düsseldorf, Germany).

Using the panoramic radiographs, CCAs were reviewed with aid of the corresponding CT images. The shape of CCAs on the panoramic radiographs was allocated to one of 6 types and follows: single plaque-like, multiple plaque-like, tubular, oval, linear, and amorphous type (Fig. 1). The relative position of CCAs to the hyoid bone, cervical vertebra and mandibular angle were evaluated.

Statistical analysis

All statistical calculations were performed using Microsoft Windows Excel 2007 (Microsoft Co., Redmond, WA, USA) and SPSS 10.0 (SPSS Inc., Chicago, IL, USA). The CCAs detected on CT images devided into two groups such as Group 1: could be detected on panoramic radiographs, Group 2: no detected on panoramic radiographs. The differences of CT findings between the groups were evaluated using Two sample T-test and the Mann-Whiney *U* test. Spearman's rank correlation coefficient was used to evaluate the relationships between detection of CACs on panoramic radiographs and CT findings: maximum HU value of CCA, maximum diameter of CCA on axial image, number of cuts that CCAs were detected, and vertical location of CCA relative to cervical vertebra. Multiple linear regression analysis was carried out and significant explanatory variables were entered into the model by using a forward stepwise method with a significant level of 0.05.

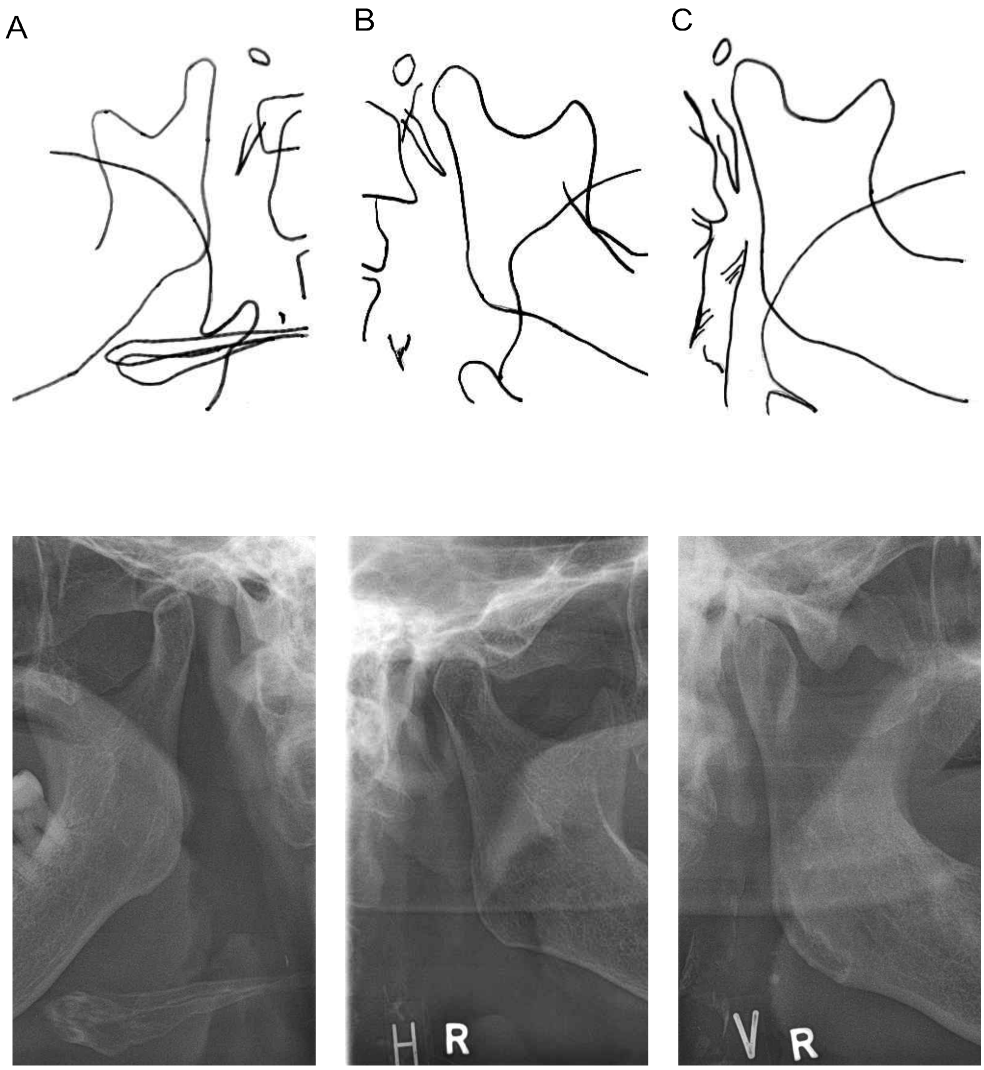

Fig. 1. The shape of the CCA: (A) Plaque−like (single) type. (B) Plaque−like (multiple) type. (C) Tubular type.

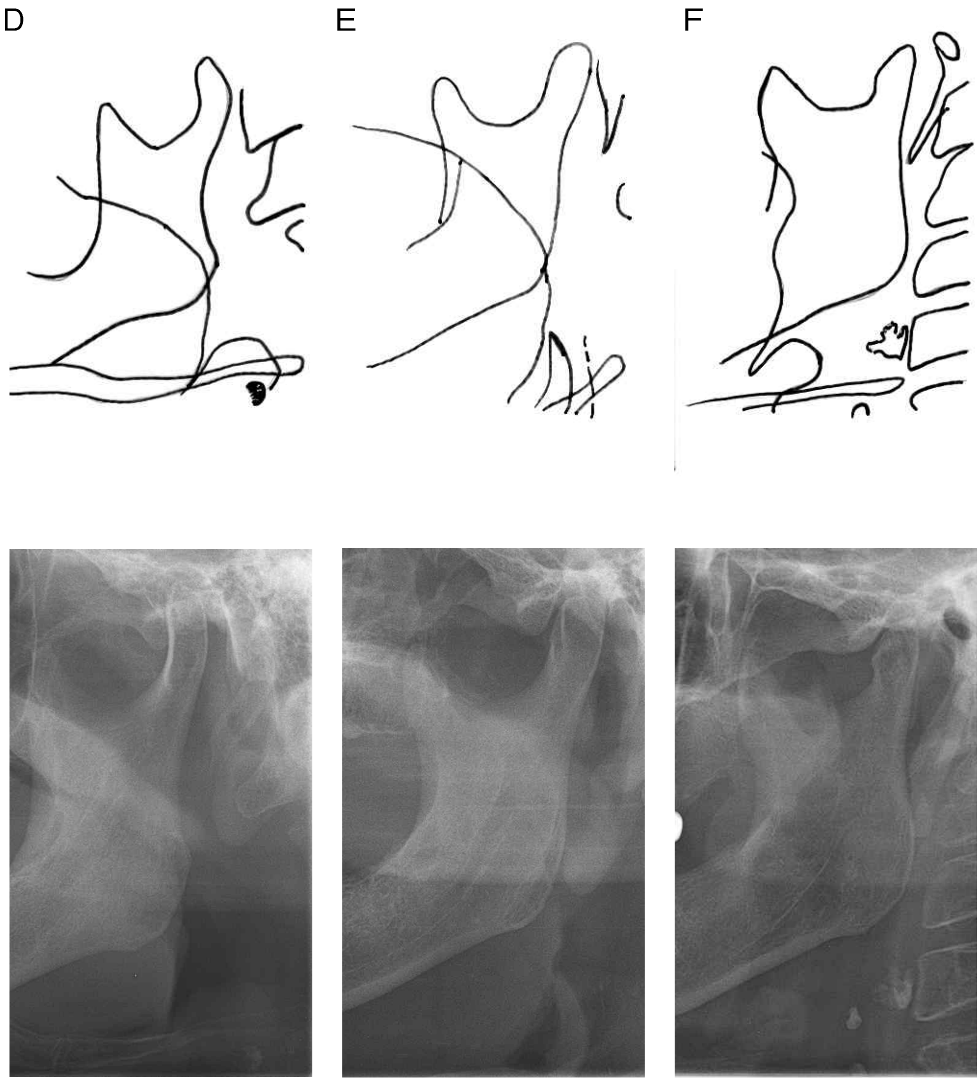

Fig. 1. The shape of the CCA (continued): (D) Oval type. (E) Amorphous type. (F) Linear type.

Ⅲ. Results

Among 342 patients, 143 patients were diagnosed from CT images as having CCAs. Calcifications were bilateral in 80 patients and right side in 29 patients, left side in 34 patients. CCAs were detected on 114 sides of 82 patients (52 female, 30 male, mean age 71.0 years) on panoramic radiographs. CCA were bilateral in 32 patients, unilateral in 50 patients. Regarding the location, 53 CCAs were located on the right side and 61 on the left side (Table 1).

CCAs were detected in 223 sides of 143 patients. The most common position of CCAs was common carotid artery (198 sides). The CCAs were located in common carotid artery only in 75 sides, common and internal carotid artery in 73 sides, common and external carotid artery in 30 sides, and common, internal, and external carotid artery in 20 sides. The CCAs were located in internal carotid artery only in 20 sides, external carotid artery only in 5 sides (Table 2).

Table 1. The number of patients having calcified carotid atheromas detected on CT and panoramic radiographs

Side	CT	Panoramic radiographs
Bilateral	80	32
Unilateral	63	50
Right only	29	21
Left only	34	29
Total	143	82

Table 2. The number of sides of calcified carotid atheromas according to the location

Carotid artery	CT	panoramic radiographs	Detection rate of panoramic radiographs
common	75	25	33.3%
internal	20	10	50.0%
external	5	2	40.0%
common, internal	73	48	65.8%
common, external	30	15	50.0%
common, internal, external	20	14	70.0%
Total	223	114	51.1%

The Group 1 had a lower maximum HU value, a smaller maximum diameter, and lower number of axial cuts on CT images than the Group 2 ($p<0.05$). A significant difference was found in the location relative to cervical vertebra between the groups. (Table 3) In correlation analysis, the detection of CCAs on panoramic radiographs were significantly associated with maximum HU value, maximum diameter, and the number of cuts, vertical location of CCA (Table 4). Multiple linear regression analysis showed that the detection of CCAs on panoramic radiographs was significantly associated with maximum HU value of CCA and the vertical location of CCA relative to cervical vertebra. The maximum diameters and the number of axial cuts were exclued in the final model.

Table 3. The CT findings of calcified carotid atheromas

	Detected on panoramic radiographs	Non-detected on panoramic radiographs
Maximum density value (HU)	1532.4 ± 56.6	787.6 ± 39.9
Maximum diameter (mm)	6.2 ± 0.3	3.7 ± 0.3
Number of axial cuts	4 ± 0.2	2.5 ± 0.1
Cervical vertebra at the level of CCAs	3.0 ± 0.0	3.5 ± 0.1

Table 4. Spearman' s rank correlation coefficient between whether be detected on panoramic radiographs(panoramic radiographs) and computed tomography findings of calcified carotid atheroma.

		Maximum diameter	Number of axial cuts	Maximum density value	Vertical location
Detection on panoramic radiographs	rs	.312**	.355**	.477**	−.380**
	sig.	.000	.000	.000	.000

rs = Spearman' 's rank correlation coefficien

**. Correlation is significant at the 0.01 level(2-tailed).

The shape of CCAs on panoramic radiograph is shown in Table 5. The most common shape is ‘multiple plaque-like’ type (33.3%) and followed by ‘single plaque-like’ type (21.1%).

Table 5. Calcified carotid atheromas classification according to shape on panoramic radiographs

Morphologic type	n	%
Plaque-like (single)	24	21.1
Plaque-like (multiple)	38	33.3
Oval	3	2.6
Tubular	21	18.4
Amorphous	22	19.3
Linear	6	5.3
Total	114	100

The relative location of CCAs relative to hyoid bone, cervical vertebra and mandibular angle is shown in Tables 6 and 7.

Table 6. Correlation with horizontal and vertical location of CCAs relative to the tip of the great horn of hyoid bone

	Horizontal location		
Vertical location	medial	at the level	distal
superior	12 (10.5%)	19 (16.7%)	9 (7.9%)
superior, at the level	3 (2.6%)	10 (8.8%)	1 (0.9%)
at the level	1 (0.9%)	8 (7.0%)	1 (0.9%)
at the level, inferior	5 (4.4%)	8 (7.0%)	0 (0.0%)
inferior	7 (6.1%)	13 (11.4%)	4 (3.5%)
superior-inferior	5 (4.4%)	9 (7.9%)	1 (0.9%)

Table 7. The relative location of calcified carotid atheromas relative to anatomical structures

Anatomical structure	Location	n	%
Tip of the greater horn of hyoid bone	superior	46	40.4
	superior, at the level	11	9.6
	at the level	10	8.8
	at the level, inferior	12	10.5
	inferior	24	21.1
	superior−inferior	11	9.6
Tip of the greater horn of hyoid bone	medial	33	28.9
	at the level	67	58.8
	distal	16	14.0
	not determined	7	6.1
Cervical vertebra	2nd	2	1.8
	2nd−3rd	11	9.6
	3rd	49	43.0
	3rd−4th	40	35.1
	4th	34	29.8
	4th−5th	3	2.6
	not determined	16	14.0
Mandibular angle	medial	7	6.1
	at the level	16	14.0
	distal	91	79.9

Ⅳ. Discussion

This is the first report in the literature about localization of CCAs on panoramic radiographs with aid of CT images. Of the previous reports about detection of CCA on panoramic radiograph, there was only one report using CT as gold standard, that reports was about the diagnostic accuracy of the PR for the detection of CCA.[25] CT images allow precise differential diagnosis and localization. And we were able to estimate the cause of the false negative readings with aid of CT images.

This study categorized the shape of CCAs as 6 types: single plaque-like, multiple plaque-like, tubular, oval, linear, and amorphous. The 'plaque-like' type was defined as small, homogeneous radiopacity that had smooth margin on vessel wall side. It was the most common type in this study, however it had never been described. It might be due to small CCAs which were difficult to diagnosis without aid of CTs. The 'amorphous' type defined as large, irregular, heterogeneous radiopacity that had not vertico-linear margin. This type of CCAs could be similar to lymph node calcification, however cervical lymph node calcification is a rare condition. In a study, only 1% of the 2,300 neck CT scans revealed cervical lymph node calcification.[26] In the samples of our study, only one case of lymph node calcification was diagnosed, which the lymph node calcification was observed superimposed on mandibular angle. The 'oval' type might be difficult to distinguish from triticeous cartilage and superior tip of thyroid cartilage. Only 2.6% of CCAs showed this type.

In our study CCAs often found superior to the tip of greater horn of hyoid bone and only 21.1% of CCAs were found inferior. This result was contrary to the description of some authors that CCAs mostly found inferior to the hyoid bone. When CCA was located inferior to the hyoid bone it could be difficult to distinguish from triticeous cartilage and thyroid cartilage.[24,27] In the previous reports about diagnosis of CCA on panoramic radiograph, triticeous cartilage and thyroid cartilage contribute to most of misdiagnosis.[25,28] The triticeous cartilages are bilateral ovoid structures that are part of a complex of structures found in the area of the laryngeal skeleton.[24] The triticeous cartilage is located centrally in the lateral thyrohyoid ligament.[27] On a panoramic radiograph, the tritieous cartilage situated in an imaginary line that connects the greater horn of the hyoid and the superior horn of the thyroid cartilage.[27] Carter et al[11] described the location of calcified triticeous cartilage on panoramic radiographs more medially than CCAs. Our findings were contrary to their results. Of the CCAs inferior to the hyoid bone, the only 16.7% of CCAs were located lateral to the tip of greater horn of hyoid bone and the most of CCAs (54.2%) were located at the level of the tip of greater horn of hyoid bone. Therefore it would be important to diagnose differentially between triticeous cartilages and CCAs based on the shape and outline; the calcified triticeous cartilages were mostly oval, with a smooth, well-defined corticated border.[27]

The most frequent location of CCAs relative to cervical vertebra was at the level of C3 and next frequent location was at the level of intervertebral space C3-4. Several authors have described differently for the location of CCA relative to cervical vertebra.[22,24] According to our findings, CCAs were located adjacent C2-C4, most frequently adjacent C3. Only one CCA was observed on panoramic radiographs among CCAs were located below C4 level. It might be due to the limitation of area covered by panoramic radiographs. Additionally, the size and density of CCAs could be the reason of CCAs were undetected on panoramic radiographs. In our result, the Group that CCAs were not detected on panoramic radiographs had a lower maximum density value, a smaller maximum diameter and lower number of axial cuts on CT images than the Group that CCAs were detected on panoramic radiographs, significantly. Especially, the density and vertical location of CCAs were highly correlated with detectabillity of CCAs on panorimic radiographs than size of CCAs. Some calcifications might be superimposed on cervical vertebra on panoramic radiographs. Patient position of panoramic radiography might affect the detectability of CCAs.[25,29] In 7 patients, It is supposed to CCAs were superimposed on indicating letter on the right side. It is considered be better to move the location of the indicating letter for diagnosis of CCA.

Ⅴ. Conclusion

The shape of calcified atheroma on panoramic radiographs were varied, ‘Plaque–like’ type was most common. Most common location of the CCA was at the level of C3 and superior to the tip of greater horn of hyoid bone vertically and same level of the tip of greater horn of hyoid bone, posterior of mandibular angle horizontally. The HU value and vertical location of CCAs were highly correlated with detectabillity of CCAs on panorimic radiographs.

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국문 초록

전산화단층영상에서 관찰된 경동맥석회화의 파노라마방사선영상에서의 형태와 위치

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1. 목 적

경동맥석회화 진단을 위한 파노라마방사선영상의 유용성에 관한 연구들이 진행되어 왔으나 진단 기준에 대한 객관적인 검증이 부족하였다. 이에 CT영상에서 확인한 경동맥석회화를 대상으로 파노라마방사선영상에서 관찰되는 경동맥석회화의 위치와 형태를 분석하였다.

2. 방 법

2010년 1월부터 2011년 12월까지 서울대학교치과병원에 내원하여 전산화단층촬영(CT)과 파노라마방사선촬영을 모두 시행한 55세 이상 환자 342명을 대상으로 하여 연구를 진행하였다. 한 명의 구강악안면방사선학 전공자가 CT영상을 판독하고, CT영상을 참고하여 파노라마방사선영상에서 경동맥 석회화를 진단하였다. CT영상에서 관찰되는 경동맥석회화는 파노라마방사선영상에서 관찰되는 것과 관찰되지 않는 것으로 분

류하여 차이를 분석하였다. 파노라마방사선영상에서 관찰되는 경동맥석회화의 형태를 여섯 가지로 분류하였고, 설골, 경추, 하악각에 대한 상대적인 위치를 평가하였다.

3. 결 과

연구대상 342명 중 143명의 환자의 CT영상에서 총 223례의 경동맥석회화가 관찰되었으며, 이 중 82명의 파노라마방사선영상에서 총 114례의 경동맥석회화가 관찰되었다. CT영상에서 관찰되는 경동맥석회화 증례를 위치별로 분류하면 경동맥석회화가 총경동맥에만 위치한 경우가 가장 많았으며, 이 중 30%만이 파노라마방사선영상에서 관찰되었다. 경동맥석회화가 내경동맥에만 위치한 경우는 그 40%가 외경동맥에만 위치한 경우는 그 50%가 파노라마영상에서 관찰되었으며 총경동맥, 내경동맥, 외경동맥 모두에 위치한 경우는 70%가 파노라마방사선영상에서 관찰되었다. CT영상에서 관찰되는 경동맥석회화 증례 중 파노라마방사선영상에서 관찰되지 않는 경우는 관찰되는 경우에 비해 최대 CT값과 크기가 유의하게 작았으며 수직 위치 분포도 유의한 차이를 보였다. 파노라마방사선영상에서 관찰되는 경동맥석회화를 형태에 따라 분류하였을 때, 다수의 플라크 형태가 38례(33.3%)로 가장 많았으며, 한 개의 플라크 형태, 무정형, 관형, 선형, 타원형 순으로 관찰되었다. 경추를 기준으로 한 경동맥석회화의 위치는 3번 경추에 인접한 경우가 49례(43.0%)로 가장 많았으며, 3, 4번 경추 사이에 인접한 경우가 40례(35.1%)로 뒤를 이었다. 설골의 대각 부위를 기준으로 한 경동맥석회화의 위치는, 상하로는 상방에서 관찰되는 경우가 46례(40.4%)례로 가장 많았으며, 내외측으로는 동일 선상에서 관찰되는 경우가 67례(58.8%)였다. 하악각 부위를 기준으로 한 경동맥석회화의 위치는 내측이 7례(6.1%), 동일 선상인 경우가 16례(14.0%), 외측이 91례(79.9%)로 관찰되었다.

4. 결 론

CT영상에서 경동맥석회화가 관찰되더라도 파노라마방사선영상에서 관찰이 불가능한 경우가 있었다. 경동맥석회화는 파노라마방사선영상에서 다양한 형태로 관찰되었고, 플라크 형태가 가장 많았다. 위치를 분석하였을 때 수직적으로는 설골의 상방, 경추의 3번에 인접하여 주로 관찰되었으며, 수평적으로는 하악각의 외측, 설골 대각 부위와 같은 위치에서 주로 관찰되었다.

주요어 : 경동맥석회화, 파노라마방사선영상, CT영상
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